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Organic farming in India and challenges

R.K. Tiwari, B.S. Dwivedi, Nirmala Singh, A.K. Pandey and **S.K. Rao**
National Project on Organic Farming
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Krishi Vigya Kendra
Rewa 486 001(MP)

Abstract

Organic agriculture is one of the broad spectrum of production methods, being considered in support of the environment and human health. The demand for organic food is steadily increasing both in the developed and developing countries with an annual average growth rate of 20-25 %. Organic agriculture, is one of the fastest-growing sectors of agricultural production. However, there are certain issues that need to be addressed before we go for a large-scale conversion to organic agriculture. Some of the important issues are: Can organic farming produce enough food for everybody? Is it possible to meet the nutrient requirements of crops entirely from organic farming? Is the food produced by organic farming superior in taste and quality? Is economically feasible? This article presents a critical review on these aspects in India perspective.

Organic agriculture is a production system that avoids or largely excludes the use of synthetic compounds viz. fertilizers, pesticides, growth-regulators and livestock-feed additives, and thus offers some solution to the problems currently besetting the agricultural sector of industrialized or green revolution countries. The broader aims of organic farming are: sustainability of natural resources, minimize the cost of cultivation, provide healthy food, augment farm profits and improve soil health. Although in the market place to provide clarity on the organic claim, the organic agriculture requires certification, but broadly any system using the methods of organic agriculture and being based on four basic principles (the principle of health, ecology, fairness and care) may be classified as organic agriculture.

Keywords: Organic farming, Natural Resource, Sustainability

Organic agriculture is one among the broad spectrum of production methods that are supportive of the environment. Organic production system is based on specific standards precisely formulated for food production and aim at achieving agro-ecosystems, which are socially and ecologically sustainable. It is based on minimizing the use of external inputs through efficient use of on- farm resources compared to industrial agriculture. Thus the use of synthetic fertilizers and pesticides is avoided.

Organic in organic agriculture is a labeling term that denotes products that have been produced in accordance with retain standards during food production, handling, processing and marketing stages, and certified by a duly constituted certification body or authority. The organic label is therefore a process claim rather than a product claim. It should not necessarily be interpreted to mean that the foods produced are healthier, safer or all natural. It simply means that the products follow the defined standard of production and handling, although survey indicates that consumers consider the organic label as an indication of purity and careful handling.

Many definitions have been proposed for organic agriculture. Ethical issues such as fair labour practices and animal ethics have also been included in organic agriculture definitions. To promote organic agriculture and to ensure fair practices in international trade of organic food, the Codex Alimentarius commission, a joint body of FAO/ WHO farmed certain guidelines for the production, processing, labelling and marketing of organically produced foods, with a view to facilitate trade and prevent misleading claims. The codex Alimentarius Commission defines organic agriculture as a holistic food production management system, which promotes and enhances agro ecosystem health, including biodiversity, biological cycles and soil biological activity. It emphasizes the use of management practices in preference to the use of on- farm input, taking into account that regional conditions require locally adapted system. This is accomplished by using, agronomic, biological and or mechanical methods, as opposed to using synthetic materials, to fulfill any specific function within the system.

Present status of Organic Farming-World Crop/Agriculture

- Worldwide, 31 million hectares of land is under organic farming
- Managed by 70,000 farmers
- 138 countries growing organic food
- Australia has maximum land under organic farming
- USA sales over US$26 billion

Animal Husbandry

- Organic Animal husbandry -7.2 % (59 US billion dollars) of the total organic product business
- Argentina is largest exporter of organic beef
- Largest organic egg consumer is Israel
- France and Italy export Organic Cheese

Present status of Organic Farming-India Crop/Agriculture

- 0.95 mha (0.96 mha cultivable and rest forest area) land is under organic farming
- Rank at 33rd in world in terms of area under organic farming
- Rank 88th in terms of the ratio of agricultural land under organic crop to total farming area.
- India produced 1,624,339 MT certified organic produce during 2009-10
- It also produced 10,887 MT cotton during 2009-10 - the largest producer of organic cotton
- Madhya Pradesh has highest area under organic farming (1.1 mha or 52%)
- Maharashtra is at second (0.96 mha or 33.6%)
- Orissa is at third (0.67 mha or 9.7%)
- Uttrakhand and Sikkim are organic States

Present status of Organic Export from India

- India exported 135 organic products under 15 categories during 2009
- It valued US$116 million
- Average growth of organic market in India is 50%
- Among the products exported, cotton is at top followed by basmati rice and honey.
- The demand of Indian organic products is increasing in Europe
- There are 294 organic exporters in India

Major Organic Food Products Exported during 2009-10

- 5,250 MT organic Basmati rice
- 2,962, MT Honey
- 2,727 MT Tea
- 1,922 MT dry fruits
- 1,834 MT processed food
- 1,396 MT Sesame
- India exports its 70% organic products to Europe followed by the US (20%), South -East Asian countries (5%), Japan (3-5%)

Aims

Organic farming tries to bridge the widening gap between man and nature with the following broader aims. However, the relative importance, for an individual or a community of farmers, may vary.

Sustainability of natural resources

Organic agriculture is a holistic way of farming, and besides production of goods of high quality, it primarily aims at conservation of the natural resources (soil, water, climate, bio-diversity and non-renewable energy) for sustainable productivity in agriculture. In the context of organic farming the term 'sustainability' is used in a wider sense, to encompass not just conservation of non-renewable resources (soil, water, minerals, energy, bio-diversity), but also the issues of environmental and social sustainability. The very basic approach to organic farming envisages to:

(i) Improve and maintain the natural landscape and agro-ecosystem;

(ii) Avoid over-exploitation and pollution of natural resources;

(iii) Minimize the consumption of non-renewable energy sources;

(iv) Exploit synergies that exist in natural ecosystems;

(v) Maintain and improve soil health by stimulating activity of soil organisms with organic manures and avoid harming them with pesticides;

(vi) Obtain optimum economic returns, within a safe, secure and healthy working environment; and

(vii) Acknowledge the virtues of indigenous knowledge and traditional farming system (ITKs).

Minimizing cost of cultivation

Organic farming is one of the environment-friendly approaches of reducing dependency on external inputs and achieving the optimum productivity by making the best use of ecological principles and process, leading to reduced costs of cultivation. This is very important for resource-poor farmers, especially for those who are operating in high risk- prone areas of dryland and rainfed agriculture.

Healthy food

Healthy food means a food that is free from harmful chemicals and heavy elements, and is tasteful and nutritious. Nevertheless, the organic agriculture practices cannot ensure that products are 'completely free' of harmful residues, as they may possibly trespass into the organic production systems through general environmental pollution also. But this is one of the major aims of organic farming and all feasible methods are used to minimize pollution of not only farm products but also of surrounding environment, including air, soil and water.

Augmentation of profits

Organically produced foods have a great demand in export markets, especially those of European and North American countries, and they fetch a sizeable premium as compared with conventionally grown farm products. In domestic sector also, the demand for organic food is increasing tremendously, especially among mid- and high- income segments, which has become more cautious about harmful effects of food grown with the use of pesticides and synthetic fertilizers, and potential hazards of environmental pollution caused due to modern practices in agriculture.

Improvement in soil health

As such the objective of soil health and production sustainability lies at the heart of organic farming and is one of the major considerations determining its acceptability. In organic production systems the soil health is maintained and improved through stimulation of activity of soil organisms with organic manures and by avoiding harming them with the use of synthetic pesticides as well as fertilizers. Some of the important features of organic farming in the context of soil health and environment protection:

(i) Organically managed soils have a high potential to counter soil degradation, erosion and desertification, as they are more resilient both to water stress and nutrient loss.

(ii) Organic farming protects the long- term fertility of soils by maintaining organic matter levels, fostering soil biological activity, giving due importance to the basic principles of crop rotation and intercropping, and providing crop nutrients indirectly by using sources that are not readily soluble.

(iii) In organic farming, the supply of the nutrients is more balanced, which helps to keep the plants healthy and improve the biological activity of soil, which in turn improves nutrient mobilization from organic matter and native soil reserves and minimizes the losses of nutrients, thus protecting the environment.

(iv) Microorganisms have a good feeding base and create a stable soil structure.

(v) Inclusion of legumes or cover crops, mulching, intercropping and agro- forestry, plays an important role in protection against soil erosion and degradation.

(vi) Organic- agriculture technologies increase the organic matter content of the soil, which has a positive effect on soil aggregation and water-holding capacity.

(vii) Animal manure, green-manure and composts favour the composition processes and can replenish nutrients required by the crops and supply the soil with essential organic matter.

(viii) Legume crops are a highly valuable source of nitrogen. Closed nutrient cycles and efficient use of local resources (e.g. compost, dung or seeds) are especially important for subsistence farmers depending on few and limited assets.

(ix) Water-retention capacity of the soil is increased due to their higher level of organic matter content and permanent soil cover. Due to the resulting capacity for higher moisture retention, the amount of water needed for irrigation is reduced.

(x) Organic agriculture helps to mitigate the climate change, because it reduces emission of greenhouse gases, especially nitrous oxide, because no chemical nitrogen fertilizers are used and nutrient losses are minimized.

(xi) Minimizes energy consumption by 30-70% per unit of land by eliminative the energy required to manufacture synthetic fertilizers and pesticides, and by using internal farm inputs, thus reducing the amount of fuel used for transportation.

(xii) Organic agriculture helps farmers to adopt climate change because it prevents nutrient and water loss through high organic matter content and soil covers, thus making soils more resilient to droughts and land- degradation processes

(xiii) Preserves seed and crop diversity, which promotes natural cycles in the production systems. Maintenance of diversity also helps farmers to evolve contingent cropping systems for adapting climatic changes.

(xiv) Organic agriculture encourages natural habitats of agriculturally beneficial flora and fauna and forbids the clearances of primary ecosystems.

Perspectives of organic farming in India

After nearly four decades of globally acclaimed agro technological revolution termed as 'Green Revolution', Indian agriculture is again at crossroads. On one side of the spectrum are the developed countries with almost a zero growth rate of agriculture and of environmental degradation owing to extensive industrialization and indiscriminate use of agricultural chemicals. On the other side a developing country, with population growth outstripping agricultural productivity growth, required to produce more and more food, fiber and fuel from ever shrinking agricultural land. The post-Green Revolution problems, presently threatening the sustainability of Indian agriculture as a whole and raising a serious concern about national food security include: stagnation or even decline in production and productivity growth rates of major crops, receding groundwater tables in many agriculturally important areas, deterioration of soil fertility, decline in factor productivity, low diversity of production systems, and increasing production costs, leaving agriculture as an economically on-viable enterprise for resource-poor farmers. It is due to these problems that the echo of sustainable and eco- friendly agriculture became louder. In the name of sustainability and eco- friendliness, various new farming concepts, viz. organic agriculture, natural farming, biodynamic agriculture, eco-farming, do-nothing agriculture, homa-farming etc. collectively known as 'organic farming' have been proposed in recent years, with the essential feature remaining same i.e. back to nature.

The primary concern of all organized communities and civilized societies is to meet the food requirements of its people. The cultivated area, required to maintain the present level of food grain production in India without using the fertilizers, reaches more than the total geographical area of the country. At present, there is a gap of nearly 10 m t between annual addition and removal of nutrients by crops which is met by mining nutrients from soil. A negative balance of about 8 mt of NPK is foreseen in 2020, even if we continue to use chemical fertilizers, maintaining present growth rates of production and consumption. The most optimistic estimates at present show that only about 20-30% nutrient needs of Indian agriculture can be met by utilizing various organic sources. On long-term basis, conjoint application of inorganic fertilizers along with various organic sources is capable of sustaining higher crop productivity, improving soil quality and soil productivity. The organic sources should be used in integration with chemical fertilizers to narrow down the gap between addition and removal of nutrients by crops as well as to sustain soil quality and to achieve higher crop productivity. The food security demand of the country requires that inorganic fertilizers be used in balanced doses.

Organic farming has the twin objectives of the system being sustainable and environmentally benign. To achieve these two goals, it has developed some rules and standards which must be strictly adhered to. There is a major scope for change and flexibility. Organic farming thus, does not require best use of options available but the best use of approved options. These options are usually more complex and less effective than the conventional ones. The Indian farmer should get the advantage of emerging global market on organic farming which is at present around 26 billion US $, and is expected to grow to 102 billion US $ in 2010 (NAAS, 2005). Currently, 130 countries are producing certified organic products. Organic farming as a concept/ philosophy is well tested in some of the western countries though the same is not unknown to most of the nations. But in the Indian context, it needs to be looked into more critically seeking answers to the following questions: What level of crop productivity is acceptable? Is it suitable for a country like India with such a large population to feed or can it fit in the niche areas? Are available organic sources of plant nutrients sufficient for organic farming in the form it is advocated? Are organic farming technologies sustainable in the long run? Is there any scope for promotion of organic farming in the export market, without compromising with the national food security that exists in the country?

Organic farming and crop productivity level

A number of studies showed that under drought conditions, crops in organic agriculture systems produce significantly higher yields than comparable conventional agricultural crops (Pretty 2000, Subba Rao 1999). It has also been established that organic systems have less long-term yield variability. A survey of 208 projects in developing tropical countries, in which contemporary organic practices were introduced, showed average yield increase of 5-10% in irrigated crops and 50-100% in rainfed crops.

The so-called organic transition effect, in which a yield decline in the first 1-4 years of transition to organic agriculture, followed by a yield increase when soils have developed adequate biological activity has not been born out in some reviews of yield comparison studies. However, it is generally propagated that the organic farming sustains higher yields as compared to conventional farming using inorganic fertilizers and plant- protection chemicals. There are dependable research evidences to show that balanced inorganic fertilization and integrated nutrient management have sustained crop yields on long - term basis (Dwivedi et al. 2001, Nambiar 1994, Swarup and Wanjari 2000), but convincing and clinching evidences are still to be found out to show that higher crops yields could be obtained under organic farming systems.

Crop production essentially represents extraction of resources from soil. Unless these are replaced, the soil will become depleted and infertile. The question is how fast and in what quantities these are replenished through organic sources? This becomes crucial to meet the demand of food and fibre of ever increasing population. The sustainable yield targets, which are satisfactory today, may not be tenable 10 years hence, best results world over in productivity and economic gains have been obtained with the conjoint use of organic sources and inorganic fertilisers.

Trewaves (2001) pointed out the hazards of relying solely on organic sources for nutrients. Manure break down can not be synchronized with crop growth as is desirable, but continues throughout the growing season. Manure is variable in composition and may yield unpredictable nutrition for crops growth. Long-term application of inorganic fertilizers is known to increase organic carbon owing to higher root biomass production. Soil organisms are for their role as nutrients recyclers.

At the global level, especially in developing countries with high population pressure, and with the present state of knowledge and technology, organic farming cannot produce enough food for everybody.

Organic Certification Agencies

There are two types of certification agencies -

Indian Certification Agencies

Government of India through Director General of Foreign Trade, New Delhi, allowed the export of organic products only if they are produced, processed and packed under a valid organic certificate issued by a certification agency accredited by one of the accredited agencies designated by the Government of India. The Government of India has already recognized the agencies viz,

Tamil Nadu Organic Certification Department - http://www.tnocd.org/index.html

Agricultural and Processed food products Export Development Authority (APEDA) - http://www.apeda.com/apedawebsite/index.asp

Spice Board - http://www.indianspices.com/

Coffee Board - http://www.indiacoffee.org/default.htm

Tea Board - http://www.teaboard.gov.in/

International Certification Agencies

Imported organic produce from Latin America is subject to certification standards and guidelines just as stringent as produce produced in the United States. Under the US Organic Foods Production Act of 1990 (OFPA), the USDA is required to review the certifiers of imported organic produce, in order to ensure that they meet the requirements of the US National Organic Program (NOP).

Foreign certification agencies may apply directly to the USDA for recognition and are evaluated on the same criteria as domestic agencies. Alternately, foreign governments may apply to the USDA or the US government for recognition of equivalency in their organic oversight program. Once accreditation or recognition is granted, organic products produced under the supervision of the certifying agent or foreign government will be eligible for import to the US as certified organic. The following are the some of the International agencies involved in certification of organic products.

Argencert

Argentina's leading certification agency was created in 1992. In 1997, Argencert became the first Argentine agency accredited by IFOAM.

California Certified Organic Farmers (CCOF)

CCOF's purpose is to promote and support organic agriculture in California and elsewhere.

International Federation of Organic Agriculture Movements (IFOAM)

The federation's main function is coordinating the network of the organic movement around the world. IFOAM is a democratic, grassroot oriented federation.

The Ecological Farming Association

Formerly the Committee for Sustainable Agriculture is a nonprofit educational organization that promotes ecologically sound agriculture.

Organic Farming Research Foundation (OFRF)

Sponsors research related to organic farming practices, disseminates research results to organic farmers and to growers interested in adopting organic production systems, and educates the public and decision-makers about organic farming issues.

Organic trade Association

It is a national association representing the organic industry in Canada and the United States, Members include growers, shippers, processors, certifiers, farmer associations, brokers, consultants, distributors and retailers.

Community Alliance with Family Farmers

CAFF political and educational campaigns are building a movement of rural and urban people who foster family-scale agriculture that cares for the land, sustains local economics, and promotes social justice.

Institute for Marketecology (IMO)

It is one of the first and most renowned international agencies for inspection, certification and quality assurance of ecofriendly products. Since more than 20 years, IMO has been active in the field of organic certification but it is also expert in the sectors of natural textiles, sustainable forestry, and social accountability monitoring. IMO is closely co-operating with the popular private label Naturland (IFOAM accredited) and conducts Naturland inspections world-wide. In the field of agriculture, IMO is certifying all types of agricultural products, from traditional produce such as coffee, tea, spices, cocoa, nuts, fruits, vegetables, cereals, pulses, cotton, dairy products, honey, fish & seafood. This also includes all types of food processing, product manufacturing and international trading activities.

SKAL

Skal International, Netherlands is a certification and inspection organisation, which certifies organic products, processes and inputs. Further sustainable forest/wood and textile are certified. Skal International operates worldwide in Western and Eastern Europe, South America and Southern Asia. Through the network of the shareholder nearly all countries in the world can be covered.

ECOCERT INTERNATIONAL

ECOCERT is an inspection and certification body accredited to verify the conformity of organic products against the organic regulations of Europe, Japan and the United States. The ECOCERT certification mark is one of the leading international organic certification marks, enjoying a good reputation and trusted by both consumers and the organic industry. Besides the certification of organic production, they provide all necessary information about the requirements of the organic regulations in Europe, Japan, United States and applicable national standards to their clients. They also assist in obtaining EU import authorizations for certified commodities.

DEMETER

Demeter is a world wide certification system, used to verify to the consumers in over 50 countries that food or product has been produced by biodynamic methods. The Bio Dynamic Farming and Gardening Association is the certifier in New Zealand. (The Association registered Demeter as a certification trademark in 1984.) Inspectors visit the operators (farmers and processors) annually to collect information about their methods. A committee of assessors then decides whether to grant certification. Most committee members are experienced biodynamic farmers and/or processors. The Demeter Standards are a published statement of the allowed and the required practices for certified biodynamic operators. All persons working towards Demeter certification are recommended to obtain a copy from the Bio Dynamic Farming and Gardening Association.

Certification process

Third party certification process

To certify a farm, the farmer is typically required to engage in a number of new activities, in addition to normal farming operations:

- Study the organic standards, which cover in specific detail what is and is not allowed for every aspect of farming, including storage, transport and sale.
- Compliance - farm facilities and production methods must comply with the standards, which may involve modifying facilities, sourcing and changing suppliers, etc.
- Documentation - extensive paperwork is required, detailing farm history and current set-up, and usually including results of soil and water tests.
- Planning - a written annual production plan must be submitted, detailing everything from seed to sale: seed sources, field and crop locations, fertilization and pest control activities, harvest methods, storage locations, etc.
- Inspection - annual on-farm inspections are required, with a physical tour, examination of records, and an oral interview.
- Fee - an annual inspection/certification fee (currently starting at $400-$2,000/year, in the US and Canada, depending on the agency and the size of the operation).
- Record-keeping - written, day-to-day farming and marketing records, covering all activities, must be available for inspection at any time.

In addition, short-notice or surprise inspections can be made, and specific tests (e.g. soil, water, plant tissue) may be requested.

For first-time farm certification, the soil must meet basic requirements of being free from use of prohibited substances (synthetic chemicals, etc.) for a number of years. A conventional farm must adhere to organic standards for this period, often two to three years. This is known as being in transition. Transitional crops are not considered fully organic.

Certification for operations other than farms follows a similar process. The focus is on the quality of ingredients and other inputs, and processing and handling conditions. A transport company would be required to detail the use and maintenance of its vehicles, storage facilities, containers, and so forth. A restaurant would have its premises inspected and its suppliers verified as certified organic.

Participatory certification

"Participatory Guarantee Systems are locally focused quality assurance systems. They certify producers based on active participation of stakeholders and are built on a foundation of trust, social networks and knowledge exchange"[2] (IFOAM definition 2008).

Participatory Guarantee System (PGS) represent an alternative[3] to third party certification, especially adapted to local markets and short supply chains. They can also complement third party certification with a private label that brings additional guarantees and transparency. PGS enable the direct participation of producers, consumers and other stakeholders in:

- the choice and definition of the standards
- the development and implementation of certification procedures
- the certification decisions

Participatory Guarantee Systems are also referred to as "participatory certification".

Certification and product labeling

In some countries, organic standards are formulated and overseen by the government. The United States, the European Union, Canada and Japan have comprehensive organic legislation, and the term "organic" may be used only by certified producers. Being able to put the word "organic" on a food product is a valuable marketing advantage in today's consumer market, but does not guarantee the product is legitimately organic. Certification is intended to protect consumers from misuse of the term, and make buying organics easy. However, the organic labeling made possible by certification itself usually requires explanation. In countries without organic laws, government guidelines may or may not exist, while certification is handled by non-profit organizations and private companies.

Standards

Standards regulate production methods and in some cases final output for organic agriculture. Standards may be voluntary or legislated. As early as the 1970s private associations certified organic producers. In the 1980s, governments began to produce organic production guidelines. In the 1990s, a trend toward legislated standards began, most notably with the 1991 EU-Eco-regulation developed for European Union, which set standards for 12 countries, and a 1993 UK program. The EU's program was followed by a Japanese program in 2001, and in 2002 the U.S. created the National Organic Program (NOP). As of 2007 over 60 countries regulate organic farming (IFOAM 2007:11). In 2005 IFOAM created the Principles of Organic agriculture, an international guideline for certification criteria. Typically the agencies accredit certification groups rather than individual farms.

Organic production materials used in and foods are tested independently by the Organic Materials Review Institute.

Steps to a Successful Organic Transition

The transition from conventional to organic farming requires numerous changes. One of the biggest changes is in the mindset of the farmer. Conventional approaches often involve the use of quick-fix remedies that, unfortunately, rarely address the cause of the problem. Transitioning farmers generally spend too much time worrying about replacing synthetic input with allowable organic product instead of considering management practices based on preventative strategies. Here are a few steps new entrants should follow when making the transition to organic farming:

A) Understand the basics of organic agriculture and the organic farming standards

Since organic production systems are knowledge based, new entrants and transitional producers must become familiar with sound and sustainable agricultural practices. Transitional producers should be prepared to read appropriate information, conduct their own trials and participate in formal and informal training events. As mentioned, switching from conventional to organic farming is more than substituting synthetic materials to organic allowed materials. Organic farming is a holistic system that relies on sound practices focused on preventative strategies. Since there are often few organic remedies available to organic producers for certain problems, prevention is the key element in organic production.

B) Identify resources that will help you

Existing organic farmers are generally very helpful in sharing valuable technical information. A good mentor should be able to provide transitional producers with knowledge, practical experience and suggest appropriate reading materials. Mentors are able to identify some of the most important challenges transitional farmers will be confronted with. Mentors may also help source production materials that are otherwise difficult to find. Producers should also contact agrologists, veterinarians and other agricultural and financial consultants, in order to learn ways to improve their current farming practices.

The Internet is a valuable source of information, especially to new organic farmers. A broad range of reading materials are available from many organic/ ecological organizations such as the Organic Agriculture Centre of Canada (OACC), the Atlantic Canadian Organic Regional Network (ACORN), the Canadian Organic Growers (COG), the Certified Organic Associations of British Columbia (COABC), the National Sustainable Agriculture Information Services/ Appropriate Technology Transfer for Rural Areas (ATTRA), the Sustainable Agriculture Research and Education (SARE), and the Agri-réseau/agriculture biologique- Quebec. Consider joining an organic organization or network to access these valuable resources and establish good working contacts.

C) Plan your transition carefully

Develop a transitional plan with clear and realistic goals. The plan should clearly identify various steps to be taken in making the transition to organic and be sure to include realistic timeframes. Identify your strengths and weaknesses. Consider ways to address any weaknesses, while building on strengths. The business side of the transitional plan should contain a multiple year budget and an effective/realistic marketing strategy. Make sure your list of expenses is comprehensive. Include all prerequisites to begin the transition; such as, mechanical weeding equipment, specialized composting equipment and applicators, additional handling equipment dedicated to the organic products, and processing equipment. Although the demand for organic products is continually growing, growers need to make sure they have a reliable market for the organic products they plan to produce.

Careful planning is very important. During the early part of the transitional period, yields are often depressed and premium prices for certified organic products are generally not yet obtainable. Use realistic yields and prices when evaluating the feasibility of your project.

In some instances, it is preferable to continue using conventional measures early on in the transitional process in order to avoid dramatic yield reduction which could jeopardize the financial well-being of the operation. Farmers who are planning to convert their livestock operation should consider certifying their fields first. This allows time to learn more about organic livestock management requirements while, at the same time, starting to produce organic feeds.

Although organic certifiers generally want to see the entire farm become organic, certifiers generally allow new entrants several years of transition time before the whole farm is fully certified.

Parallel production is the simultaneous production, processing or handling of organic and nonorganic crops, livestock and other products of a similar nature. Although this type of activity is highly discouraged by certifiers, some allow it, especially during the transition period. If permitted to practice parallel production, producers must be prepared to deal with significant record keeping in order to ensure traceability and organic integrity.

D) Understand your soils and ways to improve them

Since soil is the heart of the organic farming system, it is crucial that new entrants understand the various characteristics and limitations of the soils found on their farm. Soil suitability may vary significantly from one field to the next. Fields with good drainage, good level of fertility and organic matter, adequate pH, biological health, high legume content, and with less weed and pest pressure, are excellent assets. Often these fields are the first ones ready for transition and certification.

Many tools exist to assess soils. Soil chemical, physical and biological analyses, soil survey and legume composition field assessments, and field yield histories are very important and should be considered early in the transition. Unhealthy soils require particular attention.

If farmers plan to grow crops without raising any livestock, it may be necessary for them to source allowable soil amendments such as composted manure, limestone, rock dust, and supplementary sources of nitrogen, phosphorus, potassium and micro-nutrients. Even with the best of crop rotations that include green manure crops like legumes (nitrogen fixing crops), transitional growers will be challenged if they want to obtain optimal yields without additional livestock manure, compost and/or other off-farm soil inputs. When these inputs are scarce or expensive, producers may benefit from integrating livestock on their farm.

Let's not forget, under organic production, farmers must be able to recycle nutrients through proper nutrient management practices: recycling through good manure and compost utilization, crop rotations, cover crops (green manure, catch, and nitrogen fixing crops), and by reducing nutrient losses due to leaching, over-fertilization, as well as poor manure and compost management (storage, handling, and spreading).

E) Identify the crops or livestock suited for your situation

Before growing a crop or raising any livestock, consider the following: degree of difficulty to grow or raise the product organically, land and soil suitability, climate suitability, level of demand for the product, marketing challenges, capital required, current prices for conventional, transitional and organic products, and profitability over additional workload.

F) Design good crop rotations

Once the crops are chosen, carefully plan the crop rotation(s) and select the most suitable cover crops (green manure, winter cover crops, catch crops, smother crops, etc.). Crop rotations are extremely important management tools in organic farming. They can interrupt pest life cycles, suppress weeds, provide and recycle fertility, and improve soil structure and tilth. Some rotational crops may also be cash crops, generating supplemental income.

On some farms, land base availability may be a limiting factor when planning your crop rotations. The transitional plan should, therefore, include crop rotation strategies. Responding to external forces such as new market opportunities may also have a significant impact on crop rotations, so farmers need to consider the effect that growing new crops has on their crop rotations and land base availability.

G) Identify pest challenges and methods of control

It is important to know the crop's most common pests, their life cycles and adequate control measures. For instance, Colorado potato beetle may be a pest of significant importance when growing potatoes; cucumber beetles in cucurbitaceous crops (cucumber, squash, and melons); flea beetle in many seedlings crops; clipper weevil and Tarnish Plant Bug in strawberry crops.

There are several measures available to reduce pest pressure: crop rotation, variety selection, sanitation, floating row covers, catch crops, flamers, introduction of beneficial insects, bio pesticides, and inorganic pesticides. Transitional growers should be prepared to use and experiment with some of these options. When considering a new type of production, discuss pest issues with your agrologists, IPM specialists and/or other existing organic producers to optimize your chances of success.

Availability of organic supplies has improved significantly over the past few years. New pest control products containing B.t., spinosad, kaolin clay are effective and currently available to organic growers. It is often reported that the types of weeds found on the farm evolve with time as growers change the way they grow their crops and control their weeds. By keeping track of the weed population, growers will be able to refine their crop rotations and improve their control measures.

Under organic livestock management, cattlemen must provide attentive care that promotes health and meets the behavioral needs of various types of livestock. With good herd health practices, farmers rarely need to rely on conventional medicine. Organic cattlemen should, however, try to familiarize themselves with alternative remedies such as herbal/aroma therapies, homeopathy, and immune system promoters.

H) Be ready to conduct your own on-farm trials

Successful organic farmers continuously try new and/or innovative management practices. Practices such as cover cropping, inter-planting, and use of various soil and pest control materials need to be evaluated regularly by organic farmers. Be prepared to try new approaches.

I) Be ready to keep good records

Record keeping is one of the most important requirements to maintain organic integrity. Farmers are expected to keep detailed production, processing and marketing information. This information includes everything that enters and exits the farm. Third party, independent inspectors require farmers to present the above mentioned documentation when inspecting the farm operation. Once the record-keeping requirements are understood and the reporting procedure established, paperwork becomes routine.

J) Avoid these common mistakes

- Underestimating the need for good transitional and marketing plans.
- Underestimating the need to fully understand the Organic Standard. Organic producers must understand the standard in order to know what is permitted and prohibited.
- Failing to think prevention. Transitional farmers should consider improving their crop rotation, soil and crop management skills, livestock management practices (feeding program, heard health program, grazing system, housing facilities, and husbandry).

Organic farming vs potential of organic manures

Both food and therefore nutrient needs of India are expected to go up consistently in the future without a break. The net cropped area has more or less established at 143 m ha. The population of 1 billion plus is expected to grow by 14 to 15 m each year. Land is limited and shrinking whereas human and animal population are increasing. The land to man ratio has fallen rapidly in the past half century from 0.34 ha in 1950 to 0.14ha, and is projected to be 0.10 ha in 2025. At present, each hectare or net sown area has to support more than 7 persons. This pressure will only increase in the coming years. It is also disquieting that during the 1999s India witnessed rates of growth in yield and production compared to world averages. Keeping in view the conservative population estimate of 1.4 billion by 2025 and minimum caloric requirement of food, the country will need to produce at least 300 mt of food grain. For this purpose, it will be necessary to use 30 to 35 mt of NPK from various sources. In addition according to National Academy of Agricultural Sciences (NAAS, 1997) the expert on horticulture, vegetable, plantation crops, sugarcane, cotton, oilseeds and potato have projected that by 2025, the demand for fertilizers for these high value crops, which also have high export potential and claim fertilizer use on priority basis, will rise to 3.0, 2.0, 3.2, 0.9, 3.1, 1.5 and 1.0 mt respectively. This adds to the total nutrient needs by another 14 to 15 mt NPK. Thus, the country will be required to arrange for the supply of about 40 to 45 mt of nutrients by 2025.

It is neither possible nor feasible to replace chemical fertilisers completely to sustain present level of crop production. Projections on the availability of plant nutrients from organic sources for agriculture in India during 2000-2025 as worked out by Tandon (1997) are given in the Table 1 and projected plant nutrient (NPK) addition and removal as per Katyal (2001) in the Table 2. These figures apparently reveal that all trappable nutrients from organic sources will be barely able to meet the deficit of nutrients in soil after crop removal at present level of production. Ensuring nutrient supply of 45 m t to produce 300 m t of food grain and other commodities by 2025 would merely be a dream.

Organic agriculture: Scope and area approach

Only 30% of India's total cultivable area is covered with fertilizers where irrigation facilities are available and in the remaining 70% of arable land, which is mainly rainfed, negligible amount of fertilizers is being used. Farmers in these areas often use organic manure as a source of nutrients that are readily available either in their own farm or in their locality. The north - eastern region of India provides considerable opportunity for organic farming due to least utilization chemical inputs. It is estimated that 18 m ha of such land is available in the N-E, which can be exploited for organic production. With the sizable acreage under naturally organic/ default organic cultivation, India has tremendous potential to grow crops organically and emerge as a major supplier of organic products in the world's organic market.

The agro-chemicals used in agriculture are exhaustive source of energy and their timely availability in desired quantity is question marked for future because mining of the earth is the only source of their availability. The tremendous increasing trend in cost of these agro-chemicals is beyond the reach of resource poor farmers also. Under such circumstances, a change from chemically intensive agriculture to a more sustainable form of organic agriculture is desirable in present situation. JNKVV work on above aspects with help of M.P. Government, and ICAR projects under training and demonstration and research.

The state occupies prime position in terms of having more than 1.48 Lakh ha area under certified organic out of a total certified area of 3.40 Lakh ha in the country. According to an estimate 5.86 Lakh MT of production was organically produced in the country out of which 19456 MT was exported worth Rs. 300 Million during the year 2007 - 08. In the recent past a staggering growth of 39% has been registered in terms of certified area under organics country wide taking it over 12 Lakh ha as per ICCOA and a target of 20 Lakh ha is set by 2012. India commits for taking its global share in organic exports from 0.2% to 2.5%. This provides great opportunity for the state to maintain its lead and continue to harness its potential. The state has large area under extremely low external and chemical input agriculture of tribal population both in the eastern and western extremes of the state, natural grasslands, forests proves to be organic and or natural niches by "default". The external input use especially inorganic fertilizers, agro - chemicals and hybrids and genetically modifies species remain well below national average. Ecosystem consists of mainly floral and faunal biodiversity, habitat diversity and landscape conservation. The findings of many studies suggest that organic farming clearly performs better than conventional farming in respect to floral and faunal. MP State Organic Farming Policy is the statement of intent to create, facilitate, and strengthen the enabling environment for developing integrated value chains of the organic farm produce encompassing end-to-end solutions for both primary producers and consumers. The policy entails on "farm - to - fork" approach reassuring abundant supply of "healthy food for all". The policy statement provides concurrent thinking of the state with its futuristic, pragmatic pro-farmer initiatives.

Market of organic farming

- No market structure is there
- Emphasis on
  - (i) Creation of awareness
  - (ii) Producer - consumer meeting, organization of organic bazar/hat/mela
  - (iii) Change of mindset

(iv) Utilization of spiritual group, health care group etc.

Socio -economic opportunity

- Contributes to preservation of biodiversity.
- Produces healthy food.
- Ensures jobs in agriculture, food processing and marketing.
- Improves health of soil
- Low water consumption
- Low input cost
- High produce cost (Improve economic status)
- High demand due to social awareness
- Huge export potential
- Promotion of sustainable agriculture for small farmers

Facility used

Under JNKVV following facility available for the farmers

- Vermicomost unit
- NADEP unit
- KVK
- Demonstration plot organic farming
- Training centre
- Soil analysis facility
- Availability of biofertlizers
- MP organic certification agency for certification
- Collaboration with Regional center for organic farming Govt of India

Physical and mental awareness programme

- Training on preparation of Vermicomost.
- Training on preparation of different organic manures
- Training on biofertilizers
- Training on organic pest management
- Awareness on organic cultivation of fruit crops
- Awareness on organic cultivation of cereals crops
- Awareness on organic cultivation of vegetable crops

Awareness on Integrated Farming system

The report of the Task Force on organic farming appointed by the Government of India also observed that in vast areas of the country, where limited amount of chemicals is used and have low productivity, could be exploited as potential areas for organic agriculture. Arresting the

Table 1. Some projections on the availability of organic resources for agriculture in India during 2000-2025

Items	2000	2010	2025
Generators			
Human population (million)	1,000	1,120	1,300
Livestock population (million)	498	537	596
Food grain production	230	264	315
Nutrients (theoretical potential, mt N + P_2O_3 + K_2O)			
Human excreta	2.00	2.24	2.60
Livestock dung	6.64	7.00	7.54
Crop residues	6.21	7.10	20.27
Nutrients (considered tapable, mt N + P_2O_5+ K_2O)			
Human excreta	1.60	1.80	2.10
Livestock dung	2.00	2.10	2.26
Crop residues	2.05	2.34	3.39
Total	5.05	6.24	7.75

All data pertaining to nutrients in dung and in residues are counted twice to the extent these are fed to the animals.

Tapable = 30% of dung, 80% of excreta, 33% of crop residues

Decline of soil organic matter is the most potent weapon in fighting against unabated soil degradation and imperilled sustainability of agriculture in tropical regions of India, particularly those under the influence of arid, semi-arid and sub-humid climate. Application of organic manure is the only option to improve the soil organic

Table 2. Projected plant nutrient ($N + P_2O_5 + K_2O$) addition and removal in India (million tonnes)

Items	2000	2020
Addition through fertilizers	18.07	29.60
Crop removal	28.00	37.46
Balance	-10.00	-7.86
Total projected (2025) availability of plant nutrients from tappable organic sources		7.75

carbon for sustenance of soil quality and future agricultural productivity.

Studies showed that under drought condition, crop in organic agriculture system produce significantly higher yield than comparable conventional agriculture crops (Stanhill 1990 and Dormaar et al. 1988) often out yielding conventional crops (Wynen 1994) by 7-90%. Other have shown that organic systems have less long - term yield variability (Peters 1994; and Smolik et al. 1995). A survey of 208 projects in developing tropical countries in which contemporary organic practice were introduced, showed average yield increase of 5-10% in irrigated crops and 50-100% in rainfed crops (Pretty and Hine 2001).

For promotion of organic farming, identification of potential areas and crops are crucial. The Government's strategy to promote organic farming for the crops having market potential like fruits, spices oilseeds, pulses, vegetables, wheat, cotton, basmati rice etc. As far as potential areas are concerned , three priority zones have already been identified. Category-I: The top priority areas for promotion of organic farming are the rainfed areas where fertilizer and agro- chemical consumption is already very low. Category-II: Areas are primarily under rainfed farming with little irrigation support and Category-III: The last priority areas are those with moderate to heavy use of fertilizers and pesticides, mostly multiple cropped areas.

Safety, quality and taste of organic food

There is a growing demand for organic foods, driven primarily by the consumers perceptions of the quality, taste and safety of these foods and to the positive environmental impact of organic agriculture practices. The 'organic' label is not a health claim, it is a process claim. It has been demonstrated that organically produced foods have lower levels of pesticides and veterinary drug residues and in many cases lower nitrate contents. No clear trends have however been established in organoleptic quality differences between organically and conventionally grown foods. There have been many claims that eating organic foods increases exposure to microbiological contaminants. But studies investigating these claims have no evidence to support them. Organic foods must meet the same quality and safety standards applied to conventional foods. These include the CODEX General Principles of Food Hygiene and Food Safety Programmes based on the Hazard Analysis and Critical Control Point. Analysis of pesticide residues in produce in the US and Europe has shown organic products have significantly lower pesticide residues than conventional products. Nitrates are significant contaminants of foods, generally associated with intensive use of nitrogen fertilizers. Studies that compared nitrate contents of organic and conventional products found significantly higher nitrates in conventional products.

There are also claims that food produced by organic methods tastes better and contains a better balance of vitamins and minerals than conventionally grown food. However, there is no clear scientific evidence, with some studies showing increase in vitamin C, minerals and proteins, more sweeter and less tart apples etc. A crude analysis of the literature, however, favours organic products in this area. A tasting panel convened by the Consumer Association in the United Kingdom did not consistently favour the taste of organic fruits and vegetables. Quality after storage has been reported to be better in organic products relative to conventional products after comparative tests. Review of organic vs conventional product sensory analysis studies have reported results that do not clearly substantiate claims of superior organic product tastiness.

The quality of crops is controlled by a complex interaction of factors, including soil type and the ratio of minerals in added compost, manure and fertilizer. So it is difficult to separate the influence of the environment and farming system. There is scope to generate information on the quality of produce generated on organic farms in future studies. As per traditional belief that organic manure promotes quality while mineral fertilizers promote quantity. Regardless of whether the nutrients are from organic or inorganic source, plants absorb the same in form of inorganic ions: ammonium, nitrate, phosphate, potassium etc. Sensor in plant roots, if any, to distinguish between nutrients ions coming from organic or inorganic sources are to be yet discovered. Once absorbed, the nutrients are synthesized into compounds that determine the quality of produce e.g. flavour, shelf-life etc., which is the function of genetic make-up of the plants (variety). Thus, any difference in taste of modern high - yielding varieties from that of modern high - yielding varieties from that of traditional low- yielding ones is due to difference in genetic material of these varieties. There is no scientific evidence presented as yet to show that organically produced food is of better quality and taste, and use of inorganic fertilizer deteriorates it. The better taste of the organically grown food is of psychological nature, and could be attributed to 'Placebo effect' widely used in drug testing, where harmless sugar pills administered to control groups are known to cure patients of their imaginary ailments, when told of their novelty and wonderful therapeutic properties. More someone pays for it faster is the cure i.e. a clear case of 'mind over matter'.

A general perception propagated in public minds is that organically grown food is more nutritious, healthy and safe. There are no consistent and valid reports of differences in the mineral contents of organic and conventional food. However, N applications generally improve both the protein and bread- making quality. There are many factors, environmental and cultural, that influence the nutritional composition of the produce. There is no difference between the protein content and other quality parameters such as vitamins, nutraceuticals and trace minerals of conventionally and organically grown crops, which at best could be linked to the varietal characteristics. The genetically modified 'golden rice' contains higher vitamin A content over the traditional varieties will continue to have its superior nutritive value, irrespective of organic or inorganic fertilization. In the field of plant nutrient, the cry of only natural has no justification or scientific basis (Woese et al. 1997). The attitude that organic foods are safe and healthy is based on misconception that hazards in food are mainly derived from agro-chemical additives. In fact, microbes and not chemicals are the chemicals are the major source of food borne disease viz. typhoid, gastroenteritis, dysentery, cystecurcosis etc. Which contain intestinal bacteria, many of which may present substantial human health threats, can be an effective nutrient source, but the pathogen risk must be an effective nutrient source, but the pathogen risk must be seriously considered. Land application of manure is particularly associated with Salmonella, Escherichia coli and Taenia soleum, which can contaminate the soil. These pathogens are known to survive in soil for a long period. They may be carried on edible plant parts coming indirect contact with soil and get into the food chain. They may also be introduced into shallow surface waters as well as ground water polluting potable water supply (Mikkelson and Gillian 1995).

Organic farming and environment

Organic farming is eco-friendly and keeps the soils healthy without polluting environment. It is well known that nitrate is the main end product of manure decomposition, and it is continuously released from organic matter undergoing decomposition. Since nitrate release is not synchronized with either crop demand its uptake, it tends to accumulate in excessive amounts in soil and pose environmental risk. Nitrate, thus formed without being taken up by plants may leach polluting groundwater of may denitrify polluting atmosphere. The ions irrespective of their origin whether from organic or inorganic source will behave similarly. There is no evidence that NO3 ions from organic sources are less mobile or have lower denitrification potential than inorganic fertilizers. Trace elements and heavy metal concentrations in animal wastes (manures) and sewage sludge's vary widely, and can be at times very high (Table 3) and often exceed concentrations normally found in inorganic fertilizers. Field application of such organic manures which have to be applied in very high quantities to meet the requirement of major plant nutrients may lead to heavy metal accumulation in soil polluting arable land. These will find way into edible plant parts and will get into the food chain becoming health hazard.

There is increasing evidence that warns that the growing push toward industrialization and globalization of the world's agriculture and food supply imperils the future of humanity and the natural world. Industrial

Table 3. Total concentration (mg/kg of dry weight) of selected heavy metals and trace elements in fertilizers, manures and biosolids

Sources	As	Cd	Cr	Cu	Pb	Ni	Zn
Cow manure	-	8.1	58	62	16	29	71
Poultry manure	0.35-10.5	-	0.6-9.6	3.5	-	-	51-538
Sewage sludge	3.6	2.3	35	511	65	22	705

agriculture which is corporate controlled, and promotes agrochemically based, monocultural, export-oriented systems are negatively impacting public health, ecosystem integrity, food quality and nourishment, traditional rural livelihoods, and indigenous and local cultures, while accelerating indebtedness among millions of farmers, and their separation from lands that have historically fed communities and families. This transition is increasing hunger, landlessness, homelessness, despair and suicides among farmers. Meanwhile, it is also degrading the planet's life support systems, and increasing alienation of peoples from nature and the historic, cultural and natural connection of farmers and all other people to the sources of food and sustenance. Finally, it is also destroying the economic and cultural foundations of societies, undermines security and peace, and creates a context for social disintegration and violence.

Organic agriculture away from a dependence on chemical inputs, increase productivity, decrease input costs, and help reduce environmental problems. Despite all the above problems associated with industrial agriculture, there are many optimistic developments. Thousands of new and alternative initiatives are now flowering across the world to promote ecological agriculture, preservation of the livelihoods of small farmers, production of healthy, safe and culturally diverse foods, and localization of distribution, trade and marketing. Throughout the developing world there are still microcosms of intact traditional agriculture which represent millenary examples of successful forms of community-based local agriculture. These microcosms of traditional agriculture offer promising models for other areas as they promote biodiversity, thrive without agrochemicals, and sustain year-round yields. Such systems have fed much of the world for centuries, while conserving ecological integrity through application of indigenous knowledge systems and continue to do so in many parts of the planet. When agroecological principles are adopted, yield enhancement and stability of production are achieved, as well as a series of ecological services such as conservation of agrobiodiversity, soil and water conservation and enhancement, improved biological pest control, etc., regardless of scale or farm size. What varies are the technological forms utilized to optimize key agroecological processes. This variation is best done by farmers themselves; in industrial countries is expressed as organic agriculture. Evidence indicates, however, agroindustrial inputs, such as capital-intensive technology, pesticides, and chemical fertilizers, has negatively impacted the environment and rural society. Most agriculturalists had assumed that the agroecosystem/natural ecosystem dichotomy need not lead to undesirable consequences, yet, unfortunately, a number of "ecological diseases" have been associated with the intensification of food production. They may be grouped into two categories: diseases of the ecotope, which include erosion, loss of soil fertility, depletion of nutrient reserves, salinization and alkalinization, pollution of water systems, loss of fertile croplands to urban development, and diseases of the biocoenosis, which include loss of crop, wild plant, and animal genetic resources, elimination of natural enemies, pest resurgence and genetic resistance to pesticides, chemical contamination, and destruction of natural control mechanisms.

The interest in organic agriculture in developing countries is growing because it requires less financial input and places more reliance on the natural and human resources available. Studies to date seen to indicate that organic agriculture offers comparative advantage in areas with less rainfall and relatively low natural and soil fertility levels. Labour is almost non-existent. Organic agriculture does not need costly investments in irrigation, energy and external inputs, but rather organic agricultural policies have the potential to improve local food security, especially in marginal areas.

Possibly, the greatest impact of organic agriculture is on the mindset of people. It uses traditional and indigenous farming knowledge, while introducing selected modern technologies to manage and enhance diversity, to incorporate biological principles and resources into farming systems, and to ecologically intensify agricultural production. Instead of being an obstacle to progress, traditions may become an integral part of it. By adopting organic agriculture, farmers are challenged to take on new knowledge and perspectives, and innovate. This leads to an increased management in farming which can trigger greater opportunities for rural employment and economic upliftment. Thus through greater emphasis on use of local resources and self- reliance, conversion to organic agriculture definitely contributes to the empowerment of farmers and local communities.

The following conclusions can be drawn on important issues regarding organic farming

Large scale conversion to organic agriculture would result in food shortage with the present state of knowledge and technology, as the yield reduction of organic system relative to conventional agriculture average 10-15%, especially in intensive farming system.

However, in traditional rainfed agriculture, organic farming has the potential to increase the yield since 70% of total cultivable land falls in this category. Mere 5-10% increase in farm production would definitely help to achieve the targeted growth rate of 4-5% in agricultural production during X five year plan.

Organic manure is an alternative renewable source of nutrient supply. A large gap exists between the available potential and utilization of organic wastes. However, it is not possible to meet the nutrient requirements of crops entirely from organic sources, if 100% cultivable land is converted to organic farming.

Organic farming systems can deliver agronomic and environmental benefits both through structural changes and tactical management of farming systems. The benefits of organic farming are relevant both to developed nations (environmental protection, biodiversity enhancement, reduced energy use and CO2 emission) and to developing countries like India (sustainable resource use, increased crop yield without over - reliance on costly external inputs, environment and biodiversity protection etc.).

Organic foods are proved superior in health and safety but there is no scientific evidence to prove their superiority in taste and nutrition, as most of the studies are often inconclusive.

Organic farming is a holistic production system that has the advantage of efficient use and recycling of locally available resources. It is best suited to rainfed areas with scarcity of water and light soils. Some monopoly high value crops of rainfed areas like seed spices have great international demand, if produce organically. Organic production in rainfed areas not only boost the economy of this region but also sustain the productivity of natural resources. The need is to strengthen research on development of processing and marketing infrastructure, and financial as well as technical support for quality organic production.

Future prospects in India

Despite all the benefits of organic cultivation, there are some apprehensions among a group of people, including some scientists, which are often highlighted at different platforms to discourage the expansion of organic farming. The important ones are:

- Can we sustain the food security to ever -increasing population through organic farming?
- Is it possible to meet the nutrient requirements of the crops entirely through organic sources?
- Are there any significant benefits of organic farming in terms of food quality?
- Is organic farming economically viable?
- Is it possible to manage weeds, insect-pests and diseases in organic farming to sustain yield levels?

It is very easy to answer all these queries at present in Indian context. But various FAO reports on organic agriculture unequivocally state that organic agriculture can address local and global food-security challenges (Scialabba 2007). The report strongly points out that a world - wide shift to organic agriculture can fight world hunger and at the same time tackle climate change. Evidences presented to the FAO by Danish Research Center for Food and Farming confirm the potential of a new organic farming paradigm to secure more than enough food to feed the world, and reduced environmental impacts. The results, using a computer model developed by International Food Policy Research Institute, show that a 50% conversion to organic farming in sub-Saharan region of Africa would not harm food security. Instead, it would help feed the hungry by reducing the need to import subsidized food, and produce a diverse range of certified organic surpluses to be exported at premium profits. It says that conversion from chemically intensive farming to organic farming can initially decrease yields, but the adjustment evens out over time and provides numerous nonmaterial benefits. Organic agriculture has the potential to reverse the on-going trends of soil and environmental degradation under conventional farming and reduce carbon dioxide, nitrous oxide and methane green - house gases that contribute to global warming. Organic agriculture could double the soil - carbon sequestration in livestock based systems and decrease green- house gases by 48-60%. For example, organic systems have decreased the use of fossil fuels by 10-70% in Europe and 29-37% in the USA.

In the backdrop of all these reported benefits, the Indian scientific community has to strive hard to provide answers to some of these questions through hard-core research in organic farming under tropical and subtropical environments that exist in the country. There is greater need to undertake basic and applied research on these aspects, for which more resources in the form of dedicated team of scientists, better laboratory facilities and working capital would be required. The inputs from agronomists, soils scientists, microbiologists, plant pathologists, entomologists and environmentalists would be highly critical. It is necessary to undertake multi-location research to understand the scientific bases behind many organic farming practices and identify technologies for improved yields, and to conduct some basic studies like; development of innovative crop - management practices and quality detailed nutrient budgets and indicators of improvement in soil quality (carbon sequestration, dehydrogenase activity, microbial biomass, C and N in major organic - based cropping systems); understand the nutrient - release patterns of different organic sources in combination and alone; develop relationship between the crop N- demand and supply; screen crop or vegetable varieties, and to develop and assess bio-agents and bio - pesticide for effective control of insect pests and diseases of organic - based cropping systems.

Considering the global scenario of organic agriculture, National Policy for Farmers-2007 (Government of India) has clearly favoured the development of organic farming in India. The policy has placed high emphasis on organic farming , but it has categorically mentioned that organic farming movement in India suffers from a lack of adequate institutional support in the areas of research, extension, certification and marketing and it requires more scientific support than chemical farming. Similarly, according to Working Group on Horticulture, Plantation Crops and organic Farming for the XI Five - year Plan (Planning Commission, GOI, New Delhi, 2007) healthy growth rates in organic farming are expected to continue in the coming years, and ever-growing demand for organic products offers attractive opportunities for producers, especially those in less- developed areas. It is expected that spread of organic farming on 1-5% area in the high productive zone and large spread in the less-exploited areas such as, rainfed and hill areas, would help strengthen the organic movement. It will further strengthen our export- oriented programme under WTO regime.

On the contrary, in general , there is considerable latent interest among farmers in conversion to organic farming. However, they become reluctant todo so because of the following factors

- Perceived high costs of organic farming, which is mainly due to incomplete knowledge about principles and practices of organic agriculture among farmers. Farmers often seek for off-farm inputs, leading to escalation in production costs, which is against the basic philosophy of organic agriculture. Moreover, very high government subsidies on chemical fertilizers in conventional agriculture are not taken into account while comparing the production costs.
- Non-availability of adequate quantities of organic manures and other organic inputs in the local market from reliable sources. Farmers are , more often than not, forced to recycle major quantities of crop residues as animal fodder and animal dung as sources of household energy. Sizable quantities of crop residues are also sold off to paper and cardboard industry to earn cash for household needs.
- • Complete knowledge about organic farming principles, practices and advantages accrued to grower as well as mankind is not filtered down to the small farmers, which should be the actual target and potential beneficiary of organic farming. Further, whatsoever information reaches the target groups is very often not backed by scientifically proven results in tropical or subtropical climatic conditions and different farming situations prevailing in Indian subcontinent.
- Complex and costly procedures of certification.
- The risks involved in marketing of organic produce as premium rates for organic produce are not available in domestic markets.

Strategies

In Indian context, to promote and make organic farming economically viable, the following issues are needed to be addressed immediately

- Adequate research and extension support needs to be provided for improving the region -specific farming techniques and disseminating the findings for conversion and management of organic farms in farming-system mode.
- Researchers should study and quantify the role of organic agriculture in mitigating the climate change and ill-effects of modern agriculture, and also improve the resource sustainability.
- Central and state governments should acknowledge organic agriculture as an effective mechanism to reduce green house gases and sequester soil carbon. They should help farmers by promoting

organic agriculture through research and extension services.

- The governments should recognize organic agriculture in Kyoto-Protocol carbon - credit mechanisms.
- Organic market development sector needs major thrust on development of supply chains and related infrastructure to ensure competitive price of organic produce to the grower in domestic and international markets.
- Mission -mode programmes for on- farm demonstrations, training for capacity building of institutions, organic farmers, service providers, NGOs and processing or packing industry, with full research back-up are needed. Model organic farms are need to be established in public- private-partnership mode.
- Government support is required for cheaper access to organic certification of farms.

जैविक खेती उत्पादन विधि की एक विस्तृत श्रृंखला है। जो कि पर्यावरण एवं मानव स्वास्थ के समर्थन में स्वीकार की जाती है। विकसित एवं विकासशील देशों में 20-25% वाषिक वृद्धि दर के हिसाब से जैविक खाद्य की मांग उन्तरोत्तर बढ़ती जा रही है। जैविक .षि, .षित उत्पादन का एक सबसे अधिक वृद्धि करने वाला हिस्सा है। जबकि विस्तृत क्षेत्र में जैविक रूपान्तरण से पहले यह आवश्यक है कि कुछ मुख्य बिन्दुओं पर विचार किया जाए जैसे–क्या जैविक खेती के उत्पादन से सभी को पर्याप्त भोजन मिल सकता है ? क्या जैविक खेती द्वारा फसलों को आवश्यक पोषक तत्वों की पूर्ति संभ्भव है ? क्या जैविक खेती द्वारा उत्पादित उत्पाद स्वाद एवं गुण मे बेहतर होता है ? क्या यह आर्थिक रूप से व्यवहारिक है ? यह लेख भारतीय परिवेश मे इन बिन्दुओं पर सूक्ष्म समीक्षा प्रस्तुत करता है।

जैविक कृषि एक उत्पादन पद्धति है। जिसमें संश्लेषित यौगिक जैसे–उर्वरक, व्याधिनाशक, वृद्धिकारक एवं पशुधन हेतु भोज्य सम्मिश्रण प्रा.तिक संसाधनों का टिकाऊपन खेती की लागत को कम करना, स्वस्थ्य भोजन की उपलव्धता, प्रक्षेत्र का लाभ बढ़ाना एवं मृदा स्वास्थ्य सुधार। जबकि बाजार में जैविक दावे पर सुरक्षा प्रदान करना, जैविक कृषि के प्रमाणीकरण की आवश्यकता है। लेकिन विस्तृत रूप से जैविक कृषि विधि उपयोग करने वाली कोई भी पद्धति चार आधारभूत सिद्धान्तों पर आधारित है (स्वास्थ्य, परिस्थितकी, गुणवत्ता एवं देखरेख का सिद्धान्त) जिन्हे जैविक कृषि में वर्गीकृत कर सकते है।

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Growth dynamics of major crops in Madhya Pradesh

A. Jayanta Kumar and **S.B. Nahatkar**
Directorate of Research Services
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Jabalpur 482004 (MP)

Abstract

Agricultural growth throughout global history has been the pro-genitor of broad-based economic growth and development, as linkages between farm and non-farm economies generated widely-based employment, income, and growth. Agricultural growth shall thus in the future also be the sine qua non for alleviation and eradication of rural poverty and hunger in those states that have not yet fully achieved their broad-based growth. The state of Madhya Pradesh is also marching towards broad-based growth. The state of Madhya Pradesh is the second largest state of the country in terms of its geographical spread. It is primarily an agriculture State. The agriculture and allied services contributes about 23 per cent share in state economy and 65 per cent of its working force is directly engaged in agriculture. This state has a great production potential since yield gap - II is very high for most of the crops grown in the state and therefore, the study on growth dynamics of major crops was undertaken. The secondary data of 13 major crops were collected for area, production and productivity in Madhya Pradesh for 30 years i.e. 1980-81 to 2009-2010. The whole period was divided into two sub-period as pre-globalization - P_1 period (1980-81 to 1994-95) and post-globalization - P_2 period (1995-96 to 2009-10). The results show that the compound growth rate of cereals was higher during P_1 period as compared to P_2 period, except for Sorghum. But in case of pulses, the growth in production of Black gram was higher during P_2 period while it was higher for Chickpea, Lentil and Pea during P_1 period. Oilseed crop also registered high growth rate during P_1 period as compared to P_2 period. In case of Cotton, highly significant growth was recorded in the state on account of significant positive growth in productivity due to adoption of Bt Cotton production technology during P_2 period. Total food grains and oilseeds shows higher growth during P_1 period as compared to P_2 period. The relative change in output of cereals mainly Wheat and Maize was observed to be higher as compared to Paddy and Sorghum during both the period despite of marginal reduction in area of Wheat during P_2 period. Among the pulses, chickpea, lentil and pea shows higher relative change, especially, during P_2 period and Black gram which was registered negative relative change during P_1 period turn out to be positive during P_2 period. Pigeon pea crop shows negative relative change during the entire period of study. The growth of agriculture in the State of Madhya Pradesh is still having great potential since it is not negative.

Keywords: Major crops, area, production, productivity, growth and relative change

Agricultural growth throughout global history has been the pro-genitor of broad-based economic growth and development, as linkages between farm and non-farm economies generated widely-based employment, income, and growth. Agricultural growth shall thus in the future also be the sine qua non for alleviation and eradication of rural poverty and hunger in those states that have not yet fully achieved their broad-based growth. This is particularly so in Madhya Pradesh, where the numbers of rural poor including the land-less and those farming sub-marginal holdings are so large (>60%). The state of Madhya Pradesh has been the centre of agriculture excellence in selected crop like Soybean, Chickpea, quality Wheat. The total geographical area of the state is 30.82 million hectares (2009-10). The forests occupies 8.59 million hectares which is 27.87 per cent of the geographical area of the state, whereas, the cultivated area is about 49 per cent of the total geographical area which is 12.94 million hectares (2009-10). The state of Madhya Pradesh is the second largest state of the country in terms of its geographical spread. It is primarily an agriculture State. About 70 per cent population of the state is rural, which is directly or indirectly depends on agriculture. Thus, agriculture sector is the mainstay of the state economy. The agriculture and allied services contributes about 23 per cent share in state economy and 65 per cent of its working force is directly engaged in agriculture. The economy of India witnessed positive change after economic liberalization. The performances of agriculture sector of Madhya Pradesh in particular need such types of estimates and therefore the present study was undertaken.

Research Methodology

The study area pertains to the state of Madhya Pradesh excluding the area of Chhattisgarh which was carved out of Madhya Pradesh in the year 2000. Efforts are put to ensure actual data for Madhya Pradesh, the entire series (1980-81 to 1998-99) are tabulated for analysis purpose by deducting the data of the selected variables for the districts merged into Chhattisgarh i.e., the data of Bastar, Bilaspur and Raipur division. The data of remaining districts of state are pooled together to form a common figure for the state during that period. The state has a diversified cropping pattern in different agro-climatic regions and hence all the important cereals, pulses and oilseeds were selected for the present study. Thus, the study was restricted to principal crops with the assumption that the excluded crops do not affect the cropping pattern and in turn would not vitiate the main conclusions of the study. The secondary data of 13 major crops (viz. Paddy, Wheat, Maize, Sorghum, Pigeon Pea, Black gram, Chickpea, Lentil, Pea, Mustard, Soybean, Linseed and Cotton) were collected on area, production and productivity for 30 years i.e. 1980-81 to 2009-2010 from the published documents of Government of India, Government of Madhya Pradesh and various Directorates, Commission and Boards. Website of the Department of Farmers Welfare and Agriculture Development, Government of Madhya Pradesh, Publications such as Area, Production and Productivity of Major crops in Madhya Pradesh, Tables of Agricultural Statistics of Madhya Pradesh and Agricultural Statistics at a Glance. The whole period was divided into two sub-period as Pre-Globalization - P_1 Period (1980-81 to 1994-95), Post-Globalization - P_2 Period (1995-96 to 2009-10) and P_3 Period (1980-81 to 2009-10). The relative change and compound growth rate for Sub-periods and pooled period were analysed.

Results and Discussion

The relative change and compound growth rate in percentage for area, production and productivity of thirteen major crops viz. Paddy, Wheat, Maize, Sorghum, Pigeon Pea, Black gram, Chickpea, Lentil, Pea, Mustard, Soybean, Linseed and Cotton during 1980-81 to 2009-2010 was worked out and data on the same are presented in the following Sub-heads.

Relative change

Cereals

The relative change in output of cereals mainly Wheat and Maize was observed to be higher as compared to Paddy and Sorghum during both the period despite of marginal reduction in area of Wheat during P_2 period. During P_1 period, in rabi season highest relative change

Table 1. Relative change in production of major crops in Madhya Pradesh

Cereals

Crops	Period	P_1 BY	P_1 CY	P_1 RC (%)	P_2 BY	P_2 CY	P_2 RC (%)	P_3 BY	P_3 CY	P_3 RC (%)
Paddy	Area (000'Ha)	1552	1584	2.1	1657	1603	-3.3	1552	1603	3.3
	Prod (000' t)	1084	1330	22.7	1262	1390	10.1	1084	1390	28.2
	Yield (Kg/ha)	698	839	20.2	762	867	13.7	698	867	24.2
Wheat	Area (000'Ha)	3319	3913	17.89	4221	4129	-2.2	3319	4129	24.4
	Prod (000' t)	3370	6375	89.1	7142	7476	4.7	3370	7476	121.8
	Yield (Kg/ha)	1005	1622	61.4	1694	1808	6.7	1005	1808	87.8
Maize	Area (000'Ha)	692	792	14.4	762	841	1.4	692	841	21.5
	Prod (000' t)	663	1079	62.7	953	1101	15.5	663	1101	66.1
	Yield (Kg/ha)	958	1356	41.5	1250	1309	4.7	958	1309	36.6
Sorghum	Area (000'Ha)	2195	1242	-43.4	905	495	-45.3	2195	495	-77.4
	Prod (000' t)	1679	1167	-30.5	771	586	-24	1679	586	-65.1
	Yield (Kg/ha)	762	916	20.2	852	1195	40.2	762	1195	56.8
Total Cereals	Area (000'Ha)	9001.3	8415.7	-6.95	8334.7	7629.3	-9.24	9001.3	7629.3	-17.98
	Prod (000' t)	7247.3	10314	29.73	10518	10995	4.33	7247.3	10995	34.08
	Yield (Kg/ha)	805.33	1225	34.25	1261.7	1442.3	12.53	805.33	1442.3	44.16

Pulses

Crops	Period	P1 BY	P1 CY	P1 RC (%)	P2 BY	P2 CY	P2 RC (%)	P3 BY	P3 CY	P3 RC (%)
Pigeon pea	Area (000' Ha)	473	375	-20.7	331	325	-1.8	473	325	-31.3
	Prod (000' t)	333	327	-1.8	256	217	-15.2	333	217	-34.8
	Yield (Kg/ha)	703	870	23.8	773	673	-12.9	703	673	-4.3
Black gram	Area (000' Ha)	588	413	-29.8	397	529	33.2	588	529	-10.1
	Prod (000' t)	152	129	-15.1	144	194	34.7	152	194	27.6
	Yield (Kg/ha)	259	311	20.1	362	367	1.4	259	367	41.7
Chickpea	Area (000' Ha)	1939	2290	18.1	2402	2874	19.6	1939	2874	48.2
	Prod (000's t)	1279	1984	55.1	2143	2682	25.1	1279	2682	109.7
	Yield (Kg/ha)	655	843	28.7	894	925	3.5	655	925	41.2
Lentil	Area (000' Ha)	283	381	35.00	480	531	10.6	283	531	88.00
	Prod (000' t)	111	187	68.5	222	256	15.3	111	256	130.6
	Yield (Kg/ha)	391	484	23.8	463	482	4.1	391	482	23.3
Pea	Area (000' Ha)	104	136	30.8	170	207	21.8	104	207	99.01
	Prod (000' t)	31	50	61.3	63	94	49.2	31	94	193.5
	Yield (Kg/ha)	297	363	22.2	396	450	13.6	297	450	51.5
Total Pulses	Area (000' Ha)	3801	3863.7	1.6	4025	4644.7	13.34	3801	4644.7	18.16
	Prod (000' t)	2037.3	2750.7	25.93	2923	3519	16.93	2037.3	3519	42.10
	Yield (Kg/ha)	534	710.33	24.82	726.67	753.3	3.53	534	753.3	29.11
Total Food	Area (000' Ha)	12798	12279	-4.2	12360	12274	-0.69	12798	12274	-4.26
grains	Prod (000' t)	9284.7	13098	29.11	13441	14514	7.39	9284.7	14514	36.03
	Yield (Kg/ha)	725.67	1066	31.92	1087.3	1181.7	7.98	725.67	1181.7	38.59

Oilseeds & Commercial crop

Crops	Period	P1 BY	P1 CY	P1 RC (%)	P2 BY	P2 CY	P2 RC (%)	P3 BY	P3 CY	P3 RC (%)
Soybean	Area (000' Ha)	334	3214	862.3	4112	5282	28.4	334	5282	1481.4
	Prod (000' t)	203	3005	1380.1	4187	5899	40.9	203	5899	2806.01
	Yield (Kg/ha)	594	932	57.00	1016	1117	10.01	594	1117	88.05
Mustard	Area (000'Ha)	215	629	192.6	659	728	10.5	215	728	239.01
	Prod (000' t)	126	516	309.5	530	747	41.00	126	747	493.00
	Yield (Kg/ha)	588	822	40.00	802	1022	27.4	588	1022	74.00
Linseed	Area (000' Ha)	347	338	-2.6	267	112	-58.05	347	112	-67.7
	Prod (000' t)	97	112	15.5	90	45	-50	97	45	-53.6
	Yield (Kg/ha)	279	334	19.7	336	400	19.05	279	400	43.4
Total Oilseeds										
	Area (000' Ha)	896	4182	78.57	5037.3	6122.3	17.72	896	6122.3	85.36
	Prod (000' t)	426	3632.3	88.27	4807.3	6691.3	28.15	426	6691.3	93.63
	Yield (Kg/ha)	471.3	866.3	45.59	953.67	1091.3	12.61	471	1091.3	56.81
Cotton	Area (000' Ha)	596	478	-19.8	516	618	19.8	596	618	3.7
	Prod (000' t)	298	373	25.2	452	829	83.4	298	829	178.2
	Yield (Kg/ha)	500	779	55.8	876	1340	52.9	500	1340	168

P_1: Pre-globalization period of 1980-81 to 1994-95, P_2: Post-globalization period of 1995-96 to 2009-10, P_3: Period of entire study ranging from 1980-81 to 2009-10, BY: Base Year (Triennium), CY: Current Year (Triennium), RC: Relative Change in Percentage in production of wheat was recorded (89.1%) and this was mainly due to 17.89 percent increase in area followed by 61.4 percent increase in productivity of wheat, revealing that during this periods growth in production of wheat was technology driven. While in kharif season, during P_1 period, relative change in production of maize was promising (62.7%) and this was mainly contributed to higher relative change in productivity (41.5%). Sorghum crop which was mainly replaced by Soybean as observed from negative relative change of acreage of Sorghum (-43.4%) in the state. During P_2 period, relative change in production of maize was highest (15.5%) followed by paddy (10.10%) despite of reduction in acreage of paddy marginally (-3.3%). During overall period, wheat and maize registered higher relative change in production 121.80 and 66.10 percent respectively. The overall relative change in production of total cereals was 34.08 percent despite of reduction in acreage by 17.98%.

Pulses

Among the pulses, chickpea, lentil and pea shows higher relative change, especially, during P_2 period and Black gram which was registered negative relative change during P_1 period turn out to be positive during P_2 period. Pigeon pea crop shows negative relative change during the entire period of study, and this was mainly attributed to yield reduction in P_2 period and area reduction in P_1 period. During P_1 period, relative change in production of lentil was highest (68.50%) followed by pea (61.3%) and chickpea (55.1%). In chickpea, this change was due to productivity enhancement, while in lentil and pea it was due to area expansion. During P_2 period, pea and blackgram registered higher relative change in production reflecting towards inclination of farmers towards these two pulses. During overall period, pea (193.50%), lentil (130.6%) and chickpea (109.7%) shows higher relative change in production, while pigeonpea crop registered negative relative change of

Table 2. Growth rates of Major crops in Madhya Pradesh (%)

Crops	P_1			P_2			P_3		
	A	P	Y	A	P	Y	A	P	Y
Cereals									
Paddy	0.04	1.5**	1.5**	- 0.3	0.7	1.0*	0.3	1.2**	0.9
Wheat	1.0*	5.1**	4.0**	- 0.2	0.3	0.5	0.8	2.8**	2.1**
Maize	1.0**	3.2**	2.2**	0.9	0.6	- 0.4	0.4	1.9**	1.2**
Sorghum	- 4.6**	-3.8**	0.8**	- 4.4**	- 1.7**	2.9**	- 5.8*	- 4.8**	1.1**
Total Cereals	-0.69	2.57**	3.33**	-0.69	0.31	1.01	0.69	0.53	0.81
Pulses									
Pigeon pea	-1.8**	- 0.3	1.5**	-0.07	-1.5**	-1.5**	-1.6**	- 2.3**	- 0.6
Black gram	- 3.2**	-1.9**	1.3**	2.5**	3.0**	0.5	- 0.7	0.7	1.4**
Chickpea	1.6**	3.9**	2.3**	1.4**	1.9**	0.4	1.4**	2.9**	1.5**
Lentil	2.5**	4.6**	2.0**	0.9	1.3**	0.4	2.9**	3.5**	0.6
Pea	1.7**	3.6**	1.9**	1.7**	3.1**	1.3**	2.9**	4.7**	1.7**
Total Pulses	0.03	2.48**	2.44**	1.19**	1.56**	0.361	0.74	2.07**	1.32**
Total Food grains	-0.49	2.56**	3.066**	0.03	0.6	0.64	-0.19	1.57**	1.77**
Oilseeds									
Soybean	20.2**	24.9**	3.9**	1.8**	2.6**	0.8	9.5**	11.6**	2.0**
Mustard	9.8**	12.8**	2.7**	1.8**	3.7**	1.9**	4.1**	5.7**	1.6**
Linseed	- 0.5	1.1**	1.6**	- 7.1**	-5.7**	1.5**	- 4.8**	- 3.3**	1.5**
Total Oilseeds	13.41**	19.13**	5.03**	1.47	2.61	1.12	6.76**	9.49**	2.56*
Cotton	-1.1**	2.5**	3.7**	1.9**	6.5**	4.5**	0.2	3.9**	3.7**

P_1: Pre-globalization period of 1980-81 to 1994-95, P_2: Post-globalization period of 1995-96 to 2009-10, P_3: Period of entire study ranging from 1980-81 to 2009-10, A: Area, P: Production, Y: Yield ** Significant at 1% level of probability, * Significant at 5% level of probability

34.80 percent. The total pulses also registered higher relative change in production during P1 period (25.93%) as compared to P_2 period (16.93%). The total food grains production also registered higher relative change during P_1 period (29.11%) as compared to P_2 period (7.39%) despite of marginal reduction in acreage during both the periods.

Oilseed and Commercial crop

Among the oilseeds, Soybean and Mustard show high relative change during the entire period of the study but there was negative relative change in Linseed acreage and production. In case of Cotton, area, production and productivity shows higher relative change during P_2 period as compared to P_1 period and this was mainly due to introduction of Bt Cotton production technology. Amongst the oilseeds in the kharif soybean (1380.10%) and in rabi mustard (309.50%) registered higher relative change in production during P_1 period, while in P_2 period, relative change in production of soybean in kharif and mustard in rabi are at par (41%). But contribution of productivity was higher in mustard crops as against contribution of acreage in soybean crop. Total oilseeds shows positive relative changes in acreage, production and productivity revealing that most of the cereals were replaced by oilseeds and pulses crop in the state. In cotton, despite of reduction in acreage during P_1 and overall period positive relative change in production attributed towards cotton growers' responses to technological adoption, specially Bt technology during P_2 period and hybrid technology during P_1 period.

Compound Growth rates

The data on compound growth rate on area, production and productivity of major crops are presented in the Table 2.

Cereals

It was found that the growth in production of cereals was higher during P_1 period as compared to P_2 period except for Sorghum. The growth rates of Cereals production and productivity was positive and highly significant during period of 1980 to 1995 but it was sluggish during period 1996-2010, revealing that the Cereal crops were replaced by other commercial and marketed crops like cotton, oilseeds and pulses. The growth in production of wheat (5.1%) was observed to be highest during P_1 period and during overall period also this crop registered highest growth rate (2.8%), followed by maize (1.2%) and paddy (1.2%).

Pulses

But in case of pulses, the growth in production of Blackgram was higher during P_2 period while it was higher for Chickpea, Lentil and Pea during P_1 period. The lentil crop registered highest growth rate (4.6%) during P_1 period followed by chickpea (3.9%) and pea (3.6%) while pigeoapea and blackgram registered negative growth in production. This revealed that most of the kharif pulses are replaced by oilseeds especially by soybean crop in the state, while during rabi most of the pulses are gaining popularity among farmers as source of income. Even during P_2 period, when Soybean crop was well established in the cropping pattern of the state, the growth in area of blackgram in kharif in non soybean growing areas registered significantly (3%) and during rabi season, pea (3.1%), chickpea (1.9%) and lentil (1.3%) registered significant positive growth in their acreage. The production growth in total pulses was positive and significant during both the periods. However, the growth of total food grain production was positive during P_1 period and it was significantly higher as compared to P_2 period.

Oilseeds and Commercial crop

Oilseeds crop also registered high growth rate during P_1 period as compared to P_2 period. In case of Cotton, highly significant growth was recorded in the state on account of significant positive growth in productivity due to introduction of Bt Cotton production technology during P_2 period. Total food grains and oilseeds shows higher growth during P_1 period as compared to P_2 period. Soybean and mustard registered positive and significant growth in area, production and productivity during both the periods along with highly significant growth in production of total oilseeds. The cotton crop production also registered significant growth during both the period but growth in production was higher during P_2 period as compared to P_1 period.

The rate of reduction of acreage of Cereals was almost same during 1981-1995 and 1996-2010, but growth of production of Cereals was higher during 1981-1995 as compared to 1996-2010 and this was mainly attributed to higher productivity growth. The growth in acreage of pulses was higher during 1996-2010 but productivity of pulses registered higher growth during 1981-1995 and it is very interesting to observe that kharif pulses especially pigeonpea replaced by soybean and rabi pulses like chickpea, pea and lentil replaced wheat acreage marginally and also used rabi fallow land due to increase in irrigation facilities. Cotton area which starts declining during 1981-1995 again gained momentum and increased significantly during 1996-2010 period. This show that cropping pattern of the state is changing and farmers are responsive to price and technological changes especially in case of rabi pulses, oilseeds and cotton.

समूचे विश्व के इतिहास में आर्थिक वृद्धि एवं विकास, कृषि वृद्धि पर निर्भर रहा है क्योंकि कृषि एवं गैर कृषि आधारित आर्थिकी रोजगार, आय एवं वृद्धि के सृजन है। उन राज्यों ने जहॉं अभी तक पूरी तरह से व्यापक वृद्धि हासिल नही की है भविष्य में उन राज्यों में गरीबी एवं भूख के उन्मूलन के लिए कृषि विकास अनिवार्य है। मध्यप्रदेश राज्य भी व्यापक विकास की ओर अग्रसर है । मध्यप्रदेश भौगोलिक प्रसार की दृष्टि से देश का दूसरा सबसे बड़ा राज्य है । यह मुख्य रूप से कृषि आधारित राज्य है। राज्य की अर्थ व्यवस्था में कृषि एवं कृषि से संबंधित सेवाओं की 23 प्रतिशत का योगदान है एवं समस्त कार्यबल का 65 प्रतिशत हिस्सा प्रत्यक्ष रूप से कृषि में लगा हुआ है। इस राज्य में भविष्य में अधिक उत्पादन की संभावनाएँ हैं। अधिकतर फसलों में उपज अंतर -II अधिक है, अतः प्रमुख फसलों की उत्पादन की गतिशीलता पर अध्ययन किया गया है । मध्यप्रदेश में 30 वर्षों के लिए 1995-96 से 2009-10 तक प्रमुख 13 फसलों का क्षेत्र, उत्पादन एवं उत्पादकता का द्वितीयक डाटा संग्रह किया गया । पूरी अवधि को दो उप अवधियों में विभाजित किया गया है । प्रथम वैश्वीकरण के पूर्व पी-1 अवधि (1980-81 से 1994-95 तक) एवं वैश्वीकरण के बाद पी-2 अवधि (1995-96 से 2009-10) तक । परिणाम यह बताते हैं कि पी-2 अवधि की तुलना में पी-1 अवधि के दौरान ज्वार को छोड़कर अनाज वाली फसलों की वृद्धि दर अधिक थी । पी-2 अवधि के दौरान दलहनी फसलों में उड़द के उत्पादन में वृद्धि अधिक थी जबकि चना, मसूर एवं मटर के उत्पादन में पी-1 अवधि के दौरान अधिक थी। कपास के मामले में पी-2 अवधि के दौरान बीटी कपास उत्पादन तकनीकी अंगीकरण से प्रदेश में कपास उत्पादकता में अधिक सकारात्मक वृद्धि दर्ज की गई । पी-2 अवधि की तुलना में पी-1 अवधि के दौरान सम्पूर्ण अनाज एवं तिलहनी फसलों के उत्पादन में अधिक वृद्धि हुई । दोनो अवधि के दौरान धान एवं ज्वार की तुलना में गेहूँ एवं मक्के की उत्पादकता में अधिक सकारात्मक परिवर्तन देखा गया, जबकि पी-2 अवधि के दौरान गेहूँ के उत्पादन क्षेत्र में कमी देखी गई । मुख्यतः पी-2 अवधि के दौरान दलहनी फसलों में चना, मसूर एवं मटर में अधिक सकारात्मक परिवर्तन देखा गया । उड़द में पी-1 अवधि के दौरान नकारात्मक सापेक्ष परिवर्तन दर्ज किया गया जबकि पी-2 अवधि के दौरान सकारात्मक परिवर्तन दर्ज किया गया । अरहर फसल अध्ययन की पूरी अवधि के दौरान ऋणात्मक सापेक्ष परिवर्तन को दर्शाती है । मध्यप्रदेश में कृषि में वृद्धि की अधिक संभावनायें हैं क्योंकि प्रमुख फसलों की वृद्धि दर अभी भी धनात्मक है।

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Status and management of wheat root aphid

S.K. Shrivastava
Directorate of Research Services
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Jabalpur 482 004 (MP)

Wheat (*Triticum* L.) is an important cereal crop in India, growing on 29 million ha and producing 93.9 million tones with productivity of 3140 kg per ha. It is cultivated in 4.89 million ha in Madhya Pradesh with production 12.75 million tons and productivity 2609 kg/ha. More than a dozen insect pests including non insect pest (mite) are associated with wheat crop in Madhya Pradesh. Among these termites, brown wheat mite (*Petrobia latens*), Shoot fly (*Atherigona bituberculata* Malloch) and root aphid (*Rhapalosiphum rufiabdominals* Sos) were major insect pests (Rawat and Sahu 1970).

Root aphid (*Rhapalosiphum rufiabdominals* Sos) reported for the first time infesting roots of wheat seedling in Madhya Pradesh under un-irrigated condition in 1965 and 1968 (Rawat and Sahu 1970). During recent years it has been found infesting roots of un-irrigated as well as irrigated wheat crop from December to February (Verma et al. 1995). Efforts have been made to pool together the available information on this pest which could help to develop strategies for the sustainable management of root aphid (*Rhapalosiphum rufiabdominals* Sos).

Common Name: Wheat root aphid, Cereal root aphid, Red rice root aphid and Rice root aphid

Scientific Name: *Rhopalosiphum rufiabdominalis* (Sasaki)

Other Names Used

Aphis splendens Hall 1926; *Aresha setigera* Blanchard 1939; *Aresha shelkovnikovi* Mordvilko 1921; *Cerosipha californica* Essig 1944; *Cerosipha subterranea* (Mason) Zimmermann 1948; *Pseudocerosipha pruni* Shinji 1932; *Rhopalosiphum avenae* George 1925; *Rhopalosiphum californicum*; *Rhopalosiphum fucanoi* Moritsu 1947; *Rhopalosiphum gnaphalii* Tissot 1932; *Rhopalosiphum oryzae*; *Rhopalosiphum papaveris*; *Rhopalosiphum phragmitidis* Börner; *Rhopalosiphum rufiabdominalis* (Sasaki); *Rhopalosiphum shelkovnikovi*; *Rhopalosiphum splendens* Palmer 1939; *Rhopalosiphum subterraneum* Mason 1937; *Siphocoryne splendens* Theobald 1915; *Toxoptera rufiabdominalis* Sasaki 1899; *Yamataphis oryzae* Matsumura 1917; *Yamataphis papaveris* Takahashi 1921; *Yamataphis rufiabdominalis* Takahashi 1923

Taxonomic Position:

Phylum- Arthropoda; Class- Insecta; Order-Hemiptera;

Suborder Sternorrhyncha; Superfamily-Aphidoidea; Family-Aphididae

Taxonomy and Nomenclature

R. rufiabdominals was first described by Sasaki as *Toxoptera rufiabdominalis* in Japan in 1899. Doncaster (1956) reviewed the subsequent descriptions of this aphid from around the world and the confusion in the literature, largely due to its similarity to other *Rhopalosiphum* species. Doncaster (1956) and Tanaka (1961) re-described the aphid.

Geographic Distribution

R. rufiabdominals is virtually worldwide in distribution, but is of economic importance only in warmer climates, particularly upland rice in Japan. It is widespread in North and East Africa, North and South America, Middle East and India.

Europe : Italy (Ciampolini et al. 1993); Portugal; Azores; Madeira; Russia (CIE 1971); Spain (Melia 1986).

Asia

Bangladesh (APPPC, 1987),

China : Fujian (CIE 1971); Hong Kong (APPPC 1987; CIE 1971); Taiwan (CIE 1971); Yunnan (Ding 1985); Zhejiang (CIE 1971).

India : Bihar (Misra et al. 1985); Himachal Pradesh (Misra & Parihar 1983); Punjab (Singh et al.1994); Kerala (Pai et al. 1980); Madhya Pradesh (Rawat and Sahu 1970; CIE 1971); Maharashtra; Orissa; Rajasthan; Uttar Pradesh; West Bengal (CIE,1971).

Indonesia : (CIE 1971); Java (CIE 1971); Iran (Hodja 1984); Iraq (CIE 1971); Israel (CIE 1971).

Japan : Hokkaido; Honshu; Kyushu; Ryukyu; Archipelago and Shikoku (CIE 1971).

Jordan : (CIE 1971); Korea (CIE 1971); Korea (APPPC 1987); (CIE 1971); Malaysia (CIE 1971); Nepal (CIE, 1971); Pakistan (CIE 1971); Philippines (CIE 1971); Sri Lanka (CIE 1971); Thailand (CIE 1971); Turkey (CIE 1971).

Africa : Cameroon (CIE 1971); Egypt (CIE 1971); Ghana (CIE 1971); Kenya (CIE 1971); Morocco (CIE 1971); Nigeria (CIE 1971); South Africa (CIE 1971); Tanzania (CIE 1971); Zambia (CIE 1971).

Western Hemisphere

Argentina (CIE 1971); Brazil; Sao Paulo (CIE 1971); Ontario (Paliwal 1980); Chile (CIE 1971); Colombia (CIE 1971); Cuba (CIE 1971); Jamaica (CIE 1971); Mexico (CIE 1971); Peru (CIE 1971); Puerto (CIE 1971); Suriname (CIE 1971).

USA

Alabama; Arkansas; California; Colorado; Florida; Georgia; Hawaii; Indiana; Kansas; Maryland; Mississippi; Missouri; Nebraska; New Mexico; North Carolina; Ohio; Oklahoma; Oregon; South Carolina; South Dakota; Tennessee; Texas; Utah; Virginia; Wyoming; Venezuela (CIE 1971).

Oceania [Australia]

Australian Northern Territory; New South Wales; Queensland; South Australia; Tasmania; Victoria; Western Australia; New Zealand; Papua New Guinea (CIE 1971).

Host Range: (Primary/ Wild Hosts)

R. rufiabdominals is found on the leaves of its winter (primary) hosts (*Prunus* spp.) and on the roots of summer (secondary) hosts, where aphids are usually located. The aphids are generally not seen on aerial parts of rice except in some limited periods and situations. They are observed on the lower part of stems and on roots, in wheat and barley; however they may also be seen on leaves of young plants.

Winter hosts of *R. rufiabdominals* are *Prunus species*, including *P. cerasiferum*, *P. mume*, *P. yedoensis*, *P. donarium* varieties, *P. salicina* and *P. persica*. Tanaka (1961) listed ten species of *Prunus* as probable winter hosts. Torikura (1991b) reported *Malus* sp., *Pyrus* sp. and *Rhodotypos* sp. as occasional winter hosts.

Summer hosts include numerous species of *Poaceae* (particularly rice and other cereals), *Cyperaceae*, some dicots, particularly *Solanaceae* (potato, tomato) and, occasionally, *Compositae*. Doncaster (1956) and Grist and Lever (1969) list many alternative host plants.

R. rufiabdominals has become a pest of plants grown in hydroponic systems in greenhouses, in the USA and elsewhere (e.g. Etzel and Petitt 1992), and under these circumstances can infest plants outside its usual host range.

Primary hosts: *Gossypium* (cotton), *Hordeum vulgare* (barley), *Oryza sativa* (rice), *Prunus* (stone fruit), *Saccharum officinarum* (sugarcane), *Solanum melongena* (aubergine), *Triticum* (wheat).

Secondary hosts: *Poaceae* (cereals), *Avena sativa* (oats), *Cucurbita pepo* (ornamental gourd), *Eleusine*, *Iris* (irises), *Lolium* (ryegrass), *Lycopersicon esculentum* (tomato), *Nicotiana tabacum* (tobacco), *Orobanche* (broomrape), *Panicum* (millets), *Phragmites*, *Phaseolus vulgaris* (common bean), *Solanum tuberosum* (potato), *Sorghum bicolor* (common sorghum).

Affected Plant Stages: Flowering stage, seedling stage, and vegetative growing stage.

Affected Plant Parts: Whole plant, stems, and roots.

Nature of Damage

In rice, plants wilt and die if large numbers of *R. rufiabdominals* occur on the upper parts of roots. The usual effect of aphid feeding is less extreme, however, with plants becoming yellow and distorted.

In wheat, at seedling stage both nymphs as well as adults suck the cell sap from the root and from the underground-basal portion of the stems resulting in withering and discoloration of lower leaves and stunted plant

Wheat root aphid (*Rhopalosiphum rufiabdominalis* Sasaki) growth (Rawat and Sahu 1970; Parsai and Shrivastava 1997).

Pest Status and Economic Importance

In wheat, *R. rufiabdominals* causes on an average loss of 8.4% in plant height, 28.8% in number of ears, 41.9% in number of grains, 27.3% in grain yield and 3.08% in grain weight (Verma et al. 1995).

R. rufiabdominals is an economic pest of upland rice, particularly in Japan, but is not a pest of irrigated rice anywhere in the world (Grist and Lever 1969). Injury to upland rice can be severe in Japan, with losses of up to 50-70% (Yano et al. 1983). Occurrence was related to the cultivars of upland rice in China, where aphids caused light damage at the seedling stage and heavy damage at the tillering stage (Ding 1985). Generally, aphids cause more serious damage during the early growth stages (Yano et al. 1983).

R. rufiabdominals infests the roots of a range of other crops worldwide, including barley in Turkey, wheat in India, North America and Africa (Doncaster, 1956; Singh et al. 1994), aubergines in Spain (Melia 1986), cotton in Africa and the USA (Doncaster 1956; Duviard and Mercadier 1973) and sugarcane in Japan. It is reported fairly infrequently on cereals, but its subterranean habitat may mean that it is frequently overlooked.

R. rufiabdominals has become a pest of plants grown in hydroponic systems in greenhouses, in the USA and elsewhere (e.g. Etzel and Petitt 1992) and under these circumstances can infest plants outside its usual host range.

R. rufiabdominals is a vector of barley yellow dwarf virus (BYDV) (Paliwal 1980), which contributes to its economic importance as a pest of barley in Turkey and North America. Singh (1977) presented evidence of *R. rufiabdominals* being a vector of maize mosaic virus in India. It is also thought to be a non-persistent vector of cucumber mosaic virus, which causes serious damage to tobacco in some areas in Taiwan (Chen and Weng 1969).

Morphology & Marks of Identification

The abdomen of alatae are similarly coloured. Apterae and alatae 1.2-2.2 mm (Blackman and Eastop 1985). Apterae found on roots of secondary host plants, are dark green, olive or brownish with usually a reddish area at the posterior end of the abdomen between and around the siphunculi. Apterous and alate virginoparae with long fine hairs on the body and antennae. Cauda conical, with broad base narrowing to middle and distal half finger-shaped. Hind wings of alate with two oblique veins (Doncaster 1956). Apterous viviparae usually with marginal tubercules only on first and seventh abdominal segments. Appendages are brown. Body in life dark-brown, with much powdery wax (Torikura 1991b).

Alate viviparae (emigrants and gynoparae) with marginal tubercules only on first and seventh abdominal segments. Siphunculus stout, wider than hind femur at basal half. Cauda triangular (Torikura 1991b). Alate males with antennal flagellum 0.7-0.9 times as long as the body. Ovipara with antennal processus terminalis 1.4-2.1 times as long as third antennal segment.

Similarities with other Spp.

R. rufiabdominals is closely related to *R. padi* and *R. insertum*. It has been confused with other *Rhopalosiphum* species, particularly *R. padi* by various authors (Yano et al. 1983). Doncaster (1956) summarized how it differs from related species on summer hosts, most importantly by having characteristic long, fine hairs on the body and antennae; while Torikura (1991b) provided keys for *Rhopalosiphum* found in Japan, emphasizing differences between morphs on primary hosts.

Bio ecology

R. rufiabdominals is heteroecious holocyclic (host-alternating with sexual phase during life-cycle) between *Prunus* and roots of many plants, especially *Poaceae*, in Japan and other countries where a primary (winter) host is present. Emigrants and apterous fundatrigeniae are observed as late as July on winter hosts in Japan (Torikura 1991a). However, in most parts of the world, *R. rufiabdominals* is anholocyclic on roots of secondary (summer) host plants. Colonies developing on *Poaceae* and *Solanaceae* can migrate in spring to other summer hosts, e.g. from weeds to rice and other crops.

Tanaka (1961) described the life cycle in Japan, where *R. rufiabdominals* has a brief period of abundance in June-early July, with over 100 nymphs occurring on each plant in some cases. A total of 16-23 generations a year occur on upland rice. Alatae (winged forms) settle on leaves of summer hosts and descend to roots, where colonies develop at a depth of 2-3 cm. They have recorded associations with ants on roots of various hosts and are often found in nests of Tapinoma in the Middle East (Bodenheimer and Swirski 1957). The ant *Lasius niger* was observed in Japan to transfer aphids to roots (Tanaka 1961).

Hsieh (1970) studied the population biology of *R. rufiabdominals* on rice in Taiwan, where reproduction continued throughout the rice-growing season. Development of nymphal instars can be completed in 4 days (Tanaka, 1961) or about 7 days (Hsieh 1970). Becerra (1994) found in a laboratory study in Colombia (28.5°C and 86% RH) that 1st- 7th nymphal instars lasted 1.33, 1.48, 1.68, 1.49, 1.53, 1.47 and 1.00 days, respectively, while adult longevity was 3.43 days. Adults begin to reproduce after 1-2 days.

Management

Resistant varieties

Use less susceptible wheat variety DL 788 -2 under late sown condition.

Rice cultivars have been shown to have different levels of resistance to *R. rufiabdominals*. Dani and Majumdar (1978) found the Indian rice cultivar Jaya to be resistant to *R. rufiabdominals*.

Cultural Control

Late sowing of rice is recommended and application of ammonium sulphate and manure considered useful (Grist and Lever 1969). The practice of increasing the seedling rate to compensate for crop loss has declined with increased insecticide use (Grist and Lever 1969). Tanaka (1961) discussed other cultural practices.

Application of zinc @ 5-20 kg/ha in wheat crop enhanced the root aphid population, while phosphorus alone was found to suppress it (Verma et al. 1995).

Normal sowing of irrigated wheat (November) is recommended, as late sown (December) received more infestation (Verma et al. 1995; Parsai and Shrivastava 1997).

Biological Control

Natural enemies

Parasitoids

Aphelinus, attacking: nymphs, adults, in Japan

Aphidius, attacking: nymphs, adults, in China, Japan

Pathogens

Verticillium lecanii, attacking: nymphs, adults, in USA, Venezuela

The root-feeding location of *R. rufiabdominals* means that it is relatively protected from the natural enemy complexes that attack other economically important aphids. Ding (1985) found 57.4-100% parasitism by a braconid parasite, *Aphidius* sp. in a study of upland rice in China. Miyahara et al. (1968) reported only low rates of parasitism by *Aphelinus* sp. in upland rice in Japan. Coccinellids may be of minor importance in some areas, e.g. rice in Japan and Nigeria.

Effective control of *R. rufiabdominals* on squash in greenhouses in Florida was obtained using the fungal pathogen *Verticillium lecanii* (Etzel and Petitt 1992). Little information is available concerning natural enemies of this aphid, largely due to its subterranean habitat. Yano et al. (1983) described natural enemies of rice aphids in general, some of which may be predators of varying degrees of effectiveness.

Botanicals

Amongst the botanicals, the application of neem oil @ 3.05 kg a.i./ha with irrigation water at 21 days after planting found to be the most effective in controlling *R. rufiabdominals* in wheat (Verma and Shrivastava 2000).

Chemical Control

Systemic insecticides are commonly used to control *R. rufiabdominals*. For example, oxydemeton-methyl, monocrotophos and dimethoate are used in potatoes in India (Misra et al. 1985). Granular formulation of carbofuran provided the most effective control in rice in India (Majumdar and Dani 1983). However, chemical control in rice is not generally successful (Yano et al. 1983), except for certain soil applications which also kill the associated ant fauna (Miyahara et al. 1968).

The application of chlorpyriphos @ 0.20 kg a.i./ha with irrigation water at 21 days after planting found to be the most effective (ICBR: 17.14) in controlling *R. rufiabdominals* in wheat (Verma and Shrivastava 2000).

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Genetic variability, heritability and genetic advance in arboreum cotton (*Gossypium arboreum* L.)

Rajani Bisen and **G.K. Koutu**
Krishi Vigyan Kendra
Department of Plant Breeding & Genetics
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Jabalpur 482 004 (MP)

Abstract

Forty five genotypes of arboreum cotton were evaluated in randomized complete block design with three replications during Kharif season in three subsequent years of 2004 to 2006. Five competitive plants were randomly selected in each genotype, each replication and each environment for recording observations on seed cotton yield / plant and its component characters along with quality parameters. The magnitude of genetic variability for each character differed from environment to environment and it was lower than corresponding phenotypic variability for all the yield component characters and lint quality parameters in each environment. Thus, the genotypic and phenotypic coefficient of variation recorded in pooled analysis over environments showed the real heritable variation. Monopodia / plant, sympodia / plant, bolls / plant, ginning percentage and seed index showed comparatively high estimates of genotypic and phenotypic coefficient of variation in pooled analysis. On the other hand, uniformity ratio, micronaire value, fibre strength and fibre elongation exhibited comparatively low magnitude of genetic variation. Majority of the characters showed high estimate of heritability. However, high values of genetic advance as percentage of mean were recorded for monopodia / plant, seed index, ginning percentage and sympodia / plant.

Keywords: Heritability, arboreum cotton, genetic advance, variability

Cotton is an important commercial crop of the country and occupies a prime position as fibre crop of masses of the world. It plays an important role in the national economy in terms of contribution in trade, industrial activities, employment and foreign exchange earnings in India (Gite et al. 2006). Keeping in view the future needs of the country, cotton research needs to be versatile and accelerated to develop more productive cotton genotypes for various agro-ecological production areas of India. The development of cultivars of *Gossypium arboreum* L. having greater yield potential with acceptable fibre characteristics is one of the objectives of cotton breeder. Yield of cotton is affected by genetic and environmental factors, and thus interaction between them makes it difficult to select the plants with increased yield. These factors contribute to seed cotton production both directly and indirectly and the breeder is naturally interested in explaining the extent and type of association of such traits. Johnson et al. (1955) and Lerner (1958) have emphasized that heritability estimates when studied in conjunction with genetic advance, would provide more appreciable information than the study of heritability alone. Singh (1981) studied heritability and genetic advance for yield components with quality traits and observed high heritability with low genetic advance for boll weight, seed index and ginning out turn in cotton. Khorgade and Ekbote (1986) found medium to high estimate of heritability for plant height, number of sympodia, number of bolls per plant, seed index, lint index, ginning percentage and yield / plant in cotton. High estimates of genetic advance have been reported by Khordade and Ekbote (1986) and Singh and Singh (1981) for plant height, number of bolls / plant, lint index, ginning percentage, yield / plant in American cotton but no or limited work has been done on arboreum cotton. In the present study, an attempt is, therefore, made to determine the extent of heritable variation for yield components and fibre quality traits in newly developed genotypes of Gossypium arboreum in different environments as well as over environments after deleting the genotype environment interaction.

Material and methods

The present investigation was carried out at All India Coordinated Cotton Improvement Project, Main Centre, JN Krishi Vishwa Vidyalaya, Regional Research Station, Khandwa, MP, India during Kharif Season in Randomized Complete Block Design with three replications of three subsequent years of 2004 to 2006. Forty five genotypes of cotton were selected on the basis of geographical diversity. The climate of the district Khandwa is subtropical moderate. The rainy season starts in the middle of the June after commencement of South-West monsoon and lasts up to September. Soil of experimental site was shallow to medium black with loamy to clay texture and pH of 7.4. The topography is rolling to undulating with low water retention capacity. The available nitrogen, phosphorus and potash is low, medium and high respectively. Each genotype was grown in six row plot of 5.0 m length. The data in respect of various characters were analysed for analysis of variance using the method given by Panse and Sukhatme (1967). Heritability in broad sense was calculated by the method given by Hanson et al. (1956) and genetic advance as percentage of mean by formula given by Johnson et al. (1955). Genotypic and phenotypic coefficients of variation were calculated using the formula given by Burton (1952).

Results and discussion

Analysis of variance revealed significant differences among the genotypes for all the studied characters including seed cotton yield, its component traits and quality parameters in each environment and pooled over environments. Genotypic coefficient of variation ranged from 2.5 to 42.04, 2.21 to 42.57 and 2.45 to 40.09 per cent in three environments. Uniformity ratio exhibited the lowest variation, while lint yield / plant exhibited the highest genetic variation in the present material. In general, the heritable variation was low to moderate for majority of the characters in all the environments. The phenotypic coefficient of variation, ranging from 2.61 to 44.75, 2.61 to 44.75 and 2.59 to 42.44 during 2004, 2005 and 2006, respectively, followed more or less similar trend to genotypic coefficient of variation (Table 1). The magnitude of genetic variability for each character differed from environment to environment. It may be due to existence of differential genotype-environment interaction in varying environments. The magnitude of genetic variability was lower than corresponding phenotypic variability for all the yield component characters and fibre quality parameters in each environment. It may also be due to the masking influence of environmental factors in phenotypic expression of individual character.

Table 1. Genotypic and phenotypic coefficients of variation for seed cotton yield, its component traits and quality parameters during different years and over environments

Character	Genotypic coefficient of variation				Phenotypic coefficient of variation			
	2004	2005	2006	Pooled	2004	2005	2006	Pooled
Nodes/plant	16.34	16.34	17.80	12.59	17.99	17.99	19.95	16.79
Plant height	15.10	15.10	13.15	14.91	15.59	15.59	13.51	15.72
1st reproductive nodes/plant	14.61	14.61	19.04	14.91	16.01	16.01	20.62	21.85
No. of monopodia/ plant	34.20	34.20	28.19	32.83	34.88	34.88	28.75	35.63
No. of sympodia/ plant	25.54	25.54	25.05	24.59	28.13	28.13	28.95	27.84
No. of bolls/plant	39.67	39.67	35.21	30.07	42.75	42.75	38.02	37.53
Boll weight	12.29	12.29	12.38	11.71	13.29	13.29	13.04	13.29
Ginning percentage	5.53	5.53	4.94	30.99	5.63	5.63	5.03	37.98
Seed index	7.65	7.65	8.58	32.69	7.90	7.90	8.99	39.55
Staple length	7.00	7.00	7.50	5.30	7.13	7.13	7.62	5.56
Uniformity ratio	2.51	2.51	2.45	7.93	2.61	2.61	2.59	8.42
Micronaire value	7.80	7.80	7.30	7.11	8.31	8.31	8.69	7.46
Short fibre index	22.78	22.78	18.31	2.31	23.00	23.00	18.63	2.68
Fibre strength	4.74	4.74	4.20	7.54	4.96	4.96	4.54	9.76
Fibre elongation	6.19	6.19	10.80	18.24	7.96	7.96	11.36	20.98
Oil / cent	10.39	10.39	10.05	4.52	10.42	10.42	10.13	4.86
Seed cotton yield/ plant	41.04	41.04	38.68	5.04	43.34	43.34	41.05	8.42
Lint yield/plant	42.57	42.57	40.09	10.13	44.75	44.75	42.44	10.44

The estimates of genetic variability recorded over environments were lower in magnitude in comparison to those computed in individual environment. It may be attributed due to the presence of genotype-environment interaction in the computation of genetic variability in each environment (Johnson et al. 1955). Thus, the genotypic and phenotypic coefficients of variation recorded in pooled analysis over environments are the real heritable variation. Monopodia / plant, sympodia / plant, bolls / plant, ginning percentage and seed index showed comparatively high estimates of genotypic and phenotypic coefficient of variation in pooled analysis thus, offer good scope for the selection of desirable genotypes from the present material. On the other hand, uniformity ratio, micronaire value, fibre strength and fibre elongation exhibit comparatively low magnitude of genetic variation. Hence, the probability of selection for these quality characters is limited from present material.

Selection capacity of a population depends on heritable variation, measured as heritability in the present study. The heritability estimates provide no indication on expected genetic improvement that would result from selection of best individual genotypes. Hence, the knowledge of genetic gain together with heritability becomes more important. In this study, the estimate of heritability was high, in general, for all the characters in each environment (Table 2). It ranged from 60.50 to 99.50, 70.70 to 98.50 and 35.80 to 97.70 during 2004, 2005 and 2006, respectively. Similarly, genetic advance varied from 4.98 to 83.41, 4.98 to 83.41 and 4.78 to 78.02 in three environments. Seed cotton yield / plant, lint yield / plant, bolls / plant, monopodia / plant, sympodia / plant exhibited comparatively high heritability coupled with high estimates of genetic advance as percentage of mean indicating that these traits are mainly under control of additive genes, hence, selection based on phenotypic performance of these characters will be more effective (Panse 1967). Uniformity ratio, fibre strength, fibre elongation, ginning percentage and staple length showed high heritability coupled with low genetic advance. It indicates that non-additive genes play major role in the inheritance of these characters, thus, the direct selection based on these characters will not be appropriate and reliable. These results are in agreement with the findings of Girase and Mehetere (2002), Pandey et al. (2002) and Kumari and Chamundeswari (2005).

In the present study, majority of the characters showed high estimate of heritability. However, the high values of genetic advance as percentage of mean were recorded for monopodia / plant, seed index, ginning percentage and sympodia / plant. This indicates the predominance of additive genetic variance in the phenotypic expression of these characters, thus, offer

Table 2. Heritability and genetic advance as percentage of mean for seed cotton yield, its attributing characters and quality traits during different years and over years

Character	Genotypic coefficient of variation				Phenotypic coefficient of variation			
	2004	2005	2006	Pooled	2004	2005	2006	Pooled
Nodes/plant	82.60	82.60	79.60	56.30	30.60	30.60	32.71	19.47
Plant height	93.80	93.80	94.70	90.00	30.13	30.13	26.37	29.13
1st reproductive nodes/plant	83.20	83.20	85.20	46.50	27.45	27.45	36.22	20.95
No. of monopodia/plant	96.10	96.10	96.10	84.90	69.09	69.09	56.93	62.31
No. of sympodia/ plant	82.50	82.50	74.90	78.00	47.79	47.79	44.67	44.75
No. of bolls/plant	86.10	86.10	85.70	64.20	75.82	75.82	67.16	49.62
Boll weight	85.50	85.50	90.10	77.50	23.40	23.40	24.21	21.24
Ginning percentage	96.50	96.50	96.60	66.60	11.20	11.20	10.00	52.10
Seed index	93.70	93.70	91.20	68.30	15.25	15.25	16.90	55.66
Staple length	96.40	96.40	97.00	91.00	14.17	14.17	15.22	10.43
Uniformity ratio	92.50	92.50	89.60	88.60	4.98	4.98	4.78	15.38
Micronaire value	88.10	88.10	70.70	90.90	15.09	15.09	12.65	13.97
Short fibre index	98.10	98.10	96.60	74.20	46.49	46.49	37.08	4.10
Fibre strength	91.40	91.40	85.70	59.60	9.34	9.34	8.01	11.99
Fibre elongation	60.50	60.50	90.40	75.50	9.93	9.93	21.16	32.66
Oil per cent	99.50	99.50	98.50	86.30	21.35	21.35	20.56	8.65
Seed cotton yield/plant	89.60	89.60	88.80	35.80	80.04	80.04	75.07	6.21
Lint yield/plant	90.50	90.50	89.20	97.70	83.41	83.41	78.02	21.00

good scope for direct selection. On the other hand, short fibre index, staple length, fibre strength, oil percentage and seed cotton yield / plant showed high heritability with low magnitude of genetic advance as percentage of mean. It revealed the existence of dominant genes or epistatic gene interaction in the phenotypic expression of these characters. These characters can be improved following selection-breeding methods such as diallel selective mating, biparental mating and recurrent selection. Kowsalya and Raveendran (1996), Girase and Mehetere (2002) and Sambamurthy et al. (2004) have also reported more or less similar results based on their experiments conducted in single environment. However, the present study indicates the real picture of heritable variation; thus, the conclusions drawn are more reliable and realistic.

Thus, it can be concluded that characters viz., monopodia / plant, sympodia / plant, bolls / plant, ginning percentage and seed index showed high magnitude of genotypic and phenotypic coefficient of variation, heritability and genetic advance as percentage of mean over environments, thus, offer good scope for selection of desirable donors from present material. Boll weight, bolls / plant, sympodia / plant, nodes / plant and monopodia / plant contribute towards seed cotton yield, while bolls / plant, boll weight, nodes / plant and first reproductive nodes / plant determine the lint yield over environments hence, the indirect selection in the form of selection indices based on these attributes may accelerate the genetic gain for seed cotton yield and lint yield / plant in G. arboreum for rainfed farming.

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Evaluation of pearl millet genotypes for physiological efficiency and productivity

M.S. Gurjar, A.S. Gontia, A.K. Mehta, Anubha Upadhyay and **Sathrupa Rao**
Department of Plant Physiology
Jawaharlal Nehru Krishi VishwaVidyalaya
Jabalpur 482004 (MP)

Abstract

The investigations were carried out at the experimental field of All India Co-ordinated Forage Improvement Project under Department of Plant Breeding and Genetics, JNKVV, Jabalpur during the Kharif season of 2010-11. Results indicated that Genotype AVTPM 4 possessed higher net photosynthesis (1.92 μmol/m²/s), a comparatively higher chlorophyll index (35.13 g/m²) resulted in a quite higher tiller number (2.68), cob number/plant (5.98), grain number/cob (989.66) and cob length (26.36 cm) reflected in highest grain yield (93.33 g/plant and 33.10 q/ha). AVTPM 5 was ranked second in yield performance (70.33 g/plant and 32.90 q/ha). Genotypes AVTPM 1 for higher chlorophyll index (35.61g/m²), protein (%) (9.72), CO_2 utilization (29.93 ppm) and radiation use efficiency (0.0557 g/μmol/m²/s), AVTPM 3 - fat (%) (4.13), carbohydrate (%) (70.77) and fibre (%) (1.80), AVTPM 2 - PAR absorption (1203 μ mol/m²/s), Giant bajra - H_2O utilization (6.42 KPa) and water use efficiency (0.48 μmol/mmol), may be utilized in a breeding programme for varietal improvement.

Keywords: Photosynthetically Active radiation, radiation use efficiency, water use efficiency

The productivity of a crop stand depends on its capacity for photosynthesis, its photosynthesis area and the crop canopy. The genetic variability of yield differences amongst the cultivars may be related to some of the growth parameters, like net assimilation rate, crop growth rate, relative growth rate, leaf area index, specific leaf area, and leaf weight ratio and the partitioning of the dry matter into the sink. In graminaceous crops the grain yield is a product of grain weight per cob and cob number per unit area. However any attempt to increase either one or both is compensated by proportional decrease in one or both the factor, hence the grain yield remains unchanged over a wide range. Therefore, a physiological approach to overcome this problem is a prerequisite.

The relationship between photosynthetic efficiency and crop yield is a complex phenomenon. The yield is an integrated effect of numerous physiological processes and morphological components. The grain yield is mainly dependent on photosynthesis and utilization of its product by achieving better adaptation to many environmental factors including the hazards of diseases, lodging and rains.

In order to screen out the pearl millet genotypes having physiological superiority a physiological approach is needed. Efforts are also being made to identify constraints of productivity and ways to ameliorate them. Though few studies have been conducted on growth analysis in pearl millet crop, scanty information is available with regards to influence of various physiological traits and mechanisms viz., chlorophyll index, photosynthetic rate, stomatal conductance, water use efficiency and radiation use efficiency on economic productivity in pearl millet. Keeping in view of the above mentioned facts the present investigations were undertaken

Material and methods

The present investigations were carried out at the experimental field of All India Co-ordinated Forage Improvement Project under Department of Plant Breeding and Genetics, JNKVV, Jabalpur during the Kharif season of 2010-11 in a Randomized Block Design (RBD) replicated thrice. The experimental material consisted of 7 Pearl Millet genotypes viz.; Raj. Bajra chari 1 (G_1), Giant bajra (G_2), AVTPM 1(G_3), AVTPM 2 (G_4), AVTPM 3 (G_5), AVTPM 4 (G_6) and AVTPM 5 (G_7).

The chlorophyll index was worked out by using chlorophyll meter (Model-CCM 200), whereas the leaf area index (LAI) was quantified as per formula given by Gardner et al. (1985). The leaf area was recorded by using Laser area meter (LI-300) whereas, the physiological traits viz., net photosynthesis, photosynthetic active radiation absorption, H_2O and CO_2 utilization in photosynthesis and other physiological processes were recorded with the help of infrared gas analyzer (IRGA) Li-Cor -6400 (Li Cor instruments USA) as per method suggested by Kannan et al. (2007). Radiation and water use efficiencies were determined as per unit of intercepted radiation as per specifications of Sinclair and Muchow (1999), and Thakur and Kaur (2001), respectively.

Results and discussion

Chlorophyll index (g/m^2)

The leaf serves the major photosynthetic organs of pearl millet and much of the differences in the rate of photosynthesis was due to variation in leaf chlorophyll content. The photosynthetic capability of plant increased with increase in chlorophyll concentration. Chloroplast accounts for 25% of total dry matter production and 40% of the total nitrogen of leaves (Bonner 1952). The chlorophyll a/b was found to be correlated with the grains development of a crop (Kongika and Mathis 1995). The chlorophyll content had significant decrease due to water stress than it corresponding control. The maximum leaf chlorophyll content was achieved in young fully expended leaf and gradually started to decline with the advancement of age and senescence Nair et al. (2006).

The investigations showed (Table 1) that the genotype AVTPM 4 possessed the highest chlorophyll index (35.13 g/m^2) which reveals its higher photosynthetic efficiency as earlier investigations revealed a positive correlation between chlorophyll index and yield (Ghosh et al. 2000).

Net photosynthesis (µmol/m^2/s)

The net photosynthesis was maximum at flowering stage and declined at pod development stage. The genotypes produced higher seed yield also showed higher value for Pn and stomatal conductance Kalpana et al. (2003). The rate of photosynthesis was positively correlated with stomatal conductance, rate of transpiration, leaf temperature and grain yield Singh et al. (1997). The assimilates obtained through the photosynthesis are stored only for a certain period of time in the plant but very soon consumed in maintenance respiration and growth respiration to provide the energy for growth and development of structural components of plants Gardner et al. (1985).

Varieties significant at 100, 200, 300 and 400 ppm CO_2 both stomatal resistance and mesophyll resistance of diffusion of CO_2 were different among genotypes Gary and Shibles (1970). Crop yield was closely related to net photosynthesis assimilation throughout an entire season

Table 1. Chlorophyll index (g/m^2) at 60 DAS in pearl-millet genotypes

Genotypes	Chlorophyll index
G_1 Rajbajra Chari 1	32.82
G_2 Giant bajra	33.32
G_3 AVTPM 1	35.61
G_4 AVTPM 2	32.43
G_5 AVTPM 3	33.11
G_6 AVTPM 4	35.13
G_7 AVTPM 5	33.19
SEm±	0.654
CD at 5%	2.007

Table 2. Total dry weight (g/plant) of pearlmillet genotypes at successive growth intervals

Genotypes	30 DAS	45 DAS	60 DAS	75 DAS	Mean
G_1 Rajbajra Chari 1	3.73	46.80	35.59	44.32	32.61
G_2 Giant bajra	2.33	44.95	57.55	65.47	42.58
G_3 AVTPM 1	2.18	29.58	59.15	63.18	38.52
G_4 AVTPM 2	1.76	31.82	42.88	62.83	34.82
G_5 AVTPM 3	1.90	34.88	48.61	60.65	36.51
G_6 AVTPM 4	1.64	26.27	39.96	39.83	26.93
G_7 AVTPM 5	2.00	20.95	60.64	64.14	36.93
SEm±	1.20	7.87	4.50	5.86	
CD at 5%	0.39	-	13.85	18.00	

Table 3. Leaf area index (LAI) of pearl millet genotypes during successive growth intervals

Genotypes	45 DAS	60 DAS	75 DAS	Mean
G_1 Rajbajra Chari 1	2.75	4.03	3.78	3.52
G_2 Giant bajra	2.72	3.81	3.79	3.44
G_3 AVTPM 1	2.64	3.83	3.27	3.24
G_4 AVTPM 2	2.40	3.80	3.44	3.21
G_5 AVTPM 3	2.42	4.79	3.05	3.42
G_6 AVTPM 4	2.53	3.77	3.35	3.21
G_7 AVTPM 5	2.48	3.75	3.24	3.16
SEm±	0.076	0.467	0.148	0.2303
CD at 5%	0.235	1.435	0.455	0.708

* DAS - Days after sowing

communities, PAR interception and its utilization have a great influence on the productivity which is an interaction between plants and environment through the modification and interception of fluxes of radiation, heat, CO^2 etc. The PAR interception by the whole canopy was maximum in the morning and afternoon during fruit development stage of the crops (Mukherjee et al. 2003).

The PAR indicates the wavelength range of light (400-700 nm) which can excite the chlorophyll molecule which results in release of electrons involved in production of ATP and $NADPH_2$ required for reduction of CO_2 in the dark reaction of photosynthesis.

The present study revealed (Table 4) that AVTPM 2 exhibited the highest (1203.0 µmol/m^2/s) PAR uptake which was attributed to higher LAI of the genotype (Table 3), efficient canopy architecture and efficiency of absorbing tissues.

Table 4. Variation in physiological attributes of pearl millet genotypes

Genotypes	Net photo-synthesis (µmol/m^2/s)	PAR (µmol/m^2/s)	H_2O utilization (Kpa)	CO_2 utilization (ppm)	Radiation use efficiency (g/µmol/m^2/s)	Water use efficiency (µmol/mmol)
G_1 Rajbajra Chari 1	1.76	1139.33	5.11	25.17	0.0389	0.45
G_2 Giant bajra	1.64	1200.00	6.42	18.29	0.0545	0.48
G_3 AVTPM 1	1.62	1133.3	3.52	29.93	0.0557	0.33
G_4 AVTPM 2	1.75	1203.00	5.95	21.63	0.0522	0.28
G_5 AVTPM 3	1.89	1200.00	4.59	25.51	0.0505	0.31
G_6 AVTPM 4	1.92	1200.00	6.04	21.82	0.0331	0.33
G_7 AVTPM 5	1.89	1198.66	6.29	18.62	0.0535	0.40
SEm±	0.0656	30.567	0.653	2.370	0.0203	0.04
CD at 5%	0.2014	93.806	2.006	7.273	-	0.13

but instaneous measurement of photosynthesis may be misleading increasing the rate of photosynthesis and translocation and enlarging the storage capacity by selection and breeding may bring large which increases in yield Isreal (1982).

The investigations revealed (Table 4) that AVTPM 4 (1.92 µmol/m^2/s) possessed the highest net photosynthesis over the other genotypes. The genotype AVTPM 4 can be utilized in a breeding programme for evolving the varieties of higher photosynthetic efficiencies.

Photosynthetically active radiation (µmol/m^2/s)

Agricultural systems are basically photosynthetic systems and must be assessed for their efficiency in conversion of solar irradiance in terms of both primary productivity, useful and products. The morphological features as characterized by geometrical structure of plant

CO_2 utilization (ppm)

The relationship between the daily net and gross canopy CO_2 exchange rate and daily absorption of PAR were linear. Higher daily net and gross CO_2 exchange rates and photomass value in the narrow spaced canopies were attributed to a greater quantity of daily absorbed PAR through the season rates than difference in the efficiency of the various canopy structure (Wall et al. 2000).

The earlier studies indicated that the daily average net photosynthesis increased by 20.8 and 29.7% at the early stage under CO_2 levels of 550 and 750 µmol/m^2/s compared with the ambient air CO_2 concentration Lin et al. (2005).

In the present investigations (Table 4) genotype AVTPM 1 (29.93 ppm) was found to be associated with maximum CO_2 use a positive character for breeding purpose. Giant bajra (18.29 ppm) possessed the minimum CO_2 utilization. The genotypes produced higher seed yield showed higher values for CO_2 utilization Kalpana et al. (2003).

H_2O Utilization (KPa)

H_2O utilization is associated with enzymatic reactions required for every physiological mechanism. Low H_2O use may results in retardation of electron transport process needed for production of ATP and $NADPH_2$ which are required for CO_2 reduction in dark reaction of photosynthesis.

The water has been found to be an important constituent of plant system influencing the kinetics of biochemical reactions through enzyme activation. The electrons which are required for CO_2 reduction in photosynthesis are also obtained from water. In the present study (Table 4) genotype Giant bajra (6.42 KPa) exhibited the highest water utilization resulted in maximum dry matter yield. On the other hand minimum was registered in AVTPM 1 (3.52).

Radiation use efficiency (g/µmol/m^2/s)

Radiation use efficiency in crops is determined as dry matter produced per unit of intercepted radiation, can be efficiently used in the analysis of crop growth and calculation of crop simulation models. Radiation sue efficiency is often modulated on the basis of current specific leaf nitrogen (SLN g N/m^2 of leaf area) averaged for the canopy Sinclair and Muchow (1999) observed in exploring the significance of N gradients on the relationship between radiation use efficiency and average canopy SLN the specification which scales from photosynthesis at radiation use efficiency which is approximately constant for forest and natural ecosystem, and particularly for crops when growth is not limited by water or nutrient shortage efficiency of metabolic and other processes that determine radiation use efficiency Ruimy et al. (1995).

Table 5. Yield and its components of pearl millet genotypes

Genotypes	Plant height (cm)	Number of tillers/plant	Number of cobs/ plant	Number of grains/ cob	Cob length (cm)	Grain yield (g/plant)	(q/ha)
G_1 Rajbajra Chari 1	224.33	2.00	4.00	984.00	22.71	48.33	31.08
G_2 Giant bajra	222.66	2.33	6.27	997.00	26.15	58.00	32.50
G_3 AVTPM 1	224.0	1.33	3.67	983.00	24.60	50.66	32.40
G_4 AVTPM 2	222.66	2.66	4.85	984.33	26.27	62.00	32.58
G_5 AVTPM 3	222.66	3.00	4.89	988.33	25.16	58.66	32.55
G_6 AVTPM 4	220.3	2.68	5.98	989.66	26.36	93.33	33.10
G_7 AVTPM 5	221.66	2.66	4.00	989.66	26.50	70.33	32.90
SEm±	0.716	0.460	0.493	2.350	0.595	5.452	0.358
CD at 5%	2.19	0.998	1.514	7.214	1.828	16.733	1.101

Table 6. Biochemical constituents in different pearl-millet genotypes

Genotypes	Protein (%)	Fat (%)	Fibre (%)	Carbohydrate (%)	Ash (%)
G1 Rajbajra Chari 1	7.75	3.67	1.70	68.98	4.65
G2 Giant bajra	8.22	3.48	1.35	69.14	4.64
G3 AVTPM 1	9.72	3.15	1.57	69.00	4.62
G4 AVTPM 2	9.60	3.31	1.24	70.02	4.59
G5 AVTPM 3	9.47	4.13	1.80	70.77	4.62
G6 AVTPM 4	9.17	3.00	1.07	70.07	3.48
G7 AVTPM 5	8.68	3.54	1.60	70.67	4.62
SEm±	0.3106	0.2281	0.1428	0.3089	0.038
CD at 5%	0.9533	0.7001	0.4384	0.9482	0.118

The present study revealed (Table 4) that the genotype AVTPM 1 (0.0557) exhibited the highest radiation use efficiency which was attributed to the higher dry matter production by the genotype (Table 2) relative to the magnitude of PAR uptake. This genotype can be used for evolving the pearl millet genotypes having higher radiation use efficiency. AVTPM 4 (0.0331) registered the minimum.

Water use efficiency (mol/mmol)

Identification of genotypes that have a greater ability to use limited water and tolerate higher temperature is important to enhance productivity of the crop. Water use efficiency is an important trait which can contribute to productivity when water resources are scare Babitha et al. (2006). It has been proved to be an important trait particularly in adverse environmental conditions. Screening of genotypes for higher water use efficiency is a need of the day. In the present experiment (Table 4) Giant bajra (0.48) was found to be associated with higher water use efficiency revealing its drought resistant characteristics and suitability for drought sensitive areas. On the other hand AVTPM 2 (0.28) recorded the minimum.

Grain yield

Grain yield in cereals depends on number of cobs/plant, number of grains/cob. It has been observed that if an attempt is made to increase one component, there is compensatory decrease in other component and yield remains more or less same suggesting that there is some mechanism operating in plant system which is acting as constraints in controlling the productivity.

The present investigation revealed (Table 5) that genotype AVTPM 4 outyielded (93.33 g/plant and 33.10 q/ha) other genotypes for grain owing to its higher number of tillers/plant (2.68), number of cobs/plant (5.98), number of grains/cob (989.66) and cob length (26.36cm). AVTPM 5 (70.33 g/plant and 32.90 q/ha) stood second in yield performance which may be attributed to its highest cob length (26.50 cm) and a quite higher number of grains/cob (989.66). Rajbajra chari 1 possessed the minimum (48.33 g/plant and 31.08 q/ha) grain yield owing to an average performance of yield components. A highest number of tillers/plant (3.00) in AVTPM 3, number of cobs/plant (6.27) and number of grains/ear (997.0) in Giant bajra did not contribute in higher grain productivity which may be attributed to their less 1000 grain weight.

The quantification of seed quality characteristics indicated variable response. Maximum protein content (Table 6) was registered in genotype AVTPM 1 (9.72%), fat (4.13%), fibre (1.80%) and carbohydrate in AVTPM 3 (70.77) and ash in Rajbajra chari (4.65%).

Conclusions

Thus the investigations revealed that Genotype AVTPM 4 possessed higher net photosynthesis (1.92 μmol/m²/s), a comparatively higher chlorophyll index (35.13 g/m²) resulted in a quite higher magnitudes of tiller number (2.68), cob number/plant (5.98), grain number/cob (989.66) and cob length (26.36 cm), which in turn had reflected in highest grain yield (93.33 g/plant and 33.10 q/ha). AVTPM 5 was ranked second in yield performance (70.33 g/plant and 32.90 q/ha). Genotypes AVTPM 1 for higher chlorophyll index (35.61g/m^2), protein (%) (9.72), CO_2 utilization (29.93 ppm) and radiation use efficiency (0.0557 g/μmol/m^2/s), AVTPM 3 - fat (%) (4.13), carbohydrate (%) (70.77) and fibre (%) (1.80), AVTPM 2 - PAR absorption (1203 μmol/m^2/s), Giant bajra - H_2O utilization (6.42 KPa) and water use efficiency (0.48 μmol/mmol) may be utilized in a breeding programme for varietal improvement.

प्रस्तुत अन्वेषण जवाहरलाल नेहरू कृषि विश्वविद्यालय के पादप प्रजनन एवं जननकी विभाग के अखिल भारतीय चारा अनुसंधान प्रक्षेत्र में खरीफ 2010-2011 में किये गये। जीनोटाइप एव्हीटीपीएम 1 ने अधिकतम पैदावार (93.33 ग्रा./पौध एवं 33.10 क्विंटल/हे.) प्रदर्शित की जिसका कारण अधिक शुद्ध प्रकाश संश्लेषण (1.92 माइक्रोमोल/मी.2/से.), क्लोरोफिल सूचक (35.13 ग्रा./मी.^{2}) था जिसके कारण कल्लों की (2.68) एवं भुट्टों की संख्या/पौध (5.98) प्रति भुट्टा दाने की संख्या (989.66) एवं भुट्टों की लम्बाई (26.36) में वृद्धि हुई जो अधिक पैदावार में परिवर्तित हुई। एव्हीटीपीएम 5 का क्रम दाना पैदावार में दूसरा (70.33 ग्रा./पौध एवं 302.90 क्विंटल/हे.) था। जीनोटाइप एव्हीटीपीएम 1 को अधिकतम क्लोरोफिल सूचक (35.61 ग्रा./मी.^{2}), प्रोटीन (9.72%), कार्बन दिओसिद उपयोगिता (29.93 पी.पी.एम.) एवं विकरण उपयोग क्षमता (0.0557 ग्रा./माइक्रोमोल/मी.^{2}/से.), एव्हीटीपीएम 3 को वसा (4.13%), कार्बोहाइड्रेट (70.77%) एवं रेशे (1.80%), एव्हीटीपीएम 2 को प्रकाशसंश्लेषणीय सक्रिय विकरण अवशोषण (1203 माइक्रोमोल/मी.^{2}/से.), जाइन्ट बाजरा को जल उपयोग (6.42 कि.पास्कल) एवं जल उपयोग क्षमता (0.48 माइक्रोमोल/मि.मोल) के लिये फसल नस्ल सुधार में इस्तेमाल किया जा सकता है।

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Genetic divergence in rabi sorghum [*Sorghum bicolor* (L) Moench] landraces

A.M. Langhi, S.B. Chaudhary, L.L. Mane, A.R. Gaikwad and **U.C. Dhage**
Agricultural Research Station Savalvihir
Mahatma Phule Krushi Vidyapeeth
Rahuri 413722 (India)

Abstract

Genetic diversity among 196 *rabi* Sorghum (*Sorghum Bicolor*) genotypes and landraces of Maharashtra State was studied with checks for quantitative characters to study genetic diversity employing D^2 analysis with respect to grain yield and 13 cluster and 3 ungrouped genotype, namely RSLG-568, RSLG-589, RSLG-679 belongs to three ungrouped cluster XIV to XVI. The D^2 statistic showed that there was adequate diversity among the genotypes with D^2 values ranging from 7.73 to 723.97 . Clustering pattern of these genotypes did not necessarily follow the geographical distribution. On the basis of path analysis, inter cluster distances, cluster means, and *per se* performance observed in the present study, genotypes RSLG-573, RSLG-575, RSLG-679, RSLG-579, RSLG-574, RSLG-581, RSLG-628, RSLG-568, RSLG-679, RSLG-587, RSLG-740, RSLG-589, RSLG-734 and RSLG-654 were found to be overall superior genotypes for hybridization programme.

Keywords : Genetic diversity, Sorghum, Cluster

So for breaking this barrier and increasing the food grain production, we have to look at the dry land agriculture for the second green revolution. Sorghum cultivation has been the heart of dry land agriculture from years together. Being a C^4 plant, it can utilize sunlight and water very efficiently.

These and other specialized physiological features, make it a drought resistant species. It is also called as "Camel of plant world". Genetic divergence which is due to genetic factors is the basis for heritable improvement. The plant breeder have always, therefore been fascinated great amount of diversity in crop plants. The precise information about the genetic divergence therefore, is crucial for productive breeding programme.The genetically diverse parents are known to produce high heterotic effects and consequently give desirable recombinants in the breeding material or wide spectrum of transgress segregates in segregating generation. Multivariate analysis (D^2 statistic) is measure that asses the genetic variability quantitatively among a set of genotypes (Rao 1952). Thus, present investigation , attempt has been made to study the nature of diversity among the 196 genotypes of *rabi* sorghum and their suitability for hybridization programme obtained from different parts of Maharashtra.

Material and Method

An experiment material for the present investigation consist of 196 different germplasm of *rabi* sorghum available with Senior Sorghum Breeder, Sorghum Improvement Project, MPKV, Rahuri which are collected from the different places of of major Sorghum trade of Maharashtra state along with three checks i.e. Phule Chitra, Vasudha and M-35-1 in 14 × 14 double lattice design during *rabi* 2008-09 with two replications at Sorghum Improvement Project, MPKV, Rahuri. All the agronomic practices were followed to raise the crop. Observations were recorded 14 different characters those are yield and yield contributing traits from each plots ten randomly plants were tagged for taking observation. The analysis was done followed by D^2 statistic proposed by Mahalnobis (1928, 1936) clustering of genotypes was done by Tauscher's method as described by Rao (1952).

Results and Discussion

In this present study V (Stat) calculated for D^2 analysis and tested by via significant differences between the means in respect of the pooled effect of 14 the characters among 196 genotypes under study. The range of D^2 value was from 7.73 (between genotypes RSLG-709 and RSLG-725 and 723.97 (between genotypes RSLG-655 and RSLG-726) presenting in Table-

1. Narkhede et al. (2000b) reported that D^2 range as from 35.69 to 15270.60. Kadam et al. (2001) found D^2 range from 0.856 to 70.13. Patankar et al. (2005) found D^2 range from 35.37 to 7956.40.

In present investigation, one hundred ninety six genotypes were grouped into sixteen clusters (Table No 1.) The cluster I was the highest number of genotypes i.e. 56 followed and maximum intracluster distance (100.82) indicating diversity within the group but not to the extent so that they can from separate cluster as this existed genetic similarities among themselves on the basis of multiple characters causing them to belong into a single cluster and cluster II (36), III (34) IV (21), V (10), VI (9), VII (7), VIII (6), IX (4), X (3), XI (3), XII (2) and XIII (2) and remaining clusters were solitary. The maximum distance (204.10) was observed between cluster 14 & 16 (Table- 3) with contrasting mean performance for stem diameter , leaf length, plant height, time of panicle emergence, panicle length, 100 grain weight and grain yield compared to the mean performance of genotypes (Table-2). Among the genotypes that could be grouped is to 13 different cluster the maximum inter-cluster distance (331.50) was observed between cluster 6 and 13 which exhibiting contrasting mean performance for the character plant height , time of panicle emergence ,panicle length, 1000 grain weight and grain yield/plant. The next higher inter cluster distance (323.20) was observed between cluster 3 & 13 were as the smallest inter cluster distance (84.38) was observed between 4 & 8 they exhibited the difference in performance with plant height , time of panicle emergence ,panicle length, 1000 grain weight and grain yield/plant. Sarawate (1985) grouped twenty two genotypes in fourteen cluster while Barhate (1996) grouped fifty genotypes into thirteen and sixteen clusters under light and medium soil conditions respectively. Hendre (1998) grouped seventy-five genotypes into nine clusters. Narkhede (2000a) grouped sixty-four genotypes into nineteen clusters. Patankar et al. (2005) grouped forty-one genotypes in to ten clusters.

The characters which contributed maximum towards the total diversity in the present study were panicle length (18.55), time of panicle emergence (3.58), length of branches of panicle (25.11), plant height (3.86), 1000 seed weight (10.47) and grain yield per plant (33.22) were the measures contributing towards the genetic divergence in one hundred ninety six genotypes of sorghum.

Source	Times Ranked 1st	Contribution (%)
Days to maturity	15	0.08%
Stem diameters	211	1.10%
No. of leaves/plant	278	1.45%
Leaf length (cm)	48	0.25%
Leaf width (cm)	128	0.67%
Plant height	738	3.86%
No. of internodes/plant	102	0.53%
Time of panicle emergence	685	3.58%
Panicle length (cm)	3544	18.55%
Panicle width (cm)	71	0.37%
1000 seed weight (g)	2000	10.47%
Length of branches of panicle	4799	25.11%
Incidence of shoot fly	143	0.75%
Grain yield/plan (g)	6348	33.22%

Similar results were reported by Sisodia et al. (1983) for days to maturity and plant height; Sarawate (1985) for plant height and seed weight, Barhate (1996) for 1000 seed weight, plant height and flag leaf area; Hendre (1998) for plant height, 1000 seed weight and grain yield; Narkhede et al. (2000a) for 1000 grain weight, plant height and panicle length; Umaknath et al. (2002) and Patankar et al. (2005) for plant height and grain yield.

Characters	Source (clusters)	No. of genotypes	Name of genotypes
Days to maturity	XII, VVI, VIII	4	RSLG-573, 575, 679, 579
Time of panicle emergence	XII, XVII, IV	5	RSLG-573, 575, 574, 581, 628
No. of internodes per plant	XIII, XIV, XVI	4	RSLG-574. 581, 568, 679
Panicle length	XI, XV, VIII	4	RSLG-587, 740, 589, 734
No. of leaves /plant	XV, XI, XII	5	RSLG-589, 587, 740, 573, 575
Length of branches of panicle	XV, XVI, XI	4	RSLG-589, 679, 587, 740
Leaf width	XIV, XIII, VI	4	RSLG-568, 574, 581, 654

Table 1. Composition of 196 Sorghum genotypes into 16 different Clusters as per Mahalnobis D^2 Statistics (1936)

Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7	Cluster 8	Cluster 9	Cluster 10	Cluster 11	Cluster 12	Cluster 13	Cluster 14	Cluster 15	Cluster 16
RSLG-555	RSLG-583	RSLG-561	RSLG-564	RSLG-556	RSLG-552	RSLG-572	RSLG-601	RSLG-557	RSLG-558	RSLG-587	RSLG-573	RSLG-574	RSLG-568	RSLG-589	RSLG-679
RSLG-559	RSLG-590	RSLG-567	RSLG-582	RSLG-570	RSLG-554	RSLG-579	RSLG-684	RSLG-604	RSLG-594	RSLG-740	RSLG-575	RSLG-581			
RSLG-562	RSLG-592	RSLG-593	RSLG-614	RSLG-571	RSLG-585	RSLG-653	RSLG-686	RSLG-656	RSLG-687	RSLG-749					
RSLG-565	RSLG-595	RSLG-597	RSLG-619	RSLG-577	RSLG-638	RSLG-655	RSLG-731	RSLG-757							
RSLG-566	RSLG-611	RSLG-603	RSLG-624	RSLG-578	RSLG-650	RSLG-678	RSLG-732								
RSLG-576	RSLG-612	RSLG-606	RSLG-628	RSLG-580	RSLG-651	RSLG-715	RSLG-734								
RSLG-584	RSLG-613	RSLG-607	RSLG-633	RSLG-630	RSLG-654	RSLG-758									
RSLG-586	RSLG-615	RSLG-608	RSLG-652	RSLG-657	RSLG-759										
RSLG-602	RSLG-618	RSLG-609	RSLG-662	RSLG-755	RSLG-767										
RSLG-605	RSLG-620	Check-1	RSLG-669	RSLG-756											
RSLG-616	RSLG-623	RSLG-622	RSLG-682												
RSLG-617	RSLG-625	RSLG-632	RSLG-689												
RSLG-621	RSLG-626	RSLG-634	RSLG-693												
RSLG-631	RSLG-627	RSLG-636	RSLG-696												
RSLG-635	RSLG-645	RSLG-639	RSLG-702												
RSLG-637	RSLG-646	RSLG-641	RSLG-707												
RSLG-642	RSLG-648	RSLG-644	RSLG-708												
RSLG-643	RSLG-661	RSLG-658	RSLG-717												
RSLG-647	RSLG-663	RSLG-668	RSLG-725												
RSLG-649	RSLG-671	RSLG-672	RSLG-728												
RSLG-664	RSLG-674	RSLG-673	RSLG-744												
Check-2	RSLG-675	RSLG-677													
RSLG-666	RSLG-676	RSLG-688													
RSLG-670	RSLG-690	RSLG-691													
RSLG-680	RSLG-700	RSLG-692													
RSLG-681	RSLG-706	RSLG-695													
RSLG-683	RSLG-711	RSLG-719													
RSLG-685	RSLG-723	RSLG-722													
RSLG-694	RSLG-724	RSLG-727													
RSLG-697	RSLG-729	RSLG-735													
RSLG-698	RSLG-730	RSLG-736													
RSLG-699	RSLG-738	RSLG-737													
RSLG-701	RSLG-739	RSLG-743													
RSLG-703	RSLG-741	RSLG-754													
RSLG-704	RSLG-746														
RSLG-705	RSLG-763														
RSLG-709															
RSLG-710															
RSLG-712															
RSLG-713															
RSLG-714															
Chack-3															
RSLG-716															
RSLG-718															
RSLG-721															
RSLG-747															
RSLG-748															
RSLG-750															
RSLG-751															
RSLG-752															
RSLG-753															
RSLG-760															
RSLG-762															
RSLG-764															
RSLG-765															
RSLG-766															
Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7	Cluster 8	Cluster 9	Cluster 10	Cluster 11	Cluster 12	Cluster 13	Cluster 14	Cluster 15	Cluster 16
56	36	34	21	10	9	7	6	4	3	3	2	2	1	1	1

Table 2. Cluster mean performance

Characters	Incidence of shoot fly	Stem diameter	No. of leaves/ plant	Leaf length (cm)	Leaf width (cm)	Plant height (cm)	No. of internodes/ plant	Time of panicle emergence	Panicle length (cm)	Panicle width (cm)	Days to maturity	1000 seed weight (g)	Length of branches of panicle	Grain yield/ plant
CL-1	48.22	1.71	9.64	63.76	6.67	170.73	8.63	79.71	17.26	8.49	128.25	35.59	5.80	62.36
CL-2	47.06	1.71	9.75	64.97	7.08	193.78	8.53	79.19	16.42	8.57	126.61	35.65	5.87	56.21
CL-3	48.06	1.75	9.44	66.60	7.02	184.65	8.97	79.85	16.54	8.00	128.21	36.48	5.81	81.00
CL-4	42.51	1.75	9.86	64.03	7.05	174.71	8.90	74.76	17.60	8.65	129.14	34.01	5.88	37.25
CL-5	43.51	1.68	9.80	65.32	7.21	138.20	8.00	77.00	13.56	7.78	129.20	35.88	5.97	70.74
CL-6	39.79	1.85	9.00	66.56	8.18	163.44	8.78	83.56	15.61	8.71	129.44	35.11	5.59	84.96
CL-7	47.34	1.64	7.86	61.27	7.27	154.86	8.43	85.29	16.16	8.57	123.29	38.61	5.18	37.57
CL-8	58.43	1.65	8.83	65.00	6.63	205.50	8.50	76.00	17.63	8.47	129.00	33.66	6.19	37.17
CL-9	65.20	1.69	9.00	63.20	7.08	148.50	7.50	84.50	16.08	8.35	131.00	33.37	5.39	72.85
CL-10	36.61	1.69	9.33	65.80	7.50	197.33	8.00	85.00	15.30	8.53	126.00	39.01	5.36	31.27
CL-11	74.97	1.57	11.00	62.27	7.53	184.67	6.33	78.67	19.83	8.33	124.00	32.59	6.36	43.20
CL-12	52.21	1.68	10.00	76.55	7.05	129.00	8.00	71.00	10.00	8.90	123.00	40.29	5.66	51.60
CL-13	34.83	1.17	8.50	70.45	8.60	148.00	9.00	71.00	12.90	7.70	127.50	51.58	5.94	54.50
CL-14	58.90	2.06	8.00	83.40	9.40	155.00	9.00	86.00	11.70	8.20	138.00	50.20	5.40	88.80
CL-15	82.93	1.52	12.00	72.40	7.10	224.00	8.00	80.00	17.90	9.80	126.00	45.21	6.80	75.20
CL-16	50.44	1.78	9.00	56.20	7.20	272.00	9.00	79.00	17.10	10.00	123.00	35.36	6.40	83.40
Grand mean	51.93	1.68	9.44	66.74	7.41	177.77	8.35	79.41	15.72	8.57	127.60	38.29	5.85	60.50

Table 3. Intra and Inter cluster D^2 values

	CL-1	CL-2	CL-3	CL-4	CL-5	CL-6	CL-7	CL-8	CL-9	CL-10	CL-11	CL-12	CL-13	CL-14	CL-15	CL-16
CL-1	100.8242	114.6791	129.9399	135.0321	132.9917	137.4405	181.4321	138.833	122.0502	165.3545	119.4523	177.6591	263.485	170.4445	114.6227	221.7138
CL-2		116.2117	153.9415	124.6588	147.0507	170.7053	185.0292	117.2899	157.1837	143.5421	120.7019	198.7408	279.4157	216.3819	130.2194	209.67
CL-3			115.0668	222.8616	179.237	114.9087	284.1998	220.0503	135.7309	269.6226	185.0915	241.9494	323.2007	149.9597	92.71235	171.6971
CL-4				84.3556	148.2433	244.7865	141.3612	84.3896	201.404	97.1141	107.9568	176.0829	267.1593	296.3533	208.7705	314.8314
CL-5					152.8342	151.0212	224.0326	225.9445	131.5533	230.2447	195.715	123.566	241.062	142.861	176.005	352.01
CL-6						111.7125	292.2702	254.323	125.4078	290.0004	209.9167	235.13	331.5061	133.71	121.8189	203.8111
CL-7							150.3695	150.3598	212.1936	118.34	160.0957	179.5257	257.715	270.9043	277.6171	449.98
CL-8								81.346	210.6663	92.6838	101.2256	214.0833	294.1375	311.7067	189.7267	266.735
CL-9									119.1117	235.7825	151.5725	179.285	304.8113	135.9975	144.1375	289.0425
CL-10										81.32	142.7844	180.715	235.1283	295.7467	246.1667	367.5267
CL-11											85.23	216.7983	303.5717	263.5167	148.23	258.1667
CL-12												83.27	173.2325	165.91	249.16	501.145
CL-13													288.75	204.105	276.785	524.725
CL-14														0	117.78	325.01
CL-15															0	95.11
CL-16																0

Relative Contribution of different characters towards genetic divergence

Taking into account the path analysis, cluster means, cluster distances and *per se* performance, the various clusters which can provide the desired parents for hybridization for improvement in characters and high yielding genotypes are listed below.

The clustering pattern indicating wide diversity between different groups of genotypes. The grater the distance between two cluster, wider the expected genetic distance between the genotype. Therefore, identification of genetic diverse genotype would help in selecting desirable parents for hybridization programme.

In the present study hybridization between genotypes having higher inter D-distance and path analysis are expected to generate exploitable variability for the improvement in the yield and yield relating traits as well as are likely to through desirable transgress segregates in later generation of hybridization, path analysis, inter cluster distances, cluster means, and *per se* performance observed in the present study, genotypes RSLG-573, RSLG-575, RSLG-679, RSLG-579, RSLG-574, RSLG-581, RSLG-628, RSLG-568, RSLG-679, RSLG-587, RSLG-740, RSLG-589, RSLG-734 and RSLG-654 were found to be overall superior genotypes for hybridization programme. If they are utilized into multiple crossing programme would yield promising result in bringing together different desirable gene into the common genetic background.

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Correlation and Path analysis in rabi sorghum landraces

A.M. Langhi, S.B. Chaudhary, L.L. Mane, A.R. Gaikwad and **U.C. Dhage**
Mahatma Phule Krushi Vidyapeeth
Rahuri 413 722 (India)

Abstract

To understand the association of yield and yield contributing to each other 196 genotypes including three check varieties were evaluated in 14 X 14 double Lattice design. The data of 10 random plants of each genotype were recorded on 14 quantitative characters, including grain yield and its component characters. The phenotypic coefficient of variation was high for most of the characters especially, incidence of shoot fly (21.89), panicle width (21.79) length of branches of panicle (21.34) and grain yield per plant (27.59).Correlation co-efficient analysis reveled that, the days to maturity at genotypic level showed significant and positive correlation with grain yield . Path coefficient analysis days to maturity traits that showed highest positive direct effect towards the grain yield

Keywords: Correlation, Path analysis, Sorghum

Sorghum is an important food crop for dry land area. Grain yield of Sorghum is a complex character affected directly or indirectly by every gene present in plant . Genotypic and phenotypic correlation indicates the degree is which various morpho-physiological characters are associate with economic productivity. Expression of complex traits yield upon the interrelationship of the component traits . The selection programme for high

Yield requires not only the understanding a knowledge of the variability present in the germplasm / landraces of the crop, but also the association and contribution of various plant attributes which grain yield therefore in the present investigation we have short listed important traits which have among association with grain yield . Hence, an attempt was made to study 14 quantitative characters, their correlations and effects on 196 genotypes of *rabi* sorghum. Since beginning of agriculture, cultivated crops have been subjected to intensive natural and human selections and the trend continues. This has resulted in huge collection of different crop species, land races and varieties distributed throughout the world, which comprises valuable germplasm collection. Information regarding genetic variability present in a population and estimates of heritability are prerequisites for improvement of any crop.

Material and methods

An experiment material consist of 196 different germplasm of *rabi* sorghum available with Senior Sorghum Breeder, Sorghum Improvement Project, MPKV, Rahuri which are collected from the different places of major *rabi* Sorghum growing area of Maharashtra state and the material was evaluated in 14 × 14 double lattice design with three checks i.e. Phule Chitra, Vasudha and M-35-1 during *rabi* 2008-09 with two replications at Sorghum Improvement Project, MPKV, Rahuri. Recommended cultural practices were followed to raise good crop of Sorghum. Observations on qualitative difference 14 characters on ten randomly selected plants. The appropriate variances and co-variances were used for calculating phenotypic correlation coefficient (Johnson et al. 1955) and to establish the cause and effect relationship, the genotypic and phenotypic correlation coefficients were partitioned in to direct and indirect effects by path analysis as suggested by De Way and Lu (1959).

Results and Discussion

The analysis of variance for fourteen quantitative character present in Table-1. The mean squares due to all characters studied were highly significant Suggesting the presence of undesirable variability for different characters among Sorghum accession under investigation. The estimates of phenotypic co-efficient of correlation among the 14 character are presented in Table-2. The correlation co-efficient were calculated for all possible pairs of 14 characters giving rise to a total of all pairs of characters, only 66 combinations of characters, the correlation co-efficient were not significant suggesting that such characters are not associate and selection for one trait will not be effect this

Table 1. Analysis of variance for 14 quantitative characters of 196 Landraces with 3 check varieties

Characters	M.S.S. Treatments (unadjusted)	Error (r.c.b.)	Blocks in replication (adjusted)	Intrablock error
Grain yield /plant (g)	553.11678**	15.0906	13.38875	15.35243
Length of branches of panicle (cm)	2.94807**	0.1097	0.12201	0.1078
1000 seed weight (g)	66.42194	4.90268	10.78191	3.99818
Days to maturity	41.74997**	30.61481	39.39796	29.26356
Panicle width (cm)	5.01436**	1.78828	2.8911	1.61862
Panicle length (cm)	18.15523**	0.94031	2.74946	0.66198
Time of panicle emergence	88.61298**	19.0617	109.79925	5.1021
No. of internodes/plant	2.19931**	1.2779	5.71801	0.59481
Plant height (cm)	786.45897**	97.43715	189.05181	83.34259
Leaf width (cm)	1.70072**	0.51639	1.93717	0.29781
Leaf length (cm)	59.03989**	25.25013	16.90114	26.53459
No. of leaves/plant	4.62306**	1.06702	1.3075	1.03002
Stem diameter (cm)	0.11977**	0.02701	0.11048	0.01417
Incidence of shoot (dead hearts %)	168.68395**	50.11871	35.86062	52.31227

*Significant at 5 % level ** Significant at 1 % level

programme of other trait . Therefore, only correlation co-efficient among 25 pair combinations of character are imported to be interpreted. Out of this significant correlation co-efficient, only one combinations i.e. panicle length showed significant negative correlation co-efficient. This suggests that there was no corresponding increase in grain yield with increase in panicle length. All the character except stem diameter, plant height, No. internodes per plant, panicle length should significant positive correlation with grain yield. This suggests that increase in the intensity of their characters may being about increase in grain yield.

Days to maturity, which showed the maximum degree of correlation with grain yield and seems to be the important trait for improving the grain yield. This suggested that increase in these characters was responsible for increase in grain yield.

The estimates of direct and indirect effects of various characters on grain yield are presented in Table-3. The path Co-efficient analysis appeared to provide a clue to the contribution of various components of yield to over all grain yields in the genotypes under study. It provides an effective way of finding out direct and indirect sources of correlate. It was revealed in the present study that the genotypic correlation coefficients were higher in magnitude than the phenotypic correlation coefficients between most of the characters. This indicated the strong inherent association between the various characters studied and the genotypic expression of the correlation was comparatively less influenced by the environmental deviation.

Thus to summaries, the characters viz., days to maturity was positively and significantly correlated with grain yield per plant and the character viz., panicle length was negatively and significantly correlated with grain yield per plant. Considering the 196 genotypes studied the desirable plant type in sorghum should be with maximum days to maturity and minimum panicle length for high grain yield per plant as the most of genotypes having loose panicle.

The positive significant correlation was observed between grain yield per plant with the days to maturity and panicle width at genotypic level, Prabhakar (2001) reported similar results for days to 50 per cent flowering and days to maturity. The negative significant correlation was observed between grain yield per plant with the panicle length at both phenotypic and genotypic level. Rajkumar et al. (2007) reported similar result for panicle length.

In the present studies days to maturity had high positive direct effect on grain yield per plant at the same time this trait also had significant and positive correlation with grain yield per plant. This characters also had positive indirect effects on grain yield per plant via leaf width indicating importance of these character during selection programme.

Table 2. Estimates of Phenotypic and genotypic correlation coefficients among 14 quantitative characters in *rabi* sorghum

Characters		Days to Maturity	Stem diameter	No. of leaves/ plant	Leaf Length (cm)	Leaf width (cm)	Plant height (cm)	No. of internodes/ plant	Time of panicle emergence	Panicle length (cm)	Panicle length (cm)	1000 seed wt. (g)	Length of branchesf of panicle	Incidence of shoot fly	Grain yield/ plant
Days to maturity	P	1	-0.0388	-0.0636	-0.0607	-0.0763	-0.0701	-0.0474	-0.1132	0.1779*	-0.0173	0.0648	-0.0409	-0.0722	0.0788
	G	1	-0.116	0.0746	-0.2351**	-0.0728	-0.0851	-0.4209**	-0.1986**	0.2577**	-0.0936	0.1464*	-0.1101	-0.0913	0.1619*
Stem diameter	P		1	-0.1029	0.0099	-0.0876	0.010	0.0366	-0.0202	0.1049	0.0336	-0.0342	0.1139	-0.03	-0.0401
	G		1	-0.1135	-0.0005	-0.1578*	-0.0077	0.0912	-0.0158	0.1461*	0.0552	-0.0635	0.1414*	-0.0359	-0.0378
No of leaves/ plant	P			1	0.0069	0.0375	0.0388	-0.0147	-0.0891	0.0563	0.0233	0.0558	0.1701*	0.058	0.0634
	G			1	0.0604	0.0625	0.0415	-0.0609	-0.1668*	0.0591	0.0564	-0.0734	0.1993**	0.0528	0.0795
Leaf length (cm)	P				1	0.2382**	-0.0762	0.2064**	-0.0016	0.0272	0.0286	-0.0284	-0.1147	0.0285	0.0422
	G				1	0.3787**	-0.1321	0.4576**	0.016	0.032	0.0703	-0.0345	-0.1593*	0.0076	0.0613
Leaf width (cm)	P					1	0.0055	0.169*	0.0888	-0.1347	-0.0941	0.0781	-0.0547	0.0842	0.0637
	G					1	-0.0347	0.4137**	0.1641*	-0.1327	-0.1518*	0.0701	-0.0483	0.0851	0.0805
Plant height	P						1	0.0606	-0.1163	0.2189**	-0.025	-0.0957	0.0685	0.0385	-0.0496
	G						1	0.2449**	-0.115	0.2517**	-0.0459	-0.1235	0.0689	0.0398	-0.0496
No of internodes/ plant	P							1	-0.0297	-0.1284	-0.1011	0.0432	-0.0328	0.0035	-0.0227
	G							1	-0.3549**	-0.2208**	-0.2583**	0.0995	-0.062	-0.0013	-0.0342
Time of Panicle emergence	P								1	-0.086	0.1316	-0.0294	-0.0869	0.0148	0.1185
	G								1	-0.1007	0.162*	-0.0355	-0..1133	0.0148	0.1333
Panicle length (cm)	P									1	0.0471	-0.1075	0.12	-0.0399	-0.146*
	G									1	0.0754	-0.1107	0.1251	-0.6693	-0.1498*
Panicle width (cm)	P										1	-0.0186	-0.1469*	-0.0314	0.0146
	G										1	-0.0218	-0.1825**	-0.1611	0.0118
1000 seed wt. (g)	P											1	0.0606	-0.0555	0.0345
	G											1	0.0634	-0.0852	0.0332
Length of branches of panicle	P												1	0.0065	0.0049
	G												1	0.0149	0.0078
Incidence of shoot fly	P													1	0.0065
	G													1	0.0149
Grain yield / plant	P														1
	G														1

* Significant at 5 % level ** Significant at 1 % level

Table-2 Estimates of Phenotypic and genotypic correlation coefficients among 14 quantitative characters in *rabi* sorghum

Characters	Days to Maturity	Stem diameter	No. of leaves/ plant	Leaf Length (cm)	Leaf width (cm)	Plant height (cm)	No. of internodes/ plant	Time of panicle emergence	Panicle length (cm)	Panicle length (cm)	1000 seed wt. (g)	Length of branchesf of panicle	Incidence of shoot fly	Grain yield/ plant
Days to maturity	0.5331	-0.0011	-0.0127	-0.0234	0.0093	-0.0007	-0.1337	-0.0742	-0.081	-0.0097	-0.0097	-0.0185	-0.0159	0.1619*
Stem diameter	-0.0619	0.0098	-0.0193	-0.0001	0.0202	-0.0001	0.029	-0.0059	-0.0397	0.0057	0.0042	0.0237	-0.0035	-0.0378
No of leaves/ plant	-0.0398	-0.0011	0.1704	0.006	-0.008	0.0003	-0.0193	-0.0623	-0.0161	0.0058	0.0049	0.0335	0.0052	0.0795
Leaf length (cm)	-0.1253	0	0.0103	0.0993	-0.0486	-0.001	0.1454	0.006	-0.0087	0.0073	0.0023	-0.0267	0.0012	0.0613
Leaf width (cm)	-0.0388	-0.0016	0.0106	0.0376	-0.1283	-0.0003	0.1314	0.0613	0.0361	-0.0157	-0.0046	-0.0081	0.0008	0.0805
Plant height	-0.0454	-0.0001	0.0071	-0.0131	0.0044	0.0077	0.0778	-0.043	-0.0685	-0.0047	0.0082	0.0116	0.0084	-0.0496
No of internodes/ plant	-0.2244	0.0009	-0.0104	0.0455	-0.0531	0.0019	0.3177	-0.1325	0.0601	-0.0267	-0.0066	-0.0104	0.0039	-0.0342
Time of Panicle emergence	-0.1059	-0.0002	-0.0284	0.0016	0.0211	-0.0009	-0.1127	0.3735	0.0274	0.0168	0.0023	-0.019	-0.0001	0.1333
Panicle length (cm)	0.1587	0.0014	0.0101	0.0032	0.017	0.0019	-0.0701	-0.0376	-0.272	0.0078	0.0073	0.021	0.0015	-0.1498*
Panicle width (cm)	-0.0499	0.0005	0.0096	0.007	0.0195	-0.0004	-0.082	0.0605	-0.0205	0.1035	0.0014	-0.0306	-0.0068	0.0118
1000 seed wt. (g)	0.078	-0.0006	-0.0125	-0.0034	-0.009	-0.001	0.0316	-0.0132	0.0301	-0.0023	-0.0662	0.0106	-0.009	0.0332
Length of branches of panicle	-0.0587	0.0114	0.034	-0.0158	0.0062	0.0005	-0.0197	-0.0423	-0.034	-0.0189	-0.0042	0.1678	-0.0084	0.0078
Incidence of shoot fly	-0.0859	-0.0004	0.009	0.0012	-0.001	-0.0007	0.0126	-0.0005	-0.004	-0.0072	0.006	-0.0143	0.0985	0.0149
Grain yield / plant														

Residual effects R = 0.9076

* Significant at 5 % level

** Significant at 1 % level

Underline figure denote direct effect

Selection for this trait could be rewarding, similar results were found by Prabhakar (2000) for days to maturity and Veerbhadhiran and Kennedy (2001b) for 1000 seed weight and days to 50 % flowering panicle length had high negative direct effect while it was negative correlated with grain yield per plant which reveals that selection for these traits could not yield much breeding objectives.

In the present study the high residual effect suggested that the characters included in the study were not sufficient to explain the variability in the dependent variable.Based on findings of the present investigation, the most desirable ideotype of sorghum should posses more days to maturity and low panicle length selection on the basis of these criteria would improve the efficiency of selection programme.

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Association of yield attributing traits with grain yield of transplanted rice

Monika Soni and **K. K. Jain**
Department of Agronomy
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Jabalpur 482 004 (MP)

Abstract

The present investigation was made out during kharif, 2010 and 2011 with 18 treatments in split plot design with three replications on the same site without changing the layout plan. The treatment consisted with 6 weed control practices viz., bispyribac sodium @ 20 ml ha^{-1}, penoxsulam @ 20 ml ha^{-1}, pyrazosulfuron-ethyl @ 25 ml ha^{-1}, cyhalofop-butyl @ 75 ml ha^{-1} + almix @ 4 ml ha^{-1} and fenoxaprop-p ethyl @ 60 ml ha^{-1} + almix @ 4 ml ha^{-1} and weedy check as main plot treatment and three day time application (morning, afternoon and evening) as sub plot treatment. These herbicides were applied as post emergence i.e. 15 days after transplanting (DAT). The experimental soil was neutral in reaction (pH 7.12), medium in organic carbon (0.68 %), N (272 kg ha^{-1}), P (15.50 kg P_2O_5 ha^{-1}) and high in available K (295 kg K_2O ha^{-1}) content. The yield attributing traits viz., plant height, number of effective tillers, length of panicle and 1000 grain weight were recorded at harvest and leaf area index (LAI at 60-90 DAT) during both the years. The result revealed that amongst the yield attributing traits LAI recorded the highest and positive correlation (0.908 and 0.879) with the grain yield of rice during both the years. However the regression studies revealed that the increases in one unit of LAI there was 0.82 and 0.75 t ha^{-1} increase in grain yield of rice followed by 100 grain weight (0.36 and 0.33 t ha^{-1}).

Keywords: grain yield

Rice (*Oryza sativa* L.) is one of the most important staple crops occupying first position among cereal crops. Madhya Pradesh the rice occupies 1.45 mha area for cultivation and contributes 3.45% in the production of India. Transplanted rice production affected by various biotic and abiotic factors. Weeds are one of the biotic factors that limit the production of transplanted rice in severe infestation (singh et al. 2008). Among all the weed control practices chemical weed control in transplanted rice is of prime important for prompting the growth and development of crop and less dependence on labour, those availability on peak period of crop-weed competition increasing day by day which finally, results yield reduction in transplanted rice. There is reduction in grain yield of rice by 25.9% due to major weeds (Mishra et al. 2007). Several researches initiating for evaluate the post emergence herbicides which found more effective to reducing the weed density in addition to the numerous factors that affect herbicide performance viz., rate, temperature, weed height, adjuvant, relative humidity, day time (morning afternoon and evening) and dew. Research has shown that the relative importance of these factors vary among herbicides. Day time application is one of the important factors that affect the efficacy of post emergence herbicides (Bob Hartzler 2003). Crop growth parameters play an important and positive role in getting higher rice grain production (Jain and Sharma 2011). Hence, the present study was under taken.

Material and methods

A field experiment was conducted during kharif season, 2010 and 2011 with 18 treatments in split plot design with three replications on the same site without changing the layout plan. Jabalpur lies between 22^0 49' to 24^0 8' North latitude and 78^0 21' to 80^0 58' East longitude with 411.78 meters above the mean sea level. Jabalpur belongs to Kymore Plateau and Satpura Hills agro climatic zone as per classification by National Agricultural Research Project. Recently, this area has classified as agro-ecological sub region number 10.1 (Vindhyan scarplands and Baghelkhand and Narmada valley, hot dry sub-humid ecological sub region with medium deep clayey black soils. Jabalpur enjoys a typical subtropical climate with hot dry summers and cool dry winters. Temperature extremes vary between minimum temperatures of 2^0C in the month of December-January to maximum temperature of 45^0C in the month of May-June. The monsoon commenced in the third week of June and terminated in

Table 1. Correlation matrix between yield attributing traits and grain yield (t ha^{-1})

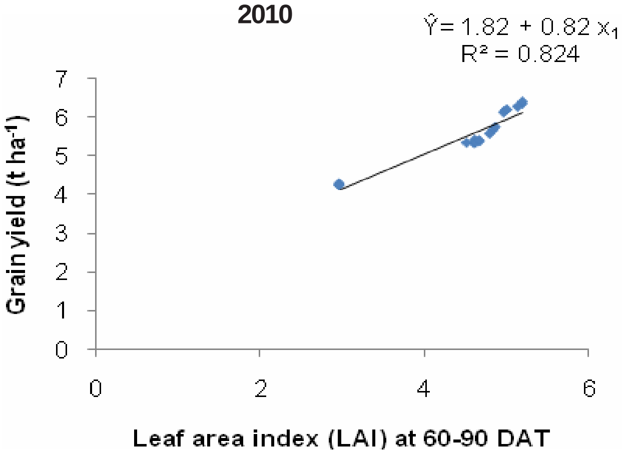
Character	Plant height (cm) X_2	Effective tillers X_3	Length of panicle (cm) X_4	1000 grain weight (g) X_5	Grain yield (t ha^{-1}) Y
2010					
X_1 - leaf area index (LAI)	0.596**	0.730**	0.490**	0.768**	0.908**
X_2 - Plant height (cm)	-	0.485**	0.351**	0.735**	0.721**
X_3 - Effective tillers	-	-	0.342*	0.611**	0.854**
X_4 - Length of panicle (cm)	-	-	-	0.397**	0.476**
X_5 - 1000 grain weight (g)	-	-	-	-	0.831**
2011					
X_1 - leaf area index (LAI)	0.542**	0.674**	0.422**	0.743**	0.879**
X_2 - Plant height (cm)	-	0.706**	0.332*	0.738**	0.655**
X_3 - Effective tillers	-	-	0.409**	0.809**	0.865**
X_4 - Length of panicle (cm)	-	-	-	0.384**	0.457**
X_5 - 1000 grain weight (g)	-	-	-	-	0.802**

** significant at 0.01 level
* significant at 0.05 level

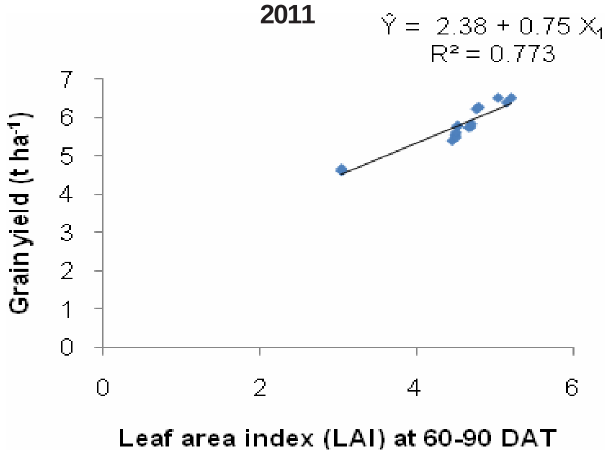
Table 2. Regression between yield attributing traits and grain yield (t ha^{-1})

Character	$\hat{Y} = a + bx$	t_{16} d. f.	R^2
2010			
X_1 - Leaf area index (LAI)	$\hat{Y} = 1.82 + 0.82\ X_1$	15.60	0.824
X_2 - Plant height (cm)	$\hat{Y} = -3.76 + 9.77 \times 10\text{-}2\ X_2$	7.50	0.520
X_3 - Effective tillers	$\hat{Y} = -0.29 + 1.99 \times 10\text{-}2\ X_3$	11.85	0.730
X_4 - Length of panicle (cm)	$\hat{Y} = 3.96 + 6.56 \times 10\text{-}2\ X_4$	3.90	0.227
X_5 - 1000 grain weight (g)	$\hat{Y} = -3.26 + 0.36\ X_5$	10.78	0.691
2011			
X_1 - Leaf area index (LAI)	$\hat{Y} = 2.38 + 0.75\ X_1$	13.31	0.773
X_2 - Plant height (cm)	$\hat{Y} = -1.67 + 7.65 \times 10\text{-}2\ X_2$	6.25	0.429
X_3 - Effective tillers	$\hat{Y} = 0.57 + 1.76 \times 10\text{-}2\ X_3$	12.44	0.748
X_4 - Length of panicle (cm)	$\hat{Y} = 4.38 + 5.48 \times 10\text{-}2\ X_4$	3.70	0.208
X_5 - 1000 grain weight (g)	$\hat{Y} = -2.40 + 0.33\ X_5$	9.68	0.643

2010



2011



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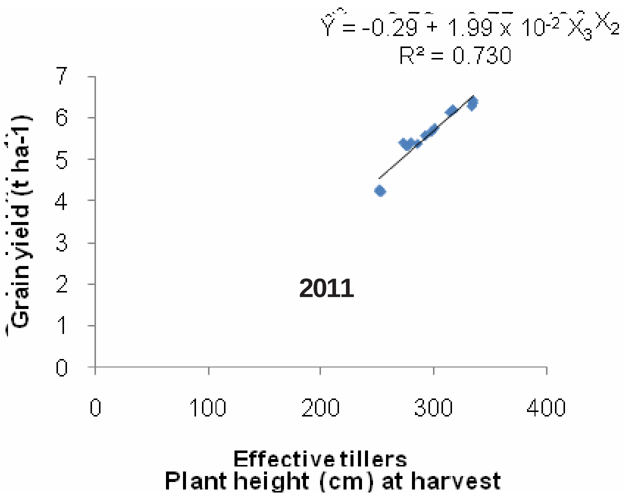

2011

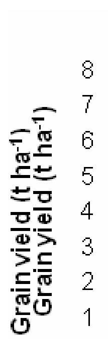

Fig. 1. Regression of yield attributing parameters on grain yield (t ha^{-1}) of rice

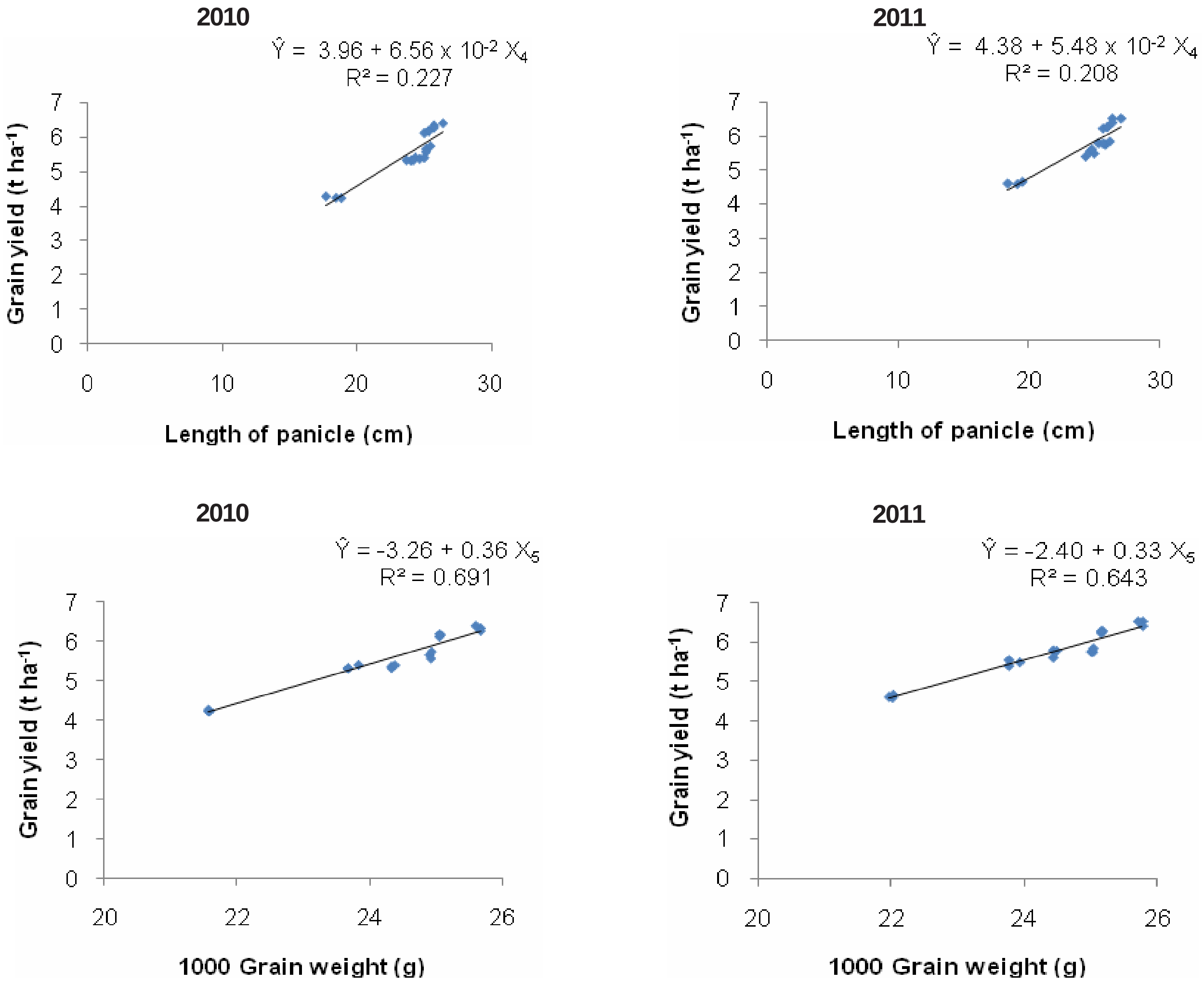

Fig. 2. Regression of yield attributing parameters on grain yield (t ha^{-1}) of rice

the last week of September. The total rainfall received during the crop season was 2578.60 and 1834.50 mm, which was equally distributed in 55 and 63 rainy days from June to third week of September in 2010 and 2011 years, respectively. Minimum and maximum mean temperature ranged from 16.50 to 33.5 °C and 35.40 to 11.40 °C in the 2010 and 2011 years, respectively. The relative humidity ranged from 31 to 94% in 2010 and 30 to 94% in 2011. It is evident that weather conditions were almost favorable for the growth and development of rice. The soil of the experimental field was neutral in reaction (pH 7.12), medium in organic carbon (0.68 %) and available N (272 kg ha^{-1}), and available P (15.50 kg P_2O_5 ha^{-1}) and high in available K (295 kg K_2O ha^{-1}) content. The treatments consisted with 6 weed control practices weedy check, bispyribac sodium @ 20 ml ha^{-1}, penoxsulam @ 20 ml ha^{-1}, pyrazosulfuron-ethyl @ 25 ml ha^{-1}, cyhalofop-butyl @ 75 ml ha^{-1} + almix @ 4 ml ha^{-1} and fenoxaprop-p ethyl @ 60 ml ha^{-1} + almix @ 4 ml ha^{-1} as main plot treatment (as post emergence) and three day time application (morning, afternoon and evening) as sub plot treatment. The field preparation was done by puddling the land once with the help of cultivator under well moist condition of the field. The 15 days old seedlings of rice cv.WGL 32100 were transplanted manually in 20 cm x 20 cm planting geometry by using 2-3 seedlings per hill. The yield attributing traits were recorded at harvest and the LAI was taken at 60-90 days after transplanting (DAT). After that the correlation and regression study was performed.

Crop-Weed Correlations

Correlation matrixes amongst yield attributing characters and grain yield, weed parameters and grain yield were computed. In order to predict the effects of different variables on yield, simple regression and regression models were used and coefficients were computed to interpret quantitative changes on yield in a crop-weed ecosystem.

The correlation coefficient (r) is calculated as suggested by Sendecor and Cochran (1967).

$$\text{Correlation coefficient (r)} = \frac{\Sigma xy - \frac{(\Sigma x).(\Sigma y)}{n}}{\sqrt{\Sigma y^2 . \frac{(\Sigma y)^2}{n} . \Sigma x^2 \frac{(\Sigma x)^2}{n}}}$$

Results and discussion

Correlation studies

The different yield attributing traits with grain yield had positive correlation during both the years (Table 1). The correlation of different yield attributing traits with grain yield indicated that the leaf area index had highest positive (0.908 and 0.879) correlation amongst different yield attributing traits followed by number of effective tillers (0.854 and 0.865), 1000 grain weight (0.831 and 0.802), plant height (0.721 and 655) and length of panicle (0.476 and 457) during both the years.

Regression studies

Amongst different yield attributing traits, the linear increase in yield was predicted with leaf area index, plant height, number of effective tillers, length of panicle and 1000 grain weight during both the years (Table 2). The increase in yield could be predicted by 0.82 and 0.75; 9.77 and 7.65 x 10^{-2}; 1.99 and 1.76 x 10^{-2}; 6.56 and 5.48 x 10^{-2}; 0.36 and 0.33 during both the years.

The results revealed that the different yield attributing traits, leaf area index was the most important yield attributing traits for resultant of higher grain yield of transplanted rice followed by 1000 grain weight during both the years.

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Production efficiency and economics of different cropping systems as influenced by tillage, mulch and fertility levels in Kymore plateau and Satpura hills zone of Madhya Pradesh

Ashish Tiwari, V.B. Upadhyay, K.K. Agrawal and **S.K. Vishwakarma**
Department of Agronomy
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Jabalpur 482 004 (MP)

Abstract

Field investigations were made at Research Farm, Adhatral, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh during 2010-11 and 2011-12 on sandy clay loam soils. Production efficiency of 52.36 kg/ha/day monetary returns of Rs 88233/ha with a B:C ratio of 2.72 were recorded maximum when rice-wheat cropping system received the minimum tillage, without mulching and recommended dose of fertilizers to both crop component followed by same cropping system with minimum tillage, mulching and recommended dose of fertility 25% N with organic manures. The former treatment was recorded the maximum (133.52 q/ha/year) rice equivalent yield than the other treatment combinations. Higher net monetary returns (88233.05) and B:C (2.72) ratio was observed with former treatments.

Keywords: Production efficiency economics, cropping systems

Lesser agricultural productivity, rural employment and economic status has been reported from Madhya Pradesh, compared to other states of the country. Farmers of the states follows the mono cropping system. Though the area under cultivation is greater. During Kharif, growing of rice has been a traditional practices and is widely accepted. Rice-wheat and rice-chickpea is 1st and 2nd pre-dominant cropping systems of the region. In Madhya Pradesh with lowest productivity varying with the variation of rainfall in different years, low productivity in upland rice is a result of crop depending on rains mostly results to moisture stress, absence of surface water accumulation, direct seeding, heavy infestation of weeds, insect pests and diseases. The occurrence of drought during crop growth period may vary and occurs at any crop growth stage. However, early drought, mid season and terminal drought after flowering are most common in rainfed upland rice crop.

Material and methods

On station experiment was conducted at Research Farm of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh during kharif 2010-11 and 2011-12 on sandy clay loam soil (pH 7.5, EC 0.48 dS/m and 0.68% OC). Two tillage operations (T_1 minimum and T_2 conventional) and four cropping systems (CS_1 - rice-wheat, CS_2 - rice-berseem; CS_3 - maize-wheat and CS_4 - sorghum-wheat) were kept as main-plot treatments and two mulches (Mo - No mulch and M_1 with mulch) and two fertility levels (F_1 - RDF and (F_2 - RDF + 25% N through organic manures) were kept as sub-plot treatment. The total 32 treatments combinations were evaluated in a split-plot design under three replications under two fertility levels. The recommended dose of fertilizer for rice and wheat were 120:60:40 kg N, P_2O_5 and K_2O/ha maize and sorghum 100:60:40 kg N, P_2O_5 and K_2O/ha and under F_2 - fertility levels recommended dose of fertilizer + 25% N, 6t FYM to rice and wheat, 5t FYM to maize and sorghum and 1t FYM to berseem were applied prior to final seed bed preparation. The crop variety Kranti, HQPM1, JS2020, GW273 and JB3 were used for rice, maize, sorghum, wheat and berseem, respectively. Rice, maize, sorghum and wheat were sown in line in a plot size of 5.0 x 4.20 m and broad cast method was adopted for sowing of berseem.

Table 1. Production efficiency, rice equivalent yield and economics of different cropping system influenced by tillage, mulch and fertility levels

Treatments		Cost of cultivation	Rice equivalent yield (q/ha/year)	Production efficiency (kg/ha/day)	Gross monetary returns (Rs/ha/year)	Net monetary returns (Rs/ha/year)	B:C ratio
T_1	$T_1CS_1M_0F_1$	51230	133.52	52.36	139463.05	88233.05	2.72
T_2	$T_1CS_1M_0F_2$	57830	115.06	45.12	143829	85999.00	2.48
T_3	$T_1CS_1M_1F_1$	53230	113.02	44.32	141287.6	88057.60	2.65
T_4	$T_1CS_1M_1F_2$	59830	115.82	45.41	144789.3	84959.30	2.42
T_5	$T_1CS_2M_0F_1$	57925	99.69	32.68	124622	66697.00	2.15
T_6	$T_1CS_2M_0F_2$	61775	104.06	34.11	130085.2	68310.20	2.10
T_7	$T_1CS_2M_1F_1$	59925	101.75	33.36	127196.5	67271.50	2.12
T_8	$T_1CS_2M_1F_2$	63775	105.20	34.49	131517.5	67742.50	2.06
T_9	$T_2CS_1M_0F_1$	54630	113.38	44.46	141738.4	87108.40	2.59
T_{10}	$T_2CS_1M_0F_2$	61230	117.12	45.92	146411.9	85181.90	2.39
T_{11}	$T_2CS_1M_1F_1$	56630	114.23	44.79	142801.1	86171.10	2.51
T_{12}	$T_2CS_1M_1F_2$	63230	118.65	46.52	148323	85093.00	2.34
T_{13}	$T_2CS_2M_0F_1$	61325	105.51	34.59	131899.2	70574.20	2.15
T_{14}	$T_2CS_2M_0F_2$	65175	107.89	35.37	134878	69703.00	2.06
T_{15}	$T_2CS_2M_1F_1$	63325	106.55	34.93	133203.2	69878.20	2.0
T_{16}	$T_2CS_2M_1F_2$	67175	109.00	35.73	136256.5	69081.50	2.02
T_{17}	$T_1CS_3M_0F_1$	47409	86.55	39.34	108199.9	60790.90	2.28
T_{18}	$T_1CS_3M_0F_2$	53459	88.59	40.26	110751.3	57292.30	2.07
T_{19}	$T_1CS_3M_1F_1$	49409	87.87	39.94	109838.5	60429.50	2.22
T_{20}	$T_1CS_3M_1F_2$	55459	90.39	41.08	112994	57535.00	2.03
T_{21}	$T_2CS_3M_0F_1$	50809	89.87	40.85	112342.9	61533.90	2.21
T_{22}	$T_2CS_3M_0F_2$	56859	92.02	41.82	115028.6	58169.60	2.02
T_{23}	$T_2CS_3M_1F_1$	52809	91.04	41.38	113811.7	61002.70	2.15
T_{24}	$T_2CS_3M_1F_2$	58859	63.19	28.72	116498.7	57639.70	1.97
T_{25}	$T_1CS_4M_0F_1$	47196	84.03	35.01	105046.9	57850.90	2.22
T_{26}	$T_1CS_4M_0F_2$	53246	87.66	36.52	109590.4	56344.40	2.05
T_{27}	$T_1CS_4M_1F_1$	49196	84.93	35.38	106171.8	56975.80	2.15
T_{28}	$T_1CS_4M_1F_2$	55246	89.39	37.24	111747.05	56501.00	2.02
T_{29}	$T_2CS_4M_0F_1$	50596	89.88	37.45	112362.6	61766.60	2.22
T_{30}	$T_2CS_4M_0F_2$	56646	94.13	39.22	117676.4	61030.40	2.07
T_{31}	$T_2CS_4M_1F_1$	52596	91.25	38.02	114076.3	61480.30	2.16
T_{32}	$T_2CS_4M_1F_2$	58646	95.27	39.69	119100.7	60454.70	2.03

Cost of tillage operation: T_1 - minimum = Rs 2200/ha; T_2 - conventional tillage = Rs 3900/ha
Cost of seeds/ha: Rice = Rs 2500; Maize = Rs 500; Sorghum = Rs 300; Wheat = Rs 2500; Berseem = Rs 4000
Cost of nutrients: FYM = Rs 550/t; Nitrogen = Rs 12.30/kg; Phosphorus = Rs 32.50/kg; Potash = Rs 21.60/kg
Labour charge Rs 125/manday
Value of grains (Rs/q): Rice = Rs 1250; Maize = Rs 1185; Sorghum = Rs 1100; Wheat = Rs 1285; Berseem = Rs 12000
Value of straw/stover (Rs/q): Rice = Rs 50; Maize and Sorghum + Rs 90; Wheat = Rs 150
Mulching 8 mandays/ha = Rs 1000/ha

Results and discussion

Production-efficiency

The highest production efficiency of 52.36 kg/ha/day was recorded under least tillage operation with rice-wheat cropping system and recommended dose of fertilizer with no mulch (T_1) was applied followed by conventional tillage with rice-wheat cropping systems with mulch and recommended dose of fertilizer with 25% N through organic sources (T_{12}). Similar views were reported by Ramesh et al. (2009) and Upadhyaya et al. (2011). The minimum production efficiency of 32.68 kg/ha/day was recorded under T_5 - treatment where minimum tillage to maize-wheat cropping system with no mulch and recommended dose of fertilizer (F1) was applied. Similar observations were made by Ahmad and Ali (1992); and Chopra and Angiras (2007).

System productivity

While comparing the total productivity of cropping systems in terms of rice equivalent yield (REY), sorghum-wheat under minimum tillage, no mulch with recommended dose of fertilizer to both crop components was the least (84.03 q/ha/year) productive among all cropping systems and nutrient management. Similar views were reported by Gupta et al. (2007). It was due to less price of sorghum in the prevailing markets as compared to other crops tested. Highest rice equivalent yield (133.52 q/ha/year) was recorded under T_1 treatment ($T_1CS_1M_0F_1$) followed by T_{10}, T_4 and T_3.

Economics

Higher net monetary returns (Rs 88233/ha/year) was obtained under recommended dose of fertilizer ($T_1CS_1M_0F_1$) to rice-wheat cropping sequence without mulching and least tillage operation with higher B:C ratio of 2.72. The minimum (Rs 56344/ha/year) net monetary returns was observed under sorghum-wheat cropping system, minimum tillage, no mulch with recommended dose of fertilizer to both crops along with 25% N through organic manures.

ज.ने.कृ.वि.वि., जबलपुर (म प्र) के बलुई दोमट मिट्टी वाले अनुसंधान प्रक्षेत्र में धान-गेहूँ, धान-बरसीम, मक्का-गेहूँ एवं ज्वार-गेहूँ फसल प्रणाली को कम एवं सुचारू जुताई बिना बिछावन एवं बिछावन तथा अनुशंसित उर्वराकें की मात्रा तथा अनुशंसित उर्वरकों की मात्रा एवं 25% अधिक मात्रा कार्बनिक खादों, उद्देश्य से वर्ष 2010-11 एवं 2011-12 के द्वारा प्रयोग किया गया । प्रति हेक्टर प्रतिदिन अधिकतम पैदावार (52.36 किलो) धान-गेहूँ फसल प्रणाली से प्राप्त हुई, धान-गेहूँ पर कम खेत तैयार, बिना बिछावन एवं अनुशंसित खाद की मात्रा दोनों फसलों को दी गई थी । ध ाान-गेहूँ फसल प्रणाली, सुचारू जुताई, बिछावन एवं अनुशंसित खाद की मात्रा + 25% कार्बनिक खाद उत्पादन की दृष्टि से दूसरे नम्बर पर रही । अधिक मुनाफा एवं फायदा खर्च का अनुपात में भी पहले वाला प्रयोग सर्वप्रथम रहा ।

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Relationship of phenological characters and seed cotton yield under moisture stress in cotton

B.T. Ninganur, B.S. Janagodar and **N.K. Biradarpatil**
Department of Crop Physiology
University of Agricultural Sciences
Dharwad-580005, Karnataka

Fifty-two genotypes belonging to *G. hirsutum*, *G. herbaceum* and *G.arboreum* were studied for influence of moisture stress on phenological characters and yield using line source sprinkler irrigation technique. Increased moisture stress decreased the number of days to 50 per cent squaring and flowering, first boll formation, 50 per cent boll opening and maturity irrespective of species. First boll formation and 50 per cent boll opening were positively correlated with mean seed cotton yield and thus indicating early boll formation and boll opening are important phenological characters in cotton under moisture stress. *G.arboreum* and *G. herbaceum* performed better at high moisture stress levels compared to *G. hirsutum genotypes*. The genotypes MSKD-26, LH-900, LRA-5166, TCH-1002, AH-107 and Abadhita in *G. hirsutum*, Kumta, RAHS-14, H-111, R-51andH-119in *G. herbaceum*, AKA-5, CAN-4, SIMA-302 and AK-235 in *G. arboreum* gave significantly higher yield across the moisture regimes.

Key words: Cotton, Drought tolerance, Phenological characters, Yield, Moisture stress.

Cotton is an important cash and fiber crop of India grown on 8.0 million hectares. The average yield of cotton is 570 kg/ha whereas, world average is 600 kg/ha (Anon 2007).There are many reasons for low productivity of cotton. Area under rainfed cotton predominates over irrigated area and more than 50 per cent of rainfed cotton is grown under erratic low rainfall conditions. Developmental pattern in cotton is an important aspect as phenological characters are varied and distinct. The phenology of cotton is very sensitive to prevailing environmental conditions (Constable 1976). Yield of seed cotton is dependent on phenological characters like number of days to 50 per cent square initiation, flowering, boll formation, rate of development of bolls and size of bolls. These characters vary with variety, environmental conditions and cultural practices (Kannayan and Veluswamy 1967 ; Kadapa 1975). This experiment was conducted to study the relationship of phenological characters and seed cotton yield in cotton (*Gossypium* spp.) genotypes under increasing moisture stress.

Material and methods

The line source sprinkler irrigation technique was laid out following the method developed by Hanks et al. (1976) in Golden Jubilee Block of Main Agricultural Research Station, Dharwad, which is situated in agro-ecological northern transition zone (Zone 8) of Karnataka. Soil was red sandy loam in texture containing 41% coarse sand, 30% fine sand, 15% silt and 14% clay with PH of 5.92. The field experiment was conducted with 52 genotypes belonging to three species of *Gossypium*. The lines were marked at 60 cm distance across the line source lay out. The recommended dose of 12.5 tones of compost and 80:40:40 NPK kg per hectare was uniformly applied in the lines. The seeds of different genotypes were sown at a distance of 20 cm in a row. Two rows on either ends of plot were sown with local check, Abadhita. The field was irrigated through line source kept at 6 m intervals on alternate days to provide uniform irrigation to the plot. The treatment of water gradient levels was imposed on 21st day after sowing.

Each genotype was raised in a single row of 7m length with a spacing of 60cm x 20 cm perpendicular to the line source on either side of the LS system with randomization. Each row was divided into 5 parts (M_1, M_2, M_3, M_4 and M_5 moisture regimes) each of 1.4m length which consisted of 7 plants. The water catch cans were placed perpendicular to LS system between rows in the middle of each part (moisture level) in line with sprinkler heads to estimate receipt of moisture levels. The water collected in each can was computed as,

$$\text{Water applied (cm)} = \frac{\text{Water collected in each can in ml (cm}^3)}{\text{Area of the can (cm}^2)}$$

The amount of water applied to each sub plot was accumulated over the duration of treatment .Any rainfall during the imposition of drought treatment was added to water input in all sub plots (Table 1).

Cumulative pan evaporation during the experimentation =82.40 cm

Water deficit created relative to the open pan evaporation that occurred during the treatment period was calculated using the formula,

$$\text{Water deficit (\%)} = \frac{X_1 - X_2}{X_1} \times 100$$

Where ,

X_1= Cumulative open pan evaporation during the experimental period (cm),

X_2= Cumulative amount of water applied (including rain) for the experimental period (cm).

Five middle plants in each treatment were selected for recording days to 50 per cent square initiation, flowering, first boll formation, boll opening and days to maturity.

Results and Discussion

Days to 50 per cent square initiation

The square formation in cotton is the beginning of reproductive phase and squares are the important components for yield in cotton. The data on days to 50 per cent square initiation as influenced by genotypes and moisture levels is presented in Table 2. In general, it was observed that increasing moisture stress level resulted in decreased days to 50 per cent square initiation irrespective of species. Among the species, on an average, *G. herbaceum* genotypes took highest number of days to 50 per cent square initiation compared to *G.hirsutum* and *G. arboreum*. At M_1 moisture level, G. *herbaceum* took on an average more number of days (55.9) to 50 per cent square initiation compared to *G.hirsutum* (48.4) and *G. arboreum* (49.9). Further, it was found that in general *G. herbaceum* genotypes recorded highest number of days to 50 per cent square initiation particularly at M_4 and M_5 moisture levels compared to other species.

Among the genotypes, H-119 took significantly higher number of days to 50 per cent square initiation (56.6) followed by H-18 (56.5), Saj 4-3-4 (54.4), Surthi Broach (53. 7), H-6 (53.6), RAHS-14 (53.4), H-124 (52.8), DB-3-12 (52.4), Jayadhar (52.2) and H-135 (51.9) in *G. herbaceum*. The number of days to 50 per cent square initiation was less in MCU-5 (45.2) followed by AH-107 (45.5), Sharada (46.0), HLS- 32179 (46.1) and Allepo x Rex (46.3) in *G. hirsutum*. The genotypes PA-183 and B.Desh-87 took significantly less number of days to 50 per cent square initiation in *G. arboreum*, indicating their sensitivity to moisture stress.

The interaction effects between moisture levels and genotypes were found significant. The genotype Saj 4-3-4 recorded significantly highest number of days to 50 per cent square initiation at M_1 moisture level and significantly lower number of days to 50 per cent square initiation was found in MCU-5 (44.5) at M5 moisture regime. At M_5 moisture regime, the genotypes R-51 (51.0), Kumta (48.5), Saj-4-3-4 (48.5), H-119 (48.0) and H-18 (48.0) recorded significantly higher values for number of days to 50 per cent square initiation as compared to other genotypes. Across the moisture regimes, *G. herbaceum* had maximum number of days (51.8) to 50 per cent square initiation followed by *G. arboreum* (48.3) and *G. hirsutum* (46.9).

Days to 50 per cent flowering

It was observed that increasing moisture stress levels resulted in decreased number of days to 50 per cent

Table 1. Particulars of water use in line source irrigation method

Particulars	M_1	M_2	M_3	M_4	M_5
Amount of water supplied (ml)	10268	7707	4870	2100	548
Amount of water by rains (ml)	2025	2025	2025	2025	2025
Total amount of water (ml)	12293	9732	6895	4025	2566
Amount of water on weight basis (g)1ml=0.997g	12256	9702	6874	4113	2563
Amount of water (cm)	85.95	68.05	48.25	28.85	18.00
Moisture deficit (%)	4.31	-17.42	-41.44	-69.99	-78.14

flowering irrespective of species (Table 3). It was from 63.4 days in M_1 to 58.6 days in M_5. Across the moisture regimes, *G. herbaceum* genotypes took highest number of days (63.9) compared to *G. hirsutum* (54.4) and *G. arboreum* (58.1).

Among the genotypes, Saj 4-3-4 recorded significantly higher number of days to 50 per cent flowering (69.8) followed by RAHS -14 (69.0), Dig-6-3-13 (68.1), DB-3-12 (66.0), Surthi Broach (65.6) and R-51 (64.9). The number of days to 50 per cent flowering was significantly less in LH-900 (50.8) followed by CNHPT-2 (51.2), CPD-446 (51.3), CPD-473 (52.3) and Allepo x Rex (52.3).

The interaction effects between moisture levels and genotypes were found significant. The genotype, Saj 4-3-4 recorded significantly highest number of days to 50 per cent flowering at M_1 moisture level and significantly lower number of days was observed in Allepo x Rex, LH-900 and CPD-473 (48.5) at M5 moisture regimes. At M5 moisture level, the genotypes, Dig-6-3-13 (65.0) RAHS-14 (65.0), Jaydhar (63.5), RAHS-2 (63.0) and Surthi Broach (61.5) recorded significantly higher values for number of days to 50 per cent flowering as compared to other genotypes.

Days to first boll formation

Increased moisture stress caused decrease in number of days to first boll formation irrespective of species (Table 4). Number of days to first boll formation had negative correlation with yield under moisture stress levels indicating early varieties are suited to stress situations. Across the moistures regimes *G. herbaceum* (76.5) genotypes took highest mean number days to first boll opening compared to *G. hirsutum* (62.6) and *G. arboreum* (72.1).

Across the moisture regimes, Jayadhar recorded significantly higher mean number of days to first boll formation (81.9) followed by Surthi Broach (80.8), H-111 (80.8), H-111 (80.0), H-18 (79.6), H-119 (79.0), H-129 (78.8), Dig-6-3-13 (78.1), H-135 (77.6) and RAHS-2 (77.5). The number of days to first boll formation was significantly less in CPD-446 (56.8), followed by LRA-5166 (58.2), Allepo x Rex (59.2), Sharada (59.4) and MSKD-26 (59.6). They were early in first boll formation under moisture stress conditions. The interaction effects between moisture levels and genotypes were found significant. The genotypes DB-3-12 recorded significantly highest days to first boll formation (93.5) and significantly lower number of days to first boll formation was found in CPD-446 (51.5). At M5 moisture level, the genotype Jayadhar (72.0), Surthi Broach (70.0), Dig-6-3-13 (69.0), H-18 (69.0) and H-111 (68.5) recorded significantly higher values for number of days to first boll formation as compared to other genotypes indicating their tolerance to drought.

Days to 50 per cent boll opening

Among the species, to *G. herbaceum* took maximum mean number of days (100.8) to 50 percent boll opening followed by *G. arboreum* (99.9) and *G. hirsutum* (95.6). But they did not differ significantly, showing no effect of moisture stress on boll opening behaviour across the species (Table 5).

However, among the moisture regimes, M_1 recorded significantly higher values for number of days (106.0) to 50 per cent boll opening followed by M_2. M_3, M_4 and M_5. These treatments differed significantly among themselves.

Among the genotypes, Dig-6-3-13 recorded significantly higher number of days (103.8) to 50 per cent boll opening followed by Jayadhar (102.1), H-10(102.0), H-131 (100.7), RAHS-2 (100.7) and Saj-4-3-4 (100.6). The number of days to 50 per centboll opening was significantly less in Abhadita (93.3) followed by HLS-321729 (93.3), Anjali (93.7), CPD-418 (94.3) and ACP-71 (94.4). This indicates the existence of genotypic variation with respect to 50 per cent boll opening under stress situations. The interaction effect between moisture levels and genotypes was found significant. The genotype Dig-6-3-13 recorded significantly highest number of days to 50 per cent boll opening at M_1 moisture level (103.8) and significantly lower number of days to 50 per cent boll opening was found in Sharada (85.0) at M5 moisture level.

At M_5 moisture level, the genotypes H-10 (95.5), H-131 (95.5), H-18 (95.5), Kumta (95.0) and Dig-6-3-13 (95.0) recorded significantly higher values for number of days to 50 per cent boll opening as compared to other genotypes.

Days to maturity

The data on number of days to maturity as influenced by genotypes and moisture levels is presented in Table 6. It was observed that increasing moisture stress levels resulted in decreased number of days to maturity irrespective of species. Among all the moisture regimes, *G. herbaceum* genotypes took the highest number of days to maturity (192.0) compared to *G. hirsutum* (167.2)

Table 2. Days to 50 per cent square initiation in cotton genotypes as influenced by different moisture levels

Sl.No	Genotypes	Moisture levels					Mean
		M_1	M_2	M_3	M_4	M_5	
	G.hirsutum						
1.	Allepo x Rex	47.5	47.0	46.0	45.5	45.5	46.3
2.	CBR – 8	53.5	54.0	47.0	46.0	46.0	49.3
3.	CPD – 446	48.0	46.5	46.5	45.5	45.5	46.4
4.	MSKD – 26	49.0	47.5	46.5	46.5	46.0	47.1
5.	Laxmi	56.5	48.5	48.5	47.0	47.0	49.5
6.	LH – 900	48.0	46.5	46.0	45.5	45.5	46.3
7.	LRA – 5166	47.5	46.5	46.5	46.0	46.0	46.5
8.	Sharada	48.0	46.5	45.5	45.0	45.0	46.0
9.	CPD – 473	48.5	47.5	47.5	46.0	46.0	47.1
10.	CNHPT - 2	47.0	47.0	47.0	46.0	46.0	46.6
11.	CPD – 431	47.5	47.5	47.0	46.0	45.0	46.6
12.	TCH – 1002	47.5	47.5	47.0	46.5	46.0	46.9
13.	NA – 1588	47.0	47.0	46.5	46.5	45.5	46.5
14.	CPD - 418	49.0	48.5	47.5	47.5	46.5	47.8
15.	Anjali	47.0	47.0	47.0	46.5	46.5	46.8
16.	RAMP – 155	48.0	47.5	47.5	47.0	46.0	47.2
17.	HLS – 321729	47.0	47.0	46.0	45.5	45.0	46.1
18.	ACP – 71	49.5	48.5	47.5	46.0	46.0	47.5
19.	AH – 107	45.5	45.5	45.5	45.5	45.5	45.5
20.	MCU – 5	46.0	45.5	45.0	45.0	44.5	45.2
21.	Abadhita (c)	48.5	47.5	47.0	46.0	45.5	46.9
	Mean	48.4	47.5	46.7	46.1	45.7	46.9
	G. herbaceum						
22.	Surthi Broach	58.0	58.0	56.5	48.5	47.5	53.7
23.	Dig – 6-3-13	56.0	55.5	48.5	48.0	47.0	51.0
24.	H – 119	61.0	61.0	57.0	56.0	48.0	56.6
25.	H – 10	48.0	47.5	47.5	47.5	46.0	47.3
26.	DDhc – 11	49.5	48.5	48.0	48.0	48.0	48.4
27.	Saj – 4-3-4	62.5	57.5	54.0	49.5	48.5	54.4
28.	Kumta	58.5	51.5	49.5	49.0	48.5	51.4
29.	DB – 3 –12	56.5	56.5	52.5	48.5	48.0	52.4
30.	RAHS – 14	57.5	56.5	56.5	49.5	47.0	53.4
31.	H – 6	58.0	57.5	56.5	48.5	47.5	53.6
32.	H – 111	58.0	56.0	55.5	48.5	47.5	53.1
33.	R – 51	61.0	60.5	57.5	52.5	51.0	56.5
34.	H – 135	56.0	55.0	52.5	49.0	47.0	51.9
35.	H – 124	59.0	56.0	53.0	49.0	47.0	52.8
36.	H – 129	50.5	45.5	48.0	47.0	46.5	47.5
37.	H – 131	48.5	48.0	47.5	47.0	46.0	47.4
38.	RAHS – 2	48.0	48.0	47.5	47.0	46.5	47.4
39.	H – 125	49.5	49.0	48.0	47.5	47.0	48.2
40.	H – 18	61.5	58.5	57.5	57.0	48.0	56.5
41.	Jayadhar (c)	60.5	57.5	48.5	47.5	47.0	52.2
	Mean	55.9	54.2	52.1	49.3	47.5	51.8
	G. arboreum						
42.	AKA – 5	49.0	48.5	48.0	46.5	46.0	47.6
43.	A 82 – 1 –1	48.0	48.0	48.0	47.0	47.0	47.6
44.	PA – 183	48.0	47.5	47.5	46.5	46.0	47.1
45.	Virnar - 79	49.5	49.0	48.0	47.5	47.0	48.2
46.	No. 23	49.5	48.5	48.0	47.5	46.5	48.0
47.	No. 30802	50.0	49.5	48.5	48.0	47.0	48.6
48.	CNA – 4	49.0	49.0	49.0	47.5	46.5	48.2
49.	B. Desh – 87	49.5	48.5	47.5	46.0	45.5	47.4
50.	CIMA 302	50.5	49.0	48.5	48.0	47.5	48.7
51.	No. 3287	50.5	49.0	48.0	48.0	47.5	48.6
52.	AK – 235 (c)	55.0	51.5	50.5	48.5	48.0	50.7
	Mean	49.9	48.9	48.3	47.4	46.8	48.3
	Grand Mean	51.6	50.4	49.1	47.6	46.6	49.0
	For comparison of				SEM ±	CD (0.05)	
	Moisture Levels (M)				0.04	0.14	
	Genotypes (G)				0.29	0.82	
	Interaction (M x G)				0.64	1.77	

M_1-No stress M_2-20% stress M_3-40% stress M_4-70% stress M_5-80% stress

Table 3. Days to 50 per cent flowering in cotton genotypes as influenced by different moisture levels

Sl.No	Genotypes	Moisture levels					Mean
		M_1	M_2	M_3	M_4	M_5	
	G.hirsutum						
1.	Allepo x Rex	55.5	55.0	52.5	50.0	48.5	52.3
2.	CBR – 8	68.5	62.5	56.0	54.5	51.5	58.6
3.	CPD – 446	54.0	53.5	51.0	50.5	48.5	51.5
4.	MSKD – 26	61.0	53.5	53.0	52.0	51.0	54.1
5.	Laxmi	59.5	66.0	65.0	62.0	60.5	62.6
6.	LH – 900	54.0	51.5	50.5	49.5	48.5	50.8
7.	LRA – 5166	56.5	55.0	54.5	51.5	50.0	53.5
8.	Sharada	56.5	53.0	53.0	51.0	50.5	52.8
9.	CPD – 473	54.0	55.0	52.0	51.0	49.5	52.3
10.	CNHPT - 2	53.0	52.5	50.5	50.5	49.5	51.2
11.	CPD – 431	60.5	51.0	51.0	50.0	48.5	52.2
12.	TCH – 1002	63.0	60.5	56.0	55.0	54.0	57.7
13.	NA – 1588	60.0	55.0	55.0	54.5	54.0	55.7
14.	CPD - 418	55.0	54.5	52.5	51.0	49.5	52.5
15.	Anjali	56.0	55.0	53.5	52.5	50.0	53.4
16.	RAMP – 155	55.5	54.5	52.0	51.0	50.0	52.6
17.	HLS – 321729	57.0	55.5	55.0	52.5	52.0	54.4
18.	ACP – 71	56.0	55.0	53.5	50.5	49.5	52.9
19.	AH – 107	54.5	54.0	53.5	52.0	50.5	52.9
20.	MCU – 5	56.5	54.0	52.0	51.5	50.5	52.9
21.	Abadhita (c)	58.0	57.5	55.0	53.5	49.5	54.7
	Mean	57.4	55.4	53.7	52.2	50.8	54.4
	G. herbaceum						
22.	Surthi Borach	67.5	67.5	66.5	65.0	61.5	65.6
23.	Dig – 6-3-13	70.5	69.5	68.0	67.5	65.0	68.1
24.	H – 119	71.0	68.5	66.5	63.5	51.0	64.1
25.	H – 10	66.5	61.5	59.0	58.0	54.0	59.8
26.	DDhc – 11	70.0	67.5	59.0	57.5	53.5	61.5
27.	Saj – 4-3-4	76.0	75.0	71.5	65.0	61.5	69.8
28.	Kumta	69.5	64.0	60.5	57.5	55.0	61.3
29.	DB – 3 –12	74.5	69.5	66.5	62.0	57.5	66.0
30.	RAHS – 14	72.5	72.0	68.5	67.0	65.0	69.0
31.	H – 6	69.0	67.5	66.0	54.0	50.5	61.4
32.	H – 111	74.5	69.5	66.0	62.5	59.0	66.3
33.	R – 51	69.5	66.5	64.5	63.5	60.5	64.9
34.	H – 135	72.0	66.0	62.5	59.5	56.5	63.3
35.	H – 124	68.5	65.5	62.5	59.0	56.0	62.3
36.	H – 129	69.0	61.5	60.0	58.5	57.5	61.3
37.	H – 131	67.0	64.0	61.0	58.0	54.0	60.8
38.	RAHS – 2	69.0	68.0	66.5	64.0	63.0	66.1
39.	H – 125	64.5	61.5	60.0	58.0	54.0	59.6
40.	H – 18	68.0	66.0	61.0	55.5	54.5	61.0
41.	Jayadhar (c)	71.5	68.5	66.0	66.0	63.5	67.1
	Mean	69.7	67.0	64.1	61.0	57.6	63.9
	G. arboreum						
42.	AKA-5	60.5	58.5	55.0	53.0	51.0	55.7
43.	A 82 – 1 –1	73.5	72.0	67.0	63.0	59.5	67.0
44.	PA – 183	60.5	57.0	55.5	53.5	53.5	56.0
45.	Virnar - 79	65.0	62.0	60.0	57.5	55.5	60.0
46.	No. 23	57.0	55.0	54.0	53.5	50.5	54.0
47.	No. 30802	61.5	58.0	55.5	54.0	50.5	55.9
48.	CNA – 4	68.5	66.0	65.0	57.5	54.0	62.2
49.	B. Desh – 87	57.0	55.5	54.5	53.0	51.0	54.2
50.	CIMA 302	60.5	58.0	56.0	52.5	50.5	55.5
51.	No. 3287	67.0	64.5	63.5	61.5	59.5	63.2
52.	AK – 235 (c)	62.0	57.5	54.0	52.0	50.5	55.2
	Mean	63.0	60.4	58.2	55.6	53.3	58.1
	Grand Mean	63.4	60.9	58.6	56.3	53.9	58.6
	For comparison of				SEM ±	CD (0.05)	
	Moisture Levels (M)				0.1	0.4	
	Genotypes (G)				0.7	1.9	
	Interaction (M x G)				1.5	4.2	

M_1-No stress M_2-20% stress M_3-40% stress M_4-70% stress M_5-80% stress

Table 4. Days to first boll formation in cotton genotypes as influenced by different moisture levels

Sl.No	Genotypes	Moisture levels					Mean
		M_1	M_2	M_3	M_4	M_5	
	G.hirsutum						
1.	Allepo x Rex	65.0	63.5	58.5	55.5	53.5	59.2
2.	CBR – 8	77.0	72.5	67.0	61.5	56.5	66.9
3.	CPD – 446	62.0	59.5	56.5	54.5	51.5	56.8
4.	MSKD – 26	66.0	63.5	58.5	56.5	53.5	59.6
5.	Laxmi	79.0	74.5	71.0	66.5	63.0	70.8
6.	LH – 900	71.5	67.0	62.5	56.5	53.0	62.1
7.	LRA – 5166	64.5	61.5	58.0	54.0	53.0	58.2
8.	Sharada	67.0	63.0	59.5	54.5	53.0	59.4
9.	CPD – 473	70.0	64.5	61.0	58.5	54.0	61.6
10.	CNHPT - 2	69.0	65.5	62.5	58.0	54.5	61.9
11.	CPD – 431	66.5	63.5	60.0	57.0	52.5	59.9
12.	TCH – 1002	79.5	74.5	71.5	67.0	60.5	70.6
13.	NA – 1588	77.5	72.5	70.0	64.0	59.0	68.6
14.	CPD - 418	71.5	69.0	64.0	59.5	54.5	63.7
15.	Anjali	70.0	65.5	62.0	57.5	54.0	61.8
16.	RAMP – 155	69.5	67.5	64.0	59.5	56.0	63.3
17.	HLS – 321729	69.0	63.5	60.5	57.5	53.0	60.7
18.	ACP – 71	72.5	68.5	63.5	58.0	55.0	63.5
19.	AH – 107	69.5	65.0	60.5	57.5	52.5	61.0
20.	MCU – 5	68.5	64.5	60.5	55.5	53.0	60.4
21.	Abadhita (c)	72.0	69.0	63.0	60.0	55.0	63.8
	Mean	70.3	66.6	62.6	58.5	54.8	62.6
	G. herbaceum						
22.	Surthi Broach	90.5	87.5	80.0	76.0	70.0	80.8
23.	Dig – 6-3-13	88.5	82.5	77.5	73.0	69.0	78.1
24.	H – 119	91.5	86.5	80.5	72.5	64.0	79.0
25.	H – 10	86.5	72.0	68.0	64.5	57.5	69.7
26.	DDhc – 11	89.0	79.5	70.0	64.5	58.5	72.3
27.	Saj – 4-3-4	92.5	85.5	74.5	68.0	63.5	76.8
28.	Kumta	88.5	75.0	67.5	61.5	57.5	70.0
29.	DB – 3 –12	93.5	79.5	74.0	67.0	61.5	75.1
30.	RAHS – 14	88.0	79.0	74.0	70.5	67.0	75.7
31.	H – 6	89.5	85.0	75.5	66.5	58.5	75.0
32.	H – 111	91.5	87.0	82.0	75.0	68.5	80.8
33.	R – 51	85.5	80.0	74.5	68.5	64.0	74.5
34.	H – 135	93.0	88.0	77.0	69.5	60.5	77.6
35.	H – 124	92.0	82.5	74.5	69.0	62.0	76.0
36.	H – 129	90.5	85.5	82.0	74.0	62.0	78.8
37.	H – 131	88.0	84.0	77.5	72.5	61.5	76.7
38.	RAHS – 2	89.5	84.0	75.5	71.5	67.0	77.5
39.	H – 125	86.0	77.0	73.0	66.5	62.5	73.0
40.	H – 18	90.5	83.5	80.5	74.5	69.0	79.6
41.	Jayadhar (c)	92.5	87.5	80.5	77.0	72.0	81.9
	Mean	89.9	82.6	75.9	70.1	63.8	76.5
	G. arboreum						
42.	AKA – 5	83.5	74.0	70.0	63.5	57.5	69.7
43.	A 82 – 1 –1	94.0	86.0	79.5	72.0	68.5	80.0
44.	PA – 183	81.5	74.5	67.0	63.0	58.0	68.8
45.	Virnar - 79	90.0	84.5	77.5	70.0	66.0	77.6
46.	No. 23	75.0	70.5	67.5	62.0	54.5	65.9
47.	No. 30802	85.5	83.5	73.0	66.5	60.5	73.8
48.	CNA – 4	85.0	76.5	72.0	67.0	58.5	71.8
49.	B. Desh – 87	84.0	80.0	74.0	67.0	62.5	73.5
50.	CIMA 302	83.5	77.5	71.5	64.5	59.5	71.3
51.	No. 3287	90.0	77.0	70.0	67.0	64.0	73.6
52.	AK – 235 (c)	79.5	73.0	68.5	62.5	58.0	68.3
Mean	84.7	77.9	71.9	65.9	60.2	72.1	
Grand Mean		80.9	82.0	69.7	64.5	59.5	71.3
For comparison of		SEM ±	CD (0.05)				
Moisture Levels (M)		3.1	12.1				
Genotypes (G)		11.2	32.0				
Interaction (M x G)		25.1	69.6				

M_1-No stress M_2-20% stress M_3-40% stress M_4-70% stress M_5-80% stress

Table 5. Days to 50 per cent boll opening in cotton genotypes as influenced by different moisture levels

Sl.No	Genotypes	Moisture levels					Mean
		M1	M2	M3	M4	M5	
	G.hirsutum						
1.	Allepo x Rex	104.5	100.0	95.5	95.5	85.5	96.2
2.	CBR – 8	107.5	101.0	98.0	91.0	88.0	97.1
3.	CPD – 446	105.0	102.5	97.5	95.0	88.5	97.7
4.	MSKD – 26	104.5	98.5	95.5	91.5	85.5	95.1
5.	Laxmi	102.0	98.0	95.5	91.5	85.5	94.5
6.	LH – 900	103.0	98.5	94.5	92.0	86.5	94.9
7.	LRA – 5166	103.5	100.0	95.5	91.5	86.5	95.4
8.	Sharada	104.5	100.0	96.5	91.5	85.0	95.5
9.	CPD – 473	104.5	102.5	99.5	94.0	90.5	98.2
10.	CNHPT - 2	101.0	97.0	95.0	93.5	85.5	94.4
11.	CPD – 431	106.5	103.5	100.0	92.5	88.5	98.2
12.	TCH – 1002	104.5	99.5	95.5	94.0	87.0	96.1
13.	NA – 1588	103.5	100.5	97.5	92.5	88.5	96.5
14.	CPD - 418	102.5	96.5	94.0	92.5	86.0	94.3
15.	Anjali	101.5	96.5	94.5	90.5	85.5	93.7
16.	RAMP – 155	102.5	99.0	96.5	92.0	87.0	95.4
17.	HLS – 321729	101.0	97.0	94.0	90.0	86.0	93.6
18.	ACP – 71	100.0	97.5	95.5	91.5	87.5	94.4
19.	AH – 107	102.0	100.0	95.5	92.0	86.5	95.2
20.	MCU – 5	105.5	101.0	98.5	93.0	90.0	97.6
21.	Abadhita (c)	99.50	96.0	92.5	92.0	86.5	93.3
	Mean	103.3	99.3	96.1	92.4	87.0	95.6
	G. herbaceum						
22.	Surthi Broach	109.0	107.5	97.5	92.5	92.5	99.8
23.	Dig – 6-3-13	113.0	108.5	105.5	97.0	95.0	103.8
24.	H – 119	110.5	103.5	97.5	97.0	92.5	100.2
25.	H – 10	111.5	104.0	101.5	97.5	95.5	102.0
26.	DDhc – 11	110.5	103.5	99.5	98.0	92.0	100.6
27.	Saj – 4-3-4	110.0	104.5	99.0	96.5	93.0	100.6
28.	Kumta	110.0	105.0	101.5	96.5	95.0	101.6
29.	DB – 3 –12	110.0	102.0	98.0	97.0	93.5	100.1
30.	RAHS – 14	110.5	101.0	98.5	96.0	92.5	99.7
31.	H – 6	108.5	104.0	99.5	96.0	91.5	99.9
32.	H – 111	107.0	102.0	99.5	95.5	89.5	98.7
33.	R – 51	110.0	104.5	102.0	96.5	94.5	101.5
34.	H – 135	106.5	102.5	98.5	97.0	93.5	99.6
35.	H – 124	110.0	102.5	100.0	95.5	92.0	100.0
36.	H – 129	110.0	106.5	101.0	96.5	92.5	101.1
37.	H – 131	109.0	104.5	102.0	98.5	95.5	101.9
38.	RAHS – 2	109.5	102.0	99.5	98.0	94.5	100.7
39.	H – 125	108.5	104.0	99.5	96.5	95.0	100.7
40.	H – 18	107.5	104.5	100.5	96.5	95.5	100.9
41.	Jayadhar (c)	109.5	105.0	102.0	99.5	94.5	102.1
	Mean	109.6	104.1	100.1	96.7	93.5	100.8
	G. arboreum						
42.	AKA – 5	106.5	100.0	96.5	94.5	90.5	97.6
43.	A 82 – 1 –1	107.5	103.5	100.0	95.0	91.5	99.5
44.	PA – 183	105.5	100.0	97.0	94.5	89.5	97.4
45.	Virnar - 79	104.0	101.0	98.5	95.0	89.5	97.6
46.	No. 23	106.0	99.0	96.5	92.5	89.0	96.6
47.	No. 30802	104.5	100.0	95.5	92.5	90.0	96.6
48.	CNA – 4	106.0	102.0	98.5	95.5	90.5	98.5
49.	B. Desh – 87	104.0	100.0	98.5	96.5	91.0	98.0
50.	CIMA 302	104.5	100.0	97.5	94.5	89.5	97.2
51.	No. 3287	104.5	102.0	96.0	93.5	89.0	97.0
52.	AK – 235 (c)	103.5	99.0	96.0	92.0	88.0	95.7
	Mean	105.1	100.6	97.3	94.2	89.9	97.4
	Grand Mean	106.0	101.4	97.9	94.4	90.1	99.9
	For comparison of				SEM ±	CD (0.05)	
	Moisture Levels (M)				4.3	16.9	
	Genotypes (G)				13.9	39.7	
	Interaction (M x G)				31.1	86.2	

M1-No stress M2-20% stress M3-40% stress M4-70% stress M5-80% stress

Table 6. Days to maturity in cotton genotypes as influenced by different moisture levels

Sl.No	Genotypes	Moisture levels					Mean
		M_1	M_2	M_3	M_4	M_5	
	G.hirsutum						
1.	Allepo x Rex	172.0	168.5	156.0	153.0	150.0	159.9
2.	CBR – 8	180.0	175.0	169.0	164.0	161.0	169.8
3.	CPD – 446	171.0	166.5	164.0	163.0	159.0	164.7
4.	MSKD – 26	173.0	170.5	166.5	162.5	160.0	166.5
5.	Laxmi	181.5	178.0	174.0	171.0	165.0	173.9
6.	LH – 900	164.0	158.0	148.0	144.0	143.5	151.5
7.	LRA – 5166	179.0	175.0	172.0	169.0	165.0	172.0
8.	Sharada	180.5	179.5	174.0	170.0	164.5	173.7
9.	CPD – 473	181.5	175.5	169.5	169.0	165.5	172.2
10.	CNHPT - 2	180.0	176.5	170.5	169.0	164.0	172.0
11.	CPD – 431	184.5	180.0	175.5	169.5	166.5	175.2
12.	TCH – 1002	164.5	162.0	153.0	146.5	144.0	154.0
13.	NA – 1588	175.0	168.5	164.0	163.0	159.5	166.0
14.	CPD - 418	174.5	169.0	164.0	159.0	154.0	164.1
15.	Anjali	179.0	175.5	174.0	167.5	165.0	172.2
16.	RAMP – 155	179.0	177.0	174.0	169.0	163.5	172.5
17.	HLS – 321729	175.5	169.5	166.5	164.0	161.5	167.4
18.	ACP – 71	170.0	166.5	158.0	155.5	154.0	160.8
19.	AH – 107	179.5	169.5	164.5	156.0	150.5	164.0
20.	MCU – 5	180.5	174.0	166.5	162.5	160.0	168.7
21.	Abadhita (c)	181.5	177.0	170.0	164.5	163.0	171.2
	Mean	176.4	172.0	166.4	162.5	159.0	167.2
	G. herbaceum						
22.	Surthi Broach	193.5	189.5	183.0	184.0	182.5	186.5
23.	Dig – 6-3-13	195.0	188.5	185.5	182.5	180.0	186.3
24.	H – 119	202.5	197.5	192.0	190.5	187.0	193.9
25.	H – 10	202.0	197.5	193.0	189.5	186.0	193.6
26.	DDhc – 11	199.0	196.0	195.0	192.5	189.5	194.4
27.	Saj – 4-3-4	199.5	196.5	193.0	191.0	188.0	193.6
28.	Kumta	202.0	198.0	190.5	185.5	180.5	191.3
29.	DB – 3 –12	202.5	197.5	195.5	193.0	190.0	195.7
30.	RAHS – 14	198.0	195.5	190.0	185.5	184.0	190.6
31.	H – 6	202.5	198.0	191.5	187.5	183.5	192.6
32.	H – 111	199.0	194.0	189.5	185.5	183.0	190.2
33.	R – 51	201.5	197.5	194.0	192.5	190.0	195.1
34.	H – 135	194.0	194.0	189.5	187.0	185.0	189.9
35.	H – 124	199.0	195.5	191.0	187.5	183.5	191.3
36.	H – 129	199.0	195.5	192.0	189.5	184.5	192.1
37.	H – 131	202.0	197.5	194.5	189.5	185.5	193.8
38.	RAHS – 2	200.5	195.5	193.5	191.5	188.5	193.9
39.	H – 125	202.5	198.0	190.5	184.5	181.0	191.3
40.	H – 18	203.0	196.5	188.5	184.0	181.5	190.7
41.	Jayadhar (c)	204.0	200.5	195.0	192.5	189.5	196.3
	Mean	200.1	195.0	191.4	188.3	185.1	192.0
	G. arboreum						
42.	AKA – 5	189.5	184.5	181.5	179.5	177.5	182.5
43.	A 82 – 1 –1	190.5	184.0	182.0	179.5	177.0	182.6
44.	PA – 183	192.0	184.0	181.5	178.5	174.5	182.1
45.	Virnar - 79	194.5	188.5	184.0	180.5	171.0	183.7
46.	No. 23	194.0	192.0	188.0	184.0	182.5	188.1
47.	No. 30802	189.5	185.5	183.5	180.0	178.0	183.3
48.	CNA – 4	192.5	189.5	185.0	182.0	180.0	185.8
49.	B. Desh – 87	191.5	189.5	186.5	183.5	181.5	186.5
50.	CIMA 302	194.0	189.5	185.5	183.0	181.5	186.7
51.	No. 3287	189.5	186.5	184.5	182.5	179.5	184.5
52.	AK – 235 (c)	194.5	192.0	189.0	184.5	182.5	188.5
	Mean	192.0	187.8	184.6	181.6	178.7	184.9
	Grand Mean	189.5	184.9	180.8	177.4	174.3	181.4
	For comparison of				SEM ±	CD (0.05)	
	Moisture Levels (M)				0.1	0.3	
	Genotypes (G)				0.4	1.2	
	Interaction (M x G)				1.0	2.7	

M_1-No stress M_2-20% stress M_3-40% stress M_4-70% stress M_5-80% stress

Table 7. Yield (g/plant) of cotton genotypes as influenced by different moisture levels

Sl.No	Genotypes	Moisture levels					Mean
		M_1	M_2	M_3	M_4	M_5	
	G.hirsutum						
1.	Allepo x Rex	22.9	18.6	16.5	9.3	5.8	14.6
2.	CBR – 8	20.9	19.4	15.8	13.2	8.8	15.6
3.	CPD – 446	22.8	21.1	15.8	12.8	8.6	16.2
4.	MSKD – 26	25.6	21.4	15.8	12.7	10.1	17.1
5.	Laxmi	18.4	15.9	10.7	8.4	6.0	11.8
6.	LH – 900	24.6	20.3	18.2	12.7	11.5	17.5
7.	LRA – 5166	25.2	22.7	20.0	18.5	14.9	20.2
8.	Sharada	20.6	17.1	14.0	10.8	7.6	14.0
9.	CPD – 473	20.2	17.7	15.9	12.7	10.8	15.5
10.	CNHPT - 2	17.9	15.2	13.9	10.0	8.0	13.0
11.	CPD – 431	18.4	15.3	11.2	8.0	6.3	11.6
12.	TCH – 1002	23.4	21.0	19.0	16.8	14.0	18.9
13.	NA – 1588	22.1	14.8	13.5	7.7	5.7	12.7
14.	CPD - 418	24.1	21.7	18.3	12.0	9.7	17.2
15.	Anjali	14.9	13.5	12.1	10.0	8.2	11.8
16.	RAMP – 155	23.2	19.1	16.9	15.3	9.8	16.9
17.	HLS – 321729	17.7	14.5	9.1	7.8	5.7	11.0
18.	ACP – 71	26.9	22.8	18.0	14.0	5.9	17.5
19.	AH – 107	21.0	19.2	14.9	10.9	4.7	14.1
20.	MCU – 5	24.2	20.7	16.8	11.5	11.0	16.9
21.	Abadhita (c)	26.0	22.3	16.9	15.0	10.0	18.0
	Mean	21.9	18.8	15.4	11.9	8.7	15.4
	G. herbaceum						
22.	Surthi Broach	15.5	14.1	12.4	11.0	9.0	12.4
23.	Dig – 6-3-13	24.9	21.9	18.1	12.0	8.9	17.2
24.	H – 119	22.9	18.3	15.3	13.2	8.9	16.3
25.	H – 10	25.5	23.0	19.5	17.2	15.4	20.1
26.	DDhc – 11	24.3	21.0	16.6	12.2	8.6	16.6
27.	Saj – 4-3-4	20.4	17.4	13.2	11.0	8.7	14.1
28.	Kumta	22.9	19.9	14.5	10.7	6.4	14.9
29.	DB – 3 –12	24.1	23.5	19.8	17.7	15.9	20.2
30.	RAHS – 14	19.2	15.6	11.7	8.1	6.9	12.3
31.	H – 6	25.5	22.4	18.9	14.9	12.9	18.9
32.	H – 111	23.5	18.8	15.6	13.9	10.0	16.3
33.	R – 51	22.1	18.7	16.3	13.9	12.1	16.6
34.	H – 135	26.5	23.0	19.9	17.0	12.9	19.9
35.	H – 124	24.6	20.0	18.0	15.3	9.7	17.5
36.	H – 129	20.9	17.4	13.8	10.1	6.6	13.8
37.	H – 131	23.3	18.4	15.6	13.0	8.6	15.8
38.	RAHS – 2	19.9	16.1	12.2	10.2	7.8	13.3
39.	H – 125	19.6	16.9	13.3	9.6	6.9	13.2
40.	H – 18	18.5	15.5	12.5	7.9	5.9	12.1
41.	Jayadhar (c)	18.0	14.9	12.0	10.6	9.9	13.1
	Mean	22.1	18.9	15.5	12.8	9.6	15.7
	G. arboreum						
42.	AKA – 5	25.2	20.1	17.6	13.7	11.9	17.7
43.	A 82 – 1 –1	22.0	20.1	18.3	14.8	10.4	17.1
44.	PA – 183	20.9	18.9	16.2	13.9	11.1	16.2
45.	Virnar - 79	23.8	20.0	15.4	11.8	7.9	15.8
46.	No. 23	20.4	16.9	15..0	13.1	9.0	14.9
47.	No. 30802	15.3	12.5	11.5	7.8	6.2	10.7
48.	CNA – 4	19.8	17.3	14.5	12.0	10.5	14.8
49.	B. Desh – 87	23.2	20.9	18.7	14.9	12.5	18.0
50.	CIMA 302	23.0	17.9	16.1	13.4	9.2	15.9
51.	No. 3287	19.1	16.8	15.2	13.3	11.0	15.1
52.	AK – 235 (c)	24.3	22.3	17.2	15.1	13.6	18.5
	Mean	21.5	18.5	16.0	13.1	10.3	15.9
	Grand Mean	21.9	18.8	15.6	12.4	9.4	15.6
	For comparison of				SEM ±	CD (0.05)	
	Moisture Levels (M)				0.1	0.4	
	Genotypes (G)				0.3	0.7	
	Interaction (M x G)				0.6	1.6	

M_1-No stress M_2-20% stress M_3-40% stress M_4-70% stress M_5-80% stress

and *G. arboreum* (184.9). Among the moisture levels, M1 recorded significantly higher values for number of days to maturity followed by M_2, M_3, M_4 and M_5 and these moisture levels differed significantly.

Among the genotypes, Jaydhar recorded the highest number of days to maturity (196.3) followed by DB-3-12 (195.7), R-51 (195.1), DDhC-11 (194.4), H-119 (193.9) in *G. herbaceum.* The number of days to maturity was significantly less in LH-900 (151.5) followed by TCH-1002 (154.0), Allepo x Rex (159.9), ACP-71 (160.8) and AH-107 (164.0) in *G. hirsutum*. The number of days to maturity was significantly high in PA-183, Virnar-79, No.23, No.30802, CNA-4, B.Desh-87, SIMA-302, No.3282 and AK-235 in *G. arboreum* when compared to all other genotypes. The genotype, Jaydhar recorded significantly highest number of days to maturity (204.0) at M1 moisture level and significantly lower number was observed in TCH-1002 (144.0) at M5 moisture level. At M5 moisture level, the genotypes R-51 (190.0), DB-3-12 (190.0), Jaydhar (189.9). DDhC-11 (189.0) and RAHS-2 (188.5) recorded significantly higher values for number of days to maturity as compared to other genotypes indicating their tolerance to drought.

G. arboreum, *G.herbaceum* and *G. hirsutum* took more number of days 50 per cent squaring, flowering first boll formation, 50 per cent boll opening and maturity at M1 (no stress) moisture level, while they took less number of days with increased moisture stress indicating stress caused early maturity. Among the three cotton species, higher moisture level (M1) recorded non-significant difference in yield. However, at higher moisture stress especially at M5 (severe stress) seed cotton yield differed significantly among the species recording significantly higher yield in *G. arboreum* (10.3 g/plant), followed by *G. herbaceum* (9.6 g/plant) compared to least yield of *G.hirsutum* (8.7 g/plant).

The high yielding *G. arboreum* and *G. herbaceum* genotypes took more number of days for all the phonological phases compared to *G. hirsutum* at higher moisture stress level (M5), thus indicating the relationship of longer the duration higher the yield under moisture stress which is not so under optimum irrigated conditions. Thus, these parameters could be used as criteria for breeding programme in developing drought tolerant varieties under rainfed condition. These studies are in conformity with Villareal(1991) who also noticed the same relationship.

लाइन सोर्स टपक सिचाँई तरीके से गाँसिपियम हिरसुप्म, गा. हरनेसियम तथा गा. आरबोरम के बॉवन प्रजातियों का मॉइस्चर स्ट्रेस का फीनोलाजाकिल तथा ग्रणों पर प्रभाव मापा गया मॉइस्चर स्ट्रेस के कारण पचास प्रतिशत फूल खुलने, बॉल बनने, खुलने तथा मेचुरिटी पर असर पड़ा । जीनोटाइप MSKD 26, LH 900, LRA 5166, TCH 1002, AH 107, Aaadhita तथा Kumata RAHS 14, HIII, R 51 तथा H119, AKA5, CAN4, SIMA302, AK235 प्रजानियों में माइस्चर स्ट्रेस में भी आधिक उपज मापी गयी ।

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Evaluation of different rice based cropping system under irrigated condition of Rewa region

Sandhya Mishra, B.M. Maurya and **P.S. Yadav**
All India Coordinated Research Project on Farming System
College of Agriculture
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Rewa 486 001 (MP)

Abstract

The present field experiment was conducted during the year 2010-11 under integrated farming system research project, Kuthulia farm of JNKVV Rewa. The study reveals that the rice varieties Pro Agro 6444 and Pro Agro 6201 were found better than Kranti and PS- 5 varieties of rice. The garlic crop gave maximum rice equivalent yield in *Rabi* which was significantly superior rest of the crops tried in *Rabi* followed by Potato, berseem and lentil. These cropping systems gave higher rice equivalent yield than wheat. The crops like chickpea, linseed, pea and mustard were found inferior than wheat. The rice- garlic cropping system gave gross monetary return of ` 237600/ha and net monetary return Rs. 106196/ha which was higher than all the rice based cropping system. However, benefit; cost ratio was 2.2 in rice- lentil, 2.0 in rice-potato, 1.9 in rice – mustard and 1.8 in rice- garlic cropping systems. Rice- Linseed cropping system gave benefit : cost ratio less than one.

Keywords : Rice, farming system

Rice- wheat, rice-gram and rice-lentil are the major cropping system in Rewa region of Madhya Pradesh. These cropping system are widely adopted by the farmers due to stable production and less labour requirement (Kumar et al. 2001). But continuous adoption of these cropping systems has lead to the problem of specific weeds, reduced soil fertility in specific root zone, development of soil sickness and infestation of similar kind of pest which ultimately resulted in decline the efficiency and productivity of system (Katyal 2003 and Kumar and Yadav 2005). Rice is the predominant crop in Rewa region of Madhya Pradesh. It is difficult to replace the rice by any other crop in rainy season due to soil and climatic condition. Hence, only option left is to replace wheat, gram and lentil crop in winter season for diversification of rice based cropping systems which have not been evaluated for Rewa region of Madhya Pradesh.

Material and Methods

The present field experiment was conducted during 2010-11 at JNKVV farm of Kuthulia under all India coordinated research project on farming system. The soil of experiment field was silty loam in texture which was low in available nitrogen (224 kg/ha) and phosphorus (8.2 kg/ha) and high in available potash (315 kg/ha). Ten cropping system (rice-wheat, rice- gram, rice- berseem, rice- potato, rice – garlic, rice—lentil, rice- linseed, rice- pea, rice-linseed + chickpea intercropping and rice- mustard) were taken in randomized block design with four replication. The fertilizer dose was 150 kg N, 75 kg P_2O_5 and 50 kg K_2O per ha, for hybrid rice (Pro-Agro 6201 and Pro- Agro 6444). The fertilizer dose was 120 kg N, 60 kg P_2O_5 and 40 kg K_2O per ha in rice variety Kranti and Pusa sugandha- 5. The rice crop was transplanted at the spacing of 20cm x 15 cm, on 26 July 2010. The gross plot size was 4.5 m x 6m, in different cropping system. *Rabi* crops were planted at recommended spacing with recommended fertilizer dose. The sowing of different *Rabi* crops were done on 16th November 2010-11. The number of irrigation were one irrigation in gram, pea and linseed, five irrigation in wheat, berseem and two irrigation in mustard and potato. All the other recommended package of practices were adopted.

Result and Discussion

The yield data of rice and different *rabi* crops have been given in Table 1. It is evident from the result that rice yield was differed significantly under different cropping systems. The rice variety Pro Agro 6444 gave 92.75 q/ha grain yield which was significantly superior

Table 1. Yield of *kharif* and *rabi* crops, rice equivalent yield, total rice equivalent yield, cost of cultivation, GMR, NMR and B:C ratio as influenced by different cropping system

Treatment	rain yield q/h (kharif)	Yield q/ha (Rabi)	Rice equivalent yield q/ha of rabi crops	Total rice equivalent yield q/ha	Cost of cultivation	GMR `/ha	NMR `/ha	B:C ratio
T_1 Rice (Kranti)- Wheat (WH-147)	75.40	69.09	103.63	177.73	49004	82904	33900	1.69
T_2 Rice (Kranti) Chickpea (JG 322)	81.55	25.45	69.99	157.54	42754	55992	13238	1.3
T_3 Rice (Pro Agro 6201)- Berseem (JB-1)	76.27	2.83 (S) 638.44 (F)	112.32	188.59	57096	89856	32760	1.5
T_4 Rice (Pro Agro 6201)-Potato (Kufri chandramukhi)	82.50	286.78	177.80	260.30	68234	142240	74006	2.0
T_5 Rice (Pro Agro 6444) Garlic (G-1)	92.75	79.34	297.54	390.29	131404	237600	106196	1.8
T_6 Rice (P S – 5) – Linseed (JL- 23)	43.30	10.64	40.20	83.50	38698	32160	6538	0.83
T_7 Rice (P S – 5) – Lentil (JL- 1)	44.72	25.82	112.82	165.04	40934	90256	49322	2.2
T_8 Rice (Pro Agro 6201)-Pea (Arkel)	85.34	75.32	94.24	179.59	48880	75400	26520	1.5
T_9 Rice (Pro Agro 6201)- Chickpea + Linseed	72.56	16.84 (G) 4.45 (L)	60.40	135.49	43836	50344	6508	1.1
T_{10} Rice (P S- 5) – Mustard (Pusa Bold)	46.69	25.07	94.14	142.38	38490	75312	36822	1.9
S Em +	2.752	-	2.727	6.057	-	-	-	-
CD at 5%	7.785	-	7.713	17.13	-	-	-	-

to all the rice variety in different cropping system followed by 85.34 q/ha in Pro Agro 6201 in rice –pea and 82.5 q/ ha in rice – potato cropping system. The rice variety Pro Agro 6444 in rice- garlic and Pro Agro 6201 in different cropping system gave 23.01% and 9.41 % higher grain yield as compared to rice variety Kranti in rice- wheat cropping system.

The data on rice equivalent yield under different cropping system has been given in Table 1. It is clear from the result that the garlic gave 187.11% higher rice equivalent yield than wheat followed by 71.5% in potato, 8.83% in berseem and 8.86% in lentil as compared to rice-wheat cropping system. The rice equivalent yield was decreased by 32.47% in chickpea, 62.21% in linseed, 9.06% in pea and mustard and 41.72% in chickpea + linseed intercropping as compare to wheat. It is because of the facts that the quantity of produce and market price of produce were higher in garlic and potato. The lower yield of rice variety Pusa Sugandha 5 in rice- linseed, rice-lentil and rice- mustard cropping system was the major reason for low productivity of these systems (Sharma *et . al.* 2004).

Data on gross monetary return, net monetary return and B:C ratio have been given in Table 1. It is clear from the result that rice- garlic system gave higher gross monetary return ` 237600/ha but it required higher cost of cultivation. The net monetary return ` 106196/ha was also maximum in rice- garlic system followed by rice-potato ` 74006/ha and rice- lentil ` 49322/ha. The benefit :cost ratio was maximum in rice- lentil system (2.2) followed by rice- potato (2.0), rice- mustard (1.9), rice- garlic (1.8) and rice- wheat (1.69). While, rice-linseed gave minimum benefit :cost ratio (0.83). The cropping system rice (Pro Agro 6444)- garlic, rice (Pro Agro 6201)- potato, rice (Pro Agro 6201)- berseem and rice (PS- 5) – mustard were found fit for crop diversification in *rabi* season as compared to rice- wheat cropping system for Kymore Satpure Agro climatic zone of Madhya Pradesh. The similar findings were also reported by Sharma and Jain (1997) and Uppadhaya *et al.* 2007.

वर्तमान प्रयोग समन्वित कृषि प्रणाली अनुसंधान परियोजना कुठुलिया रीवा में वर्ष 2010-11 में किया गया । परिणाम की विवेचना से स्पष्ट होता है कि धान की किस्म प्रो एग्रो 6444 एवं प्रो एग्रो 6201 धान की किस्म क्रान्ती एवं पूसा सुगन्धा-5 से अच्छी है। लहसुन की खेती विभिन्न रबी फसलों में अच्छी है। लहसुन के बाद आलू, बरसीम एवं मसूर की खेती रबी में अधिक धान समतुल्य उत्पादन देती है। ये फसलें गेहूँ की तुलना में लाभदायक है। फसलक्रम धान-लहसुन सर्वाधिक सकल मुनाफा एवं भाुद्ध मुनाफा देती है। लेकिन अधिकतम आय-व्यय अनुपात

धान-मसूर फसल चक्र से प्राप्त होता है। जबकि सबसे कम मुनाफा धान -अलसी फसल चक्र से प्राप्त हुआ। विभिन्न फसल क्रमों में धान-आलू, धान-सरसो एवं धान-लहसुन से आय-व्यय अनुपात 1.8 से 2.0 तक प्राप्त हुआ। अतः उनकी खेती भी धान - गेहूँ फसल क्रम की तुलना में लाभदायी है।

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Influence of doses of organic manure on direct seeded rice under condition of kymore plateau zone of Madhya Pradesh

Nisha Sapre, Ruchi Tekam and **Girish Jha**
Department of Agronomy
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Jabalpur 482 004 (MP)

Abstract

A field experiment was conducted at Department of Agronomy, JNKVV, Jabalpur (M P) during, kharif of 2011 to study the effect of shakambhari on growth and yield of direct seeded rice. Eight treatments comprising of recommended dose of fertilizer (120:60:40 kg NPK/ka) with different levels of shakambhari was evaluated in a randomized block design with three replications. RDF + 175% of Shakambhari were found superior. All the growth parameters, yield attributing characters and yield were significantly superior.

Keywords : Organic manure, rice

Rice (*Oryza sativa* L.) is the most important staple food for 65% of the population in India and most popular food of the developing world. In India it is grown on nearly 41.9 million hectare with the production of 89.13 million tones and productivity 2130 Kg/ha (Anon 2010). Direct seeded rice cultivation has become popular and promises as alternative to transplanted rice as it reduces about 30% cost of cultivation. It is practiced nearly one third of the total rice area of the country in spite of constrains because transplanting being a labour intensive and costly (Jha et al. 2007). Organic farming has entirely different perspective between developed and developing countries. It can provide high quality food material. That has been produced without any serious ecological impact and harmful residues (Marwaha and Jat 2004). Incorporation of organic manures and bio-fertilizer has exhibited a hope to reduce the cost of cultivation and minimize the adverse effects of chemical fertilizers. Hence, the present study was conducted to study the effect of different dose of organic manure Shakambhari in rice.

Material and methods

A field experiment was conducted at Product testing Unit, Department of Agronomy, JNKVV, Jabalpur, during, kharif season of 2011. Aimed to assess the productivity of rice under recommended dose of fertilizer (RDF) with different doses of Shakambhari and their subsequent effect on soil properties and plant. The soil of experimental field was clayey in texture, neutral in reaction (pH-7.3) with normal EC (0.31) and low OC (0.64). NPK availability of soil were medium (392 kg/ha), low (17.45 kg/ha) and high (297 kg/ha), respectively. The rainfall was 1451.2 mm and weather condition was normal thought out the crop season.

Eight treatments comprising of recommended dose of fertilizer (RDF) with different dose of organic manure Shakambhari viz., T_1-RDF alone (120:60:40 kg NPK ha^{-1}), T_2-RDF + 25% of Shakambhari, T_3-RDF + 50% of Shakambhari, T_4-RDF + 75% of Shakambhari, T_5-RDF + 100% of Shakambhari, T_6-RDF + 125% of Shakambhari, T_7-RDF + 150% of Shakambhari, T_8-RDF + 175% of Shakambhari, were tested in a randomized block designs having 3 replications. Rice var. IR 64 was sown directly at 20 cm row spacing on July 7, 2011. Fertilizers and Shakambhari were applied as per the treatments at different intervals. The crop was grown under assured irrigation. Weed control and other protection measures were under all treatments as recommended package of practice. The crop was harvest on November first week, 2011. Finally economic viability of the treatments was calculated.

Results and Discussion

Growth parameters

Treatment T_8 (RDF + 175% of Shakambhari) exhibited significantly higher plant height 75.7 cm over T_1 (RDF alone) 71.6 cm at maturity of crop (Fig.1). Similarly, Number of tillers/ meter row length 75.75 (Fig.2), leaf area index 7.21 and crop growth rate 13.55 g/day/m^2 (Fig.3), relative growth rate (0.0484 g/g/day/m^2), net assimilation

Table 1. Growth and growth parameters of rice as influenced by different treatments

Treatments	Plant height (cm)	No. of tillers/mrl	LAI	CGR (g/day/m^2)	RGR (g/g/day/m^2)	NAR (g/m^2/day)
T_1-RDF alone	71.10	71.6	4.54	10.41	0.0343	0.02892
T_2-RDF + 25% of Shakambhari	72.07	72.07	4.70	10.60	0.0356	0.02899
T_3-RDF + 50% of Shakambhari	72.35	72.35	5.07	10.70	0.0358	0.03024
T_4-RDF + 75% of Shakambhari	72.85	72.85	5.86	11.08	0.0382	0.03394
T_5-RDF + 100% of Shakambhari	74.13	74.13	5.89	12.51	0.0434	0.03570
T_6-RDF + 125% of Shakambhari	74.50	74.50	6.45	12.61	0.0437	0.03776
T_7-RDF + 150% of Shakambhari	74.67	74.67	6.74	13.5	0.0438	0.03917
T_8-RDF + 175% of Shakambhari	75.70	75.75	7.21	13.55	0.0484	0.04153
SEm±	0.31	0.31	0.17	0.17	0.0013	0.00112
CD(P=0.05)	0.94	0.94	0.51	0.52	0.0040	0.00340

Table 2. Yield attributes and yield of rice as influenced by different treatments

Treatments	No of tillers/meter row length	Panicle length (cm)	No. of grain/ panicle	Grain weight/ panicle	Test weight (g)	Grain yield (q/ha)	Straw yield (q/ha)
T_1-RDF alone	50.01	23.29	96.27	3.87	25.16	41.40	80.46
T_2-RDF + 25% of Shakambhari	51.5	24.24	97.12	3.98	25.2	44.14	85.08
T_3-RDF + 50% of Shakambhari	52.68	24.78	98.51	3.99	25.23	46.87	88.12
T_4-RDF + 75% of Shakambhari	53.88	24.84	99.00	4.09	25.25	50.68	92.40
T_5-RDF + 100% of Shakambhari	57.16	24.87	100.57	4.13	25.27	52.49	96.58
T_6-RDF + 125% of Shakambhari	58.87	26.17	101.26	4.21	25.31	55.21	101.81
T_7-RDF + 150% of Shakambhari	60.35	26.54	105.56	4.23	25.34	57.90	104.22
T_8-RDF + 175% of Shakambhari	62.24	26.78	108.23	4.51	25.36	60.61	107.28
SEm±	0.53	0.409	0.51	0.044	0.05	0.89	1.67
CD(P=0.05)	1.61	1.237	1.53	0.133	NS	2.69	5.07

Table 3. Economics of rice cultivation as influenced by different treatments

Treatments	GMR (Rs/ha)	Total expenditure (Rs/ha)	NMR (Rs/ha)	B:C Ratio
T_1-RDF alone	46228	18304	27924	2.53
T_2-RDF + 25% of Shakambhari	49245	20465	28780	2.41
T_3-RDF + 50% of Shakambhari	52157	22626	29531	2.31
T_4-RDF + 75% of Shakambhari	56224	24787	31437	2.27
T_5-RDF + 100% of Shakambhari	58285	26948	31337	2.16
T_6-RDF + 125% of Shakambhari	61319	29408	31911	2.09
T_7-RDF + 150% of Shakambhari	64153	31269	32884	2.05
T_8-RDF + 175% of Shakambhari	67047	33430	33617	2.01

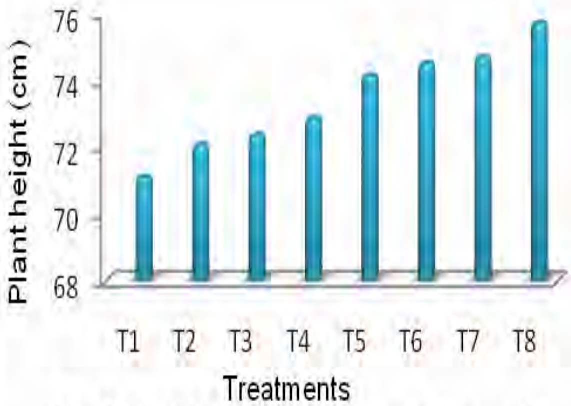

Fig. 1. Plant height (cm)of rice as influenced by different treatments

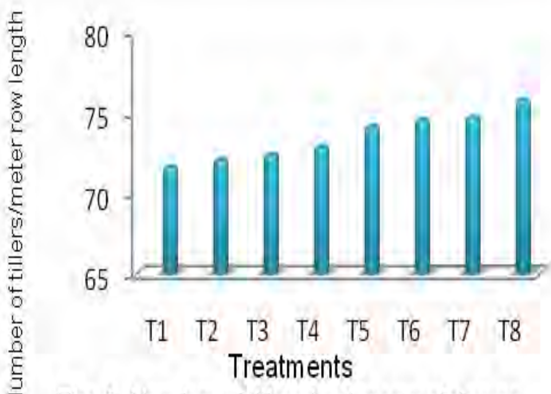

Fig. 2. Number of tillers/meter row of rice as influenced by different treatments

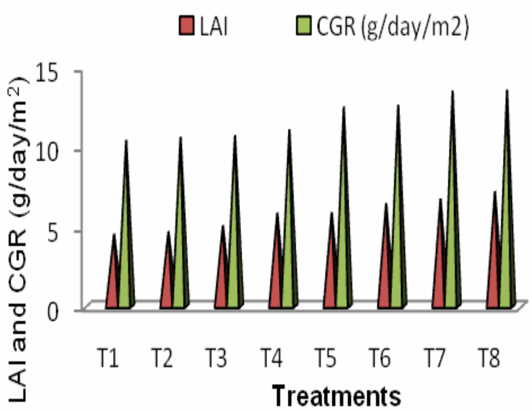

Fig. 3. Leaf area index and Crop growth rate of rice as influencd by different treatments

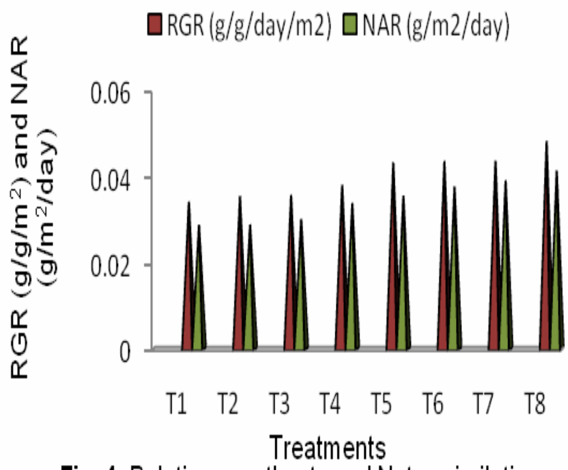

Fig. 4. Relative growth rate and Net assimilation rate of rice as influenced by different treatments

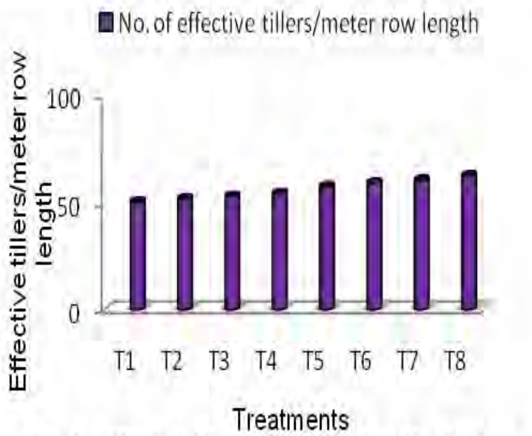

Fig.5. Effective tillers/meter row length of rice as influenced by different treatments

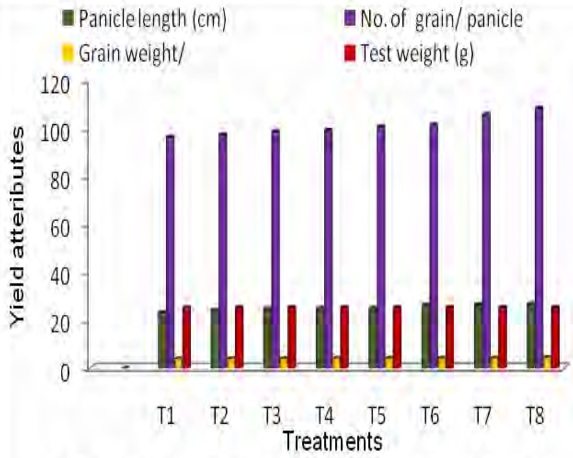

Fig.6. Length of panicle, No. of grain/panicle, grain weight/panicle, test weight of rice as influenced by different treatments

rate (0.04153 g/ m^2/day) was the highest under T_8 (Fig.4). While all the above growth parameter were minimum under T_1 (Table.1). The increase in growth parameters was attributed to the fact that application of organic manure increased the soil organic carbon that holds greater moisture in soil and creats of suitable condition for better root growth and proliferation and also opportunity to extract water from larger profile area. These results were in conformity with the findings of Rao et al. (2004) and Shekara et al. (2009).

Yield attributes and yield

Number of effective tillers/meter row length 62.24 (Fig.5), panicle length (26.7 cm), number of grains/anicle (108.23), grain weigh per panicle (4.51g) and test weigh (25.26 g) found highest under T8 (RDF + 175% of Shakambhari) (Fig.6) .While, all the above growth parameters were found minimum under T_1 (50.01,23.29 cm,96.27,3.87g and 25.16 g, respectively). Similarly, highest grain yield 60.61q/ha and straw yield 107.28q/ha were observed under T_8 .While, minimum were found under T_1 (RDF alone) 41.40q/ha and 80.46 q/ha, respectively (Table 2 and Fig.7). Increase in yield attributes and yield might be due to the favorable effect of Shakambhari on the availability of nutrients to the crop, taht enhanced the effectiveness of tillers, grains/ panicle as well as length of panicle. These results are closely conformity to the findings of Singh et al. 2008 and Mankotia et al. (2008).

Economics

The gross monetary returns was maximum (Rs 67047/ha) with T_8 (RDF + 175% of Shakambhari) followed by T_7 (RDF + 150% of Shakambhari). The gross monetary returns was remarkably minimum (Rs 46228/ha) with T_1 (RDF alone) among all treatments. Treatment T_8 recorded maximum net monetary returns (Rs 33617/ha) with 2.01 B:C ratio among all treatments. While, treatment T_1 gave the profit up to Rs 27924/ha with 2.53 B:C ratio (Table 3). After the calculation of treatment cost it was found that one gram Shakambhari valued about Rs. 4.17 and it increased the cost of cultivation about 2161Rs/ha as every increase of 25% of Shakambhari from RDF. Therefore, all the treatments show gradually increase in cost of cultivation with increasing dose of Shakambhari. These results are in conformity with the findings of Bhoite (2005).

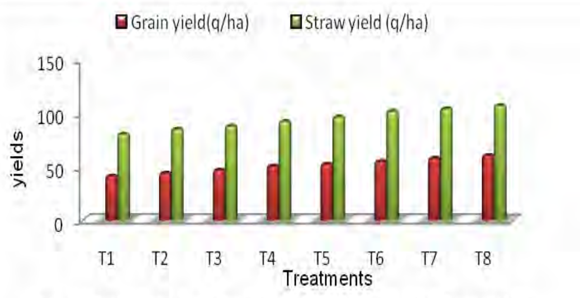

Fig. 7. Grain yield and straw yield (q/ha) of rice as influenced by different treatments

वर्ष 2011 के खरीफ मौसम में सस्य विज्ञान विभाग ज.ने.कृ.वि.वि., जबलपुर में कार्बनिक खाद शाकंभरी का सीधे बुवाई वाली धान के फसल की उपज एवं वृद्धि पर प्रभाव देखने के लिये एक प्रयोग किया गया। जहाँ उर्वरक की अनुशंसित मात्रा (120:60:40 किग्रा. नत्रजन, स्फुर, पोटाश/हे) के साथ शाकंभरी के आठ स्तरों का परिक्षण किया गया। प्रयोग यादृच्छिक खण्ड अभिकल्पना में तीन पुनरावृत्ति के साथ विन्यस्त किया गया। उर्वरक की अनुशंसित मात्रा के साथ 175 प्रतिशत शाकंभरी का उपयोग श्रेष्ठ पाया गया। यहां पौधों की वृद्धि बढाने वाले गुणों के साथ-साथ उपज बढाने वाले गुण एवं उपज सकारात्मक रुप से अधिक पायी गयी।

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Assessment of genetic purity of hybrid and their parents in rice using microsatellite markers

Chanchal Mishra, Niraj Tripathi*, D. Khare, N. Saini* and **G.K. Koutu**
Department of Plant Breeding and Genetics
*Biotechnology Centre
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Jabalpur 482 004 (MP)

Abstract

Microsatellite markers were used for fingerprinting and testing of genetic purity of hybrid and their parents in rice. 56 sequence tagged microsatellite sites (STMS) markers were employed for fingerprinting six hybrids and their parental lines (4x3). Twelve STMS markers were found polymorphic across the hybrids. All the 12 were amplified as heterozygous in all the hybrids, whereas eight (JGT 3 - 36.1, RM 15331, RM 423, RM 449, RM 510, JGT 04 -18.1, RM 8126, and JGT 11 - 16.3) may differentiate the lines as Restorer or Female (A line). Female parents (IR 58025A, IR 68886 A, IR 68897A and Pusa 6A) may be differentiated by primer RM 6938, RM 28157 and JT 02 - 9.1 whereas male parents (NPT 10, NPT 65 and NPT 70) by RM-6938 and few hybrids by JGT 02 - 9.1, JGT 04 -18.1 and RM 28157.

Key words: Hybrid rice, micro-satellite markers, genetic purity, distinctiveness

Rice is the principal food crop, feeding more than half of the world's population (Virmani 1999). Phenomenon of heterosis is exploited commercially for yield enhancement in rice primarily based on three-line system. Assessment and maintenance of genetic purity of the parental lines and hybrids is crucial for the successful adoption of hybrid rice technology. Molecular markers have the potential in achieving this goal (Yashitola et al. 2002; Rajendrakumar et al. 2007).

Identification and verification of elite crop varieties and hybrids is essential for seed production, certification, and maintenance breeding and ultimate protection. At present National Test Guidelines based on the expression of morphological traits is currently used for verification, estimation of distinctiveness and protection of a variety. Expressions of listed traits in the guidelines are sensitive to environment. Molecular markers provide an unbiased means of identifying crop varieties (Yashitola et al. 2002). The Biochemical and Molecular Techniques Group of the International Union for the Protection of New Varieties of Plants (UPOV) is evaluating different DNA marker parameters prior to its routine use in establishing distinctness, uniformity and stability of plant varieties (UPOV-BMT 2002).

To test the genetic purity of hybrid seeds, one must be able to distinguish, within a random sample of seed, those formed by crossing the female and male parents (hybrid seed); seed formed by a self-pollinated female parent (B line); the seed of male parent (A line) mixed by error; seed of other genotype or the seed is hybrid but not of designated one. The genetic heterogeneity, if any, within the parental lines could lead to lack of uniformity in the commercial F1 seeds resulting into poor acceptance of the hybrid produced and adverse mutant values. Since the STMS markers are co-dominant, they can be used for unambiguous identification of both the homozygotes and the heterozygotes at a particular marker locus. Thus, these markers have the potential to test genetic heterogeneity within the parental lines. Among the various DNA based markers currently available, genetically mapped sequence tagged microsatellite sites (STMS) are the markers of choice in rice because of their abundance, co-dominant nature and uniform distribution throughout the genome (McCouch et al. 2002). Higher level of polymorphism among rice varieties and hybrid with AFLP, ISSR and SSR marker (Saini et al. 2004; Nandkumar et al. 2004; Sundaram et al. 2008) have been reported for distinctness and hybridity test.

The primary objective of the present study was to identify the six rice hybrids of JNKVV, Jabalpur and differentiation of their parental lines by employing STMS markers, and to provide bases for protection of restorer lines developed from *indica* X *japonica* crosses with the selection pressure towards New Plant Type.

Material and Methods

DNA from the young leaves and seedlings of six rice hybrids developed by JNKVV, Jabalpur and their parental lines (Table 1) were isolated by CTAB method (Saghai-Maroof et al. 1984) and quantified in UV spectrophotometer. In all 56 SSR markers and 14 random decamer nucleotide 10 – mer primers (Williams et al. 1990) were used to test the hybridity and verify the hybrids and their parents in reference to genetic purity test during *Kharif* 2008. SSR amplified products were resolved on 3.5% (w/v) high resolution agarose (Sigma Aldrich) and 4% denatured polyacrylamide gel, as described by Chen et al. (1997).

Result and Discussion

Out of 56 SSR primers, 12 were found polymorphic across the parents and hybrids (Table 2). All the 12 markers were amplified as heterozygous in all the hybrids. In all nine markers amplified both the alleles of their respective parents in all the hybrids under study. Therefore they may identify hybrid seed without differentiating hybrids.

Eight polymorphic marker *viz.,* JGT 3 - 36.1, RM 15331, RM 423, RM 449, RM 510, JGT 04 -18.1, RM 8126, and JGT 11 -16.3 differentiate the lines as Restorer or Female. However identification of genotype was not possible with these markers. A total of 69 alleles were amplified with the maximum number *i.e.,* three by marker JGT 4 -18.1 and RM 28157.

Primer RM 6938 and JT 02 - 9.1 located on chromosome number 2; JGT 04 -18.1 on chromosome number 4 and RM 28157 on chromosome number 12 were able to discriminate female parents based on the alleles produced by these markers. Primer JT 02 - 9.1 amplified a specific allele of about 400 bp in parent 86A while primer JGT 04 -18.1 amplified specific alleles of about 96 bp and 250 bp in parent 97A and 25A respectively, while two alleles of about 110 and 250 bp were amplified in parents 86A and Pusa 6A. Primer RM 6938 differentiated the parents, 97A and 86A from 25A and Pusa 6A. Similarly Microsatellite marker RM 28157

Table 1. Details of parental lines and hybrids of rice

	Genotype	Parentage	Reference
Group I -		CMS (female) line	
	IR 58025A	IR 48483A X Pusa 167-120-3-2	Sundaram et al. (2008)
	IR 68886 A	IR 62829A X IR 62832-58-7-8-1-8-12-4	
	IR 68897A	IR 62856-15-3-1-1-7-5-10-3	
	Pusa 6A	?	
Group II -		Restorers	
	NPT 10	Selection from *indica* x *japonica* crosses	
	NPT 65		
	NPT 70		
Group II -	Hybrids		
	JRH 4	86 A X NPT 65	
	JRH 5	97 A X NPT 65	
	JRH 10	97 A X NPT 10	
	JRH 11	Pusa 6 A X NPT 70	
	JRH 12	25 A X NPT 70	
	JRH 13	86 A XNPT 10	

A set of 56 SSR markers, well distributed all over the genome *i.e.,* 5 on chromosome number 1; 7 on chromosome number 2; 4 on chromosome number 3; 1 on chromosome number 4; 5 on chromosome number 5; 4 on chromosome number 6; 5 on chromosome number 7; four on chromosome number 8; 4 on chromosome number 9; 4 on chromosome number 10; one on chromosome number 11 and 02 on chromosome number 12 were used whereas location of 10 markers were not known.

Table 2. SSR markers exhibiting polymorphic expression across the parents and hybrids of rice

Name	Forward sequences	Reverse sequences	Chromosome
RM 8126	TGGGCCTCTTTGTTTCATACTCC	TCCTCATCTCTCTCCGTGTCTCC	1
RM 6938	CCGATTAGCGATTGATATGGAGTAGG	AGTGCACAGCCATGGAATTATGC	2
RM 12469	ACTCCATCGAACCCTGTTAGAGC	GTCCATGTTTGCTTACGTGTTTGC	2
RM 423	AGCACCCATGCCTTATGTTG	AGCACCCATGCCTTATGTTG	2
RM 449	TTGGGAGGTGTTGATAAGGC	ACCACCAGCGTCTCTCTCTC	2
JGT 02-9.1	CCATGTGGCGGTCTAGGAGTATTTGT	TGCCCTTGCTAAATAAATGCTACCC	2
RM 15331	GGTTCGGTGCTTTCTCTTTCAGC	AGCGATGCCGTCCTTACACC	3
JGT 03-36.1	GCGGCAACACGACCAGCTT	CATCCTGAGTTTTGAGAAGCACCATA	3
JGT 04-18.1	CGTGGCGGTATATGAGCGTTTGTA	AGCGGGCCTCATCTCCATAGTC	4
RM 510	AACCGGATTAGTTTCTCGCC	TGAGGACGACGAGCAGATTC	6
JGT 11-16.3	GGCGGCGTATTAGCGTTGTA	AGGTTCTAGCCCATGTTAAATCTTCT	11
RM 28157	GCTTAATTTCTGACAGACCAGTGC	GATCTAAACACAGCCTTCCTTGG	12

Table 3. SSR markers differentiated the female lines

Primer	Allele Size (bp)			
	97A	86A	25A	Pusa 6A
RM 6938	265	265	270	270
RM 28157	521	497	521	497
JGT 02 - 9.1	405	400	405	405
JGT 04 -18.1	96	110/250	250	110/250

Table 4. Frequency of heterozygosity at micro satellite loci in hybrid rice

Rice hybrid			Frequency
Female parent	Male parent	Hybrid	Micro-satellite marker
IR 68886A	NPT 65	JRH 4	3/12
IR68897A	NPT 6	JRH 5	4/12
IR68897A	NPT 10	JRH 10	3/12
Pusa 6 A	NPT 70	JRH 11	3/12
IR58025A	NPT 70	JRH 12	3/12
IR 68886A	NPT 10	JRH 13	2/12

differentiated the parents, 97A and 25A from 86A and Pusa 6A. Maximum four and minimum two micro-satellite markers were able to show polymorphism in each hybrid (Table 3). The frequency of heterozygocity for a hybrid ranged from 33% to a maximum of 16% (Table 4). Atleast one polymorphism was detected with the set of markers for each of the parental combination being used in hybrid seed production. Sundaram et al. (2008) also identified some SSR markers those differentiate the few of these A lines.

The restorer lines were the advance lines of the *indica* x *japonica* crosses selected in the background of New Plant Type. Out of 56 SSR markers only one was found polymorphic. Very little diversity at molecular level showed that restorer lines might be the advance lines of the same cross with variation in phenological traits. Among the restorer lines, marker RM 6938 amplified a specific allele of about 270 bp in NPT 70 and allele of size 265 bp in NPT 10 and NPT 65. The markers RM 6938 amplified a specific allele in restorer NPT 70, which is different than the amplification in remaining two restorer lines. The markers RM 6938 may be used for protection of restorer and hybrids.

The six hybrids developed using three R-lines and four A-lines amplifying both alleles of their respective parents. No unique or cross amplification was observed in these hybrids. Marker JGT 02 - 9.1, JGT 04 -18.1 and RM 28157 amplified differently among the hybrids. By using a set of three markers we can identify and differentiate the above studied hybrids. Identification and use of such hybrid specific markers can effectively reduce the cost and simplify the procedure of hybrid identification.

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धान मे संकर एवं उनके जनकों की अनुवांशिक शुल्ता एवं फिगंर प्रिंटिंग हेतु माइक्रोसेटलाइट चिन्हकों का उपयोग किया गया । बारह एस.टी.एम. चिन्इक सभी संकरों में हेटरोजाइगस रूप मे प्रदर्शित हुए । इनसे आठ कतारों की रिस्टोरर या नर नंपुसक के रूप में पहचान की जा सकती है । नर जनकों को के.आर.एम. 6938 के द्वारा तथा कुछ संकरों को जे.जी.टी. 02-9-1, जे.जी.टी. 04-18-1 तथा आर.एम. 28157 के द्वारा अलग पहचाना जा सकता है ।

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Effect of fertilizer doses on the intensity of aerial blight (*Rhizoctonia solani)* of soybean

R.K. Varma, Kamlesh Patel and **S.D. Sawarkar**
Department of Plant Pathology
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Jabalpur (MP) 482 004

Abstract

All the fertilizer doses tested were found to reduce disease intensity of RAB in soybean. Three doses 150%NPK, 100%NP and 100%N had very little effect in reducing the disease intensity. Maximum per cent disease control of 33.0 per cent was recorded in 100%NPK+ FYM followed by 100%NPK+Zn of 29.2 per cent. Maximum of 19.7 per cent loss in 1000 seed weight due to RAB was observed in 100%N whereas minimum loss of 16.3 per cent in 150%NPK. RAB cause quantitative (yield loss, 1000 seed weight) and well as qualitative loss (discoloration, shriveled) in seeds. Nitrogen alone or in combination with Phosphorus could not reduce the disease severity. Full dose of NPK alone or with Zn helped in reducing the disease.

Keywords: Soybean, RAB, fertilizer

Major soybean (*Glycine max* (L.) Merrill) producing states in India are Madhya Pradesh, Maharashtra, Rajasthan, Karnataka and Andhra Pradesh. In Madhya Pradesh, it is being grown in an area of 55.193 lakh hectares during the year 2010 with the production of about 60.987 lakh MT. with productivity level of 1105 kg/ha (SOPA 2010). Soybean suffers from many diseases such as yellow mosaic disease (Mungbean yellow mosaic virus), charcoal rot (*Rhizoctonia bataticola*), collar rot (*Sclerotium rolfsii*), Rhizoctonia root rot and Rhizoctonia aerial blight (RAB) caused by *Rhizoctonia solani.* Rhizoctonia foliar blight has been reported to cause epiphytotics in soybean throughout the world (Jones and Belmar 1989, Yang et al. 1990, Liu and Sinclair 1991, Muyolo et al. 1995 and Embrapa 1999). Occurrence of RAB in the epidemic form was recorded in La, USA during 1973 and 1975 (Neill et al. 1977). In the year 1993 soybean yield was reduced by 18% due to RAB (Black et al. 1989) and in Brazil and northwest Brazil by 31 to 60% (Fenille et al. 2002). Annual losses due to RAB in India is 879.6mt USA 111.5mt, China 16.6mt, and in Brazil 14.4mt. It has attained serious proportion ever since it was first reported in India. In India this disease was first time came in record from Sikkim in 1987-88 (Srivastava and Gupta 1989) and from Rajasthan during a survey at Banswara (Goyal and Ahmed 1988). Cultural measures are considered as important choices for the control before the establishment of the disease. Based on evidences that potassium (K) amendments can substantially reduce the severity of several soybean diseases such as Cercospora leaf blight (*Cercospora kikuchii*), pod and stem blight (Phomopsis *phaseoli* var. *sojae*) and stem canker (*Diaporthe phaseolorum* f.sp*. meridionalis*). Despite all evidence, there is little information in the literature about the effect of NPK fertilizer application in controlling soybean foliar blight hence investigations were undertaken.

Material and Methods

The present investigation was undertaken in the Department of Soil Science and Agricultural Chemistry Research Farm, JNKVV Jabalpur during 2010-11. The materials used and methods followed were as follows:

Effect of various doses of fertilizers

To assess the effect of various fertilizer doses on disease intensity of Rhizoctonia aerial blight, a field trial was laid out in experimental farm, Department of Soil Science and Agricultural Chemistry Adhartal. The present study pertains to 10 treatments of the experimental plan, replicated four times in a randomized block design. The gross size of each plot was 17×10.8 m^2 with 1m spacing in between the plots and 2m among the replications including Treatments as T_1 – 50% NPK T_2 – 100% NPK T_3 – 150% NPK T_4 – 100% NPK + HW T_5 – 100% NPK + Zn T_6 – 100% NP T_7 – 100% N T_8 – 100% NPK + FYM T_9 – 100% NPK – S and T_{10} – Control.

Optimal NPK doses (100per cent) based on initial (1972) soil test values were nitrogen 120:80:40 and 20:80:20 for wheat and soybean respectively. Nitrogen was applied through urea, phosphorus through single super phosphate except in treatment T_9, where application of sulphur was omitted therefore, di-ammonium phosphate was used as a source for phosphorus and the dose of nitrogen was adjusted through urea, potassium was applied through murate of potash. In T_8 treatment the FYM was applied @ 15 ton ha^{-1} to soybean crop every year. For calculation of 1000 seed weight, separate plot of each treatment was sprayed with carbendazim (0.15%} first at the onset on the disease and second after 10 days of first spray. Seeds were harvested and at 9 per cent moisture 1000 seed weight were measured.

Calculation of Percent Disease Index (PDI)

Select randomly ten plants in each treatment (plot) and each selected plants should be approximately divided into three positions as bottom, middle and top. From each position three to five leaves should be graded as per the following diseases assessment key of Mayee and Datar which is mainly based on the percent leaf area infected (0 to 9 scales).

These grades are then utilized for the calculation of

Rating scale (Grade)	Description (visual observation)
0	No lesions/spots
1	1% of the leaf area covered with lesions/ spots
3	1.1 to 10% of the leaf area covered with lesions/spots, no spots on stem.
5	10.1 to 25% of the leaf area covered no defoliation-little damage.
7	25.1 to 50% of the leaf area covered, some leaves drop, death of a few plants, damage conspicuous.
9	>50.1 % of the leaf area covered, lesions/ spot vary common on all plants, defoliation common, death of plants common, damage more than 50%

PDI using the following formula of Wheeler.

On the basis of PDI, the entry/variety will be classified as follows:

$$\text{Percent disease index (PDI)} = \frac{\text{Sum of individual rating}}{\text{No. of leaves examined}} \times \frac{100}{\text{Max. disease rating}}$$

0.1 - 1.0	=	highly resistant
1.1 - 10.0	=	moderately resistant
10.1 - 25.0	=	moderately susceptible
25.1 - 50.0	=	Susceptible
> 50.0	=	highly susceptible

Calculation of Percent Disease Control (PDC)

Percent disease control was calculated by following formula.

$$\text{Percent Disease Control (PDC)} = \frac{\text{Control - Treatment}}{\text{Control}} \times 100$$

Results and Discussion

Effect of fertilizer doses

The data presented in the Table 1 indicated that range of PDI (Per cent disease index) ranged from 22.9 per cent to 55.9 per cent. Similarly range of percent loss was from 20.44 per cent to 55.22 per cent. Maximum PDI 55.9 per cent was observed in control. Among treatments maximum PDI 45.2 per cent was recorded in 100%N, whereas minimum PDI 22.9 per cent was observed in 100%NPK.+Zn. Observation showed that maximum per cent loss of 55.22 per cent was recorded in control followed by 100%N of 42.16 whereas minimum per cent loss of 20.44 was recorded in 100%NPK+FYM. All the fertilizer doses tested were found significantly effective in reducing the disease severity of RAB in soybean. Per cent disease control over control ranged from 10.7 per cent to 33.0 per cent.

Maximum per cent disease control of 33.0 per cent was recorded in 100%NPK.+Zn followed by 100%NPK+FYM of 29.2 whereas minimum per cent disease control of 10.7 per cent was recorded in 100%N. Two treatments i.e. 100%N and 100%NP had reduced 10.7 and 10.8 per cent disease control over check (no

Table 1. Effect of different fertilizer doses on disease intensity of RAB and yield of soybean

S.No.	Treatments	PDI	Yield (Kg/ha)		Loss (%)	PDC
			Protected	Unprotected		
T_1	50%NPK	35.1	3350	2260.0	32.53	20.8
T_2	100%NPK	40.6	3350	2490.0	25.67	15.0
T_3	150%NPK	30.3	3350	2512.5	25.00	25.6
T_4	100%NPK+HW	38.3	3350	2475.0	26.11	17.6
T_5	100%NPK+Zn	22.9	3350	2487.5	25.74	33.0
T_6	100%NP	45.1	3350	2287.5	31.71	10.8
T_7	100%N	45.2	3350	1937.5	42.16	10.7
T_8	100%NPK+FYM	26.7	3350	2665.0	20.44	29.2
T_9	100%NPK-S	38.5	3350	2425.0	27.61	17.4
T_{10}	Control	55.9	3350	1500.0	55.22	-
SEm±	1.34		128.66			
CD 5%	3.90		373.00			

Table 2. Effect of RAB on 1000 seed weight

S.No.	Treatment	PDI	1000 Seed Weight		Loss(%)
			Protected (g)	Unprotected (g)	
T_1	50%NPK	35.1	100	82.8	17.2
T_2	100%NPK	40.6	100	82.2	17.8
T_3	150%NPK	30.3	100	83.7	16.3
T_4	100%NPK+HW	38.3	100	82.3	17.7
T_5	100%NPK+Zn	22.9	100	83.2	16.8
T_6	100%NP	45.1	100	81.2	18.8
T_7	100%N	45.2	100	80.3	19.7
T_8	100%NPK+FYM	20.7	100	82.4	17.6
T_9	100%NPK-S	28.5	100	82.2	17.8
T_{10}	Control	55.9	100	79.0	21.0
S.Em±	1.34		0.67		
C.D. at 5%	3.90		1.94		

fertilizer) as compared to other treatments.

Effect of RAB on 1000 Seed weight

Effect of various doses of fertilizers on 1000 seeds was studied on the basis of yield in protected and unprotected crop and presented in the Table 2.

The data presented in the Table-2 indicated that range of PDI (percent disease index) of nine fertilizer doses was between 15.3 per cent to 55.9 per cent and range of per cent loss was between 16.3 per cent to 21.0 per cent. Maximum PDI 45 per cent was observed in T_7 (100%N) as compared to 55.9 per cent in control. Minimum PDI of 15.3 per cent was recorded in 50%NPK. Maximum per cent loss of 21.0 per cent was recorded in control followed by 19.7 per cent in 100%N. Minimum of 16.3 per cent loss was observed in 150%NPK followed by 16.8 per cent in 100%NPK+Zn. Data also exhibited that none of fertilizer doses had 1000 seed weight equal to protected i.e. 100g.

All the fertilizer doses tested were found to reduce disease intensity. Maximum per cent disease control of 72.6 per cent was recorded in 50%NPK followed by

100% NPK-S of 66.9. Disease intensity increased with increased doses of nitrogenous fertilizer upto recommended doses have been reported by many workers (Sarkar et al. 1991, Borthakur et al. 1989, Slaton et al. 2003, Tang et al. 2007 and Cartwright et al. 2000). Similar findings have been also reported by Guzman and Nieto (1992) and Basu (1996) in sheath blight of paddy and Patel and Bhargava (1998) in soybean. Kashem et al. (1994) reported significantly increase in disease intensity with increase in fertilizer doses. Reduction in disease intensity with the application of K have been reported by Basseto et al. 2007, Adebitan 1998 and Wan et al. 2005. Sati and Sinha (2005) found that among the treatments, K alone or in combination with N or P reduced the survival of the mycelium of the pathogen in plant debris. Thus effect of recommended/combination of fertilizer on disease intensity of RAB is lacking. The present investigation indicated variable reduction in disease intensity due to application of fertilizers. This difference in opinion might be due to difference in crop, causal agent and/or ecological variations.

प्रयोग में लाए गए सभी रासायनिक खाद की मात्रा से सोयाबीन में राइजोकटोनिया अंगमारी की व्रीवता में कमी पाई गई । तीन मात्रा 150 प्रतिशत एन.पी.के., 100 प्रतिशत एन.पी. और 100 प्रतिशत एन. में असर कम था । रोग की व्रीवता में सबसे ज्यादा कमी (33 प्रतिशत) 100 प्रतिशत एन.पी.के. + गोबर की खाद तथा 100 प्रतिशत एन.पी.के. + जिंक (29.2 प्रतिशत) पर नापी गई । 1000 बीज के वजन में सबसे ज्यादा नुकसान (19.7 प्रतिशत) 100 प्रतिशत नत्रजन तथा सबसे कम नुकसान (16.3 प्रतिशत) 150 प्रतिशत एन. पी.के. पर आंकी गई । केवल नत्रजन या नत्रजन के साथ फासफोरस उपयोग करने से रोग की व्रीवता पर ज्यादा असर नहीं आंका गया। अनुशंसित मात्रा या फिर अनुशंसित मात्रा के साथ जिंक के उपयोग से रोग की व्रीवता में कमी लाई जा सकती है ।

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Efficacy and economics of phyto extracts against *Hyadaphis coriandri* Das and *Coccinella sexmaculatus* on coriander

R. Pachori, A. Tandekar, A.S. Thakur and **A.K. Panday**
Department of Entomology
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Jabalpur 482004 (MP)

Abstract

Investigation were made at farmers field in village Amkhera of Jabalpur District, with seven phyto extracts against coriander aphid (*Hyadaphis coriandri)* and grain yield during the cropping year of 2009- 2010 . The phyto extracts applied in two different schedules significantly reduced the *H. coriandri* population as compared to control. The order of effectiveness of treatments applied against *H. coriandri* was in order of Neem (12.75), > Lantana (17.90), > Ipomea (21.85), > Akua (24.72), > Dhatura (30.65), > Parthenium (31.15), > Custard apple (40.03), > Control(62.57). Treatments were found to have effect on the yield of coriander. The maximum yield (741 kg/ha) recorded from the plot treated with the extract of Neem (5%) was found significantly superior over other treatments. The lowest yield (510 kg/ha) was observed from the untreated control plots. The coriander crop affected with aphid attracted *Coccinellid* predators. All the treatments significantly affected the population of *C. sexmaculatus* in comparison to the untreated control.

Key words: Plant extracts, predators, cost-benefit ratio.

Coriander (*Coriandrum sativum* Linn.) is one of the most important spices used in daily food by majority of Indians. It occupies an important place in the spice industry and play a major role in Indian cuisine. It is extensively grown in India, Russia, Central Europe, Asia minor and Morocco (Kumaresan et al. 1988). India is the largest producer of coriander with a world production share of about 70 per cent. In India, coriander is cultivated in an area covering 320.80 thousand ha. with a production of 233.20 thousand MT and productivity of 0.72 MT/ha. during 2006-2007 (Anon 2007). Coriander crop is affected by large numbers of insect pests and coriander aphid *H. coriandri* is most damaging pest of this crop. Aphid incidence on coriander occurs from flowering stage till maturity, resulting considerable damage in yield. Farmers are generally using synthetic insecticides for the management of the pest. The ill effects of inorganic insecticides and synthetic pyrethroids are well known and can be avoided by replacing them with bio - pesticides. The bio - pesticides have received greater importance in recent years due to their eco - friendly nature and the growing awareness about harmful effects of indiscriminate use of synthetic pesticides. To reduce the pesticides hazards, the option is the application of insecticides of plant origin which are easily available and safer to mankind. Neem plant has proved itself as wonderful insecticides of plant origin, which is harmless to higher animals including man (Walunj et al. 1996). Keeping these facts in view, the present studies were under taken to evaluate the different phyto extracts for the management of coriander aphids.

Material and Methods

The investigation was conducted on farmers field during rabi season of the year 2009-2010 in a Randomized Block Design (RBD) with three replications at village Amkhera of Jabalpur District. The coriander variety Symco 31 was grown. The phyto extracts (Custard apple 5%, Ipomea 5%, Lantana 5%, Dhatura 5%, Neem 5%, Parthenum 5%, Akua 5%) were applied twice as foliar application using Foot Sprayer. Total quantity of spray solution required for uniform coverage of the crop on per plot basis was worked out as for each treatments separately. The crop was sprayed twice with each of the phyto extracts at an interval of 7 days on the appearance of the pest. Observation was recorded on the number of *H. coriandri* a day before the spray and on 1st, 3rd and 7th days after spraying, from 10 randomly selected apical twigs (10 cm length/ 10 randomly selected plants/plot). At harvest of the crop, grain yield per plot and efficacy of the treatment was also recorded.

Results and Discussion

Effect of phyto extracts on the population of *H. coriandri*

The pre-treatment observations indicated non-significant differences in *H. coriandri* population (ranged between 61.70 to 63.40 aphid/plant/10 cm twig) among different experimental plots. All the phyto extracts were found to be significantly superior over untreated control in reducing *H. coriandri* population (Table-1).

The mean *H. coriandri* population in the treatments revealed that neem 5% (21.78 aphids/twigs) had significantly superior over all other treatments followed by Lantana 5% (25.77 aphids/twigs), Ipomea 5% (28.56 aphids/twigs) and Akua 5% (34.11 aphids/twigs). Dhatura 5% (39.44 aphids/twigs) and Parthenium 5% (40.77 aphids/twigs) were the next better treatment while custard apple 5% (46.20 aphids/twigs) were found to be least effective as compared to all other treatments. During first spraying lowest population of aphid was recorded on 7th days after application of phyto extracts followed by 3rd and 1st days after spraying similar result was also recorded after second spraying the lowest population was recorded 7th days after spraying followed by 2nd and 1st days after application.

Among the various treatments Neem 5% was found most superior treatment they reduced the *H. coriandri* population up to 64.98% over control it was followed by Lantana 5% (58.58%) and Ipomoea 5% (54.11%). Custard apple reduced the aphid population up to 25.74% it was the lowest among the treatments it was followed by Parthenium 5% (22.61%) and Akua 5% (23.54%).

Effect of different phyto extracts on the population of *Coccinella sexmaculatus* predator

The coriander crop affected by *H. coriandri* was attracted by large number of *C. sexmaculatus* predators. All the phyto extracts were significantly affected the population of *C. sexmaculatus* in comparison to the untreated control, where the population of *C. sexmaculatus* is highest. The pre-treatment observations indicated non-significant differences in population *C. sexmaculatus* (ranged between 3.93 to 4.60 per plant/10 cm twig) among different experimental plots. All the phyto extracts significantly reduced the population of *C. sexmaculatus* over untreated control. Among the first spray treatments highest number of *C. sexmaculatus* was recorded from the untreated control plot followed by Custard apple 5%, Dhatura 5%, Akua 5%, Lantana 5%, Parthenium 5%, Ipomea 5%, Neem 5%. During the second spraying the highest number of predator population was again recorded from the untreated control plot followed by Custard apple 5% >Akua 5% , Parthenium 5%, Lantana 5%, Dhatura

Table 1. Effect of different phyto extracts on the population of *H. coriandri* infesting coriander plant

Treatments	Pre treatments	Post treatment							
		First spray				Second spray			
		1st day	3rd day	7th day	Mean	1st day	3rd day	7th day	Mean
Custard apple 5%	62.93	60.90	51.50	44.70	52.37	43.33	40.27	36.50	40.03
	(7.96)	(7.84)	(7.20)	(6.72)	(7.25)	(6.62)	(6.38)	(6.08)	(6.36)
Ipomea 5%	62.40	41.10	33.80	30.80	35.23	26.97	21.30	17.30	21.85
	(7.93)	(6.45)	(5.85)	(5.59)	(5.96)	(5.23)	(4.67)	(4.22)	(4.70)
Lantan 5%	62.33	38.50	32.80	29.60	33.63	21.60	17.53	14.57	17.90
	(7.93)	(6.24)	(5.77)	(5.49)	(5.83)	(4.70)	(4.25)	(3.88)	(4.27)
Dhatura 5%	63.10	55.30	48.80	40.60	48.23	34.70	30.83	26.43	30.65
	(7.97)	(7.47)	(7.00)	(6.41)	(6.96)	(5.93)	(5.60)	(5.19)	(5.57)
Neem 5%	63.40	37.50	29.90	25.03	30.81	16.37	12.30	9.60	12.75
	(7.99)	(6.16)	(5.51)	(5.05)	(5.57)	(4.10)	(3.58)	(3.18)	(3.62)
Parthenium 5%	61.70	59.53	50.90	40.70	50.38	35.47	30.37	27.63	31.15
	(7.89)	(7.75)	(7.17)	(6.42)	(7.11)	(6.00)	(5.56)	(5.30)	(5.62)
Akua 5%	63.03	53.20	37.80	39.50	43.50	28.60	25.20	20.37	24.72
	(7.97)	(7.32)	(6.19)	(6.32)	(6.61)	(5.93)	(5.07)	(4.57)	(5.19)
Control	62.80	62.27	60.90	62.37	61.85	61.13	63.80	62.80	62.57
	(7.96)	(7.92)	(7.83)	(7.93)	(7.89)	(7.85)	(8.02)	(7.50)	(7.81)
SEm±	0.97	0.14	0.18	0.08	0.08	0.06	0.04	0.04	0.06
CD at 5%	NS	0.41	0.54	0.25	0.26	0.17	0.13	0.11	0.19

Table 2. Overall effect of different phyto extracts on *H. coriandri* and grain yields

Treatments	Mean aphid popn./ plant/10 cm twig	Reduction of *H. coriandri* popn.	Grain yield (kg/ha)	Increase in yield
Custard apple 5%	46.20 (6.83)	25.74	652.00	21.78
Ipomea 5%	28.56 (5.39)	54.11	678.00	24.78
Lantana 5%	25.77 (5.12)	58.58	688.00	25.87
Dhatura 5%	39.44 (6.32)	36.60	663.00	23.08
Neem 5%	21.78 (4.72)	64.98	741.00	31.22
Parthenum 5%	40.77 (6.42)	34.46	659.00	22.61
Akua 5%	34.11 (5.88)	45.17	667.00	23.54
Control	62.21 (7.92)	-	510.00	-
SEm±	0.03		10.24	
CD (at 5%)	0.11		28.39	

Table 3. Effect of different phyto extracts on the population of *C. sexmaculatus*

Treatments	Pre treatments	Post treatment First spray 1st day	3rd day	7th day	Mean	Second spray 1st day	3rd day	7th day	Mean	Overall mean
Custard apple 5%	4.30 (2.19)	3.80 (2.07)	3.30 (1.94)	3.23 (1.93)	3.44 (1.98)	3.70 (2.05)	2.67 (1.78)	2.50 (1.73)	2.96 (1.85)	3.20 (1.92)
Ipomea 5%	4.10 (2.14)	3.40 (1.97)	3.10 (1.89)	2.53 (1.74)	3.01 (1.87)	3.03 (1.88)	2.60 (1.76)	2.20 (1.64)	2.61 (1.76)	2.81 (1.81)
Lantan 5%	4.60 (2.17)	3.70 (2.05)	3.20 (1.92)	2.57 (1.75)	3.16 (1.91)	3.17 (1.92)	2.30 (1.67)	2.90 (1.84)	2.79 (1.81)	2.98 (1.86)
Dhatura 5%	4.53 (2.24)	3.80 (2.07)	3.10 (1.90)	2.80 (1.80)	3.23 (1.92)	3.73 (2.06)	2.03 (1.59)	2.50 (1.73)	2.75 (1.79)	2.99 (1.86)
Neem 5%	3.93 (2.10)	2.20 (1.64)	2.00 (1.58)	2.03 (1.59)	2.08 (1.60)	2.97 (1.86)	1.97 (1.57)	1.87 (1.54)	2.27 (1.66)	2.18 (1.63)
Parthenium 5%	3.97 (2.11)	3.80 (2.07)	2.80 (1.81)	2.63 (1.76)	3.08 (1.88)	3.03 (1.88)	2.87 (1.84)	2.50 (1.73)	2.80 (1.82)	2.94 (1.85)
Akua 5%	4.43 (2.22)	3.40 (1.97)	3.20 (1.92)	3.03 (1.88)	3.21 (1.92)	3.50 (2.00)	2.93 (1.85)	2.00 (1.58)	2.81 (1.81)	3.01 (1.87)
Control	4.58 (2.25)	4.20 (1.17)	4.00 (2.10)	4.50 (2.22)	4.23 (1.83)	4.13 (2.15)	3.10 (1.90)	3.60 (2.02)	3.61 (2.02)	3.92 (1.93)
SEm±	0.05	0.06	0.10	0.09	0.08	0.02	0.02	0.01	0.02	0.05
CD at 5%	NS	0.17	0.31	0.29	0.26	0.06	0.06	0.03	0.05	0.15

5%, Ipomea 5%, Neem 5%. The mean population in various treatments were in order of Custard apple 5% (3.20), Akua 5% (3.01), Dhatura 5% (2.99), Lantana 5% (2.98), Parthenium 5% (2.94), Ipomea 5% (2.81), Neem 5% (2.18). The population of *C. sexmaculatus* was minimum in plots treated with Neem 5% (2.18) while it was highest in the untreated control plot (3.92). During both the spraying the *C. sexmaculatus* population gradually decreased after 1st, 2nd and 7th day after spraying. Highest population was recorded from the pre treatment observations followed by 1st spraying and 2nd spraying.

The grain yield, recorded in all the treatments was significantly higher (652 to 741 kg/ha) than the control (510 kg/ha). Among the phyto extracts, Neem 5%, recorded significantly more grain yield (741 kg/ha) i.e., increase of 21.78 % over control while with Lantana 5 % it was (688 kg/ha) i.e., increase 24.78% over control. Jain and Yadav (1989) earlier reported 50% reduction in seed yield due to the infestation of 55 to 70 aphids/ plant at flowering stage. Ipomea 5% was the next better treatment i. e., increase the yield up to 24.78% (678.00 kg/ha) followed by Akua 5% (667.00 kg/ha) and Dhatura 5% (663.00 kg/ha). The next effective treatment in order

Table 4. Economics of different phyto extracts against *H. coriandri*

Treatments	Dose/ha	Grain Yield (kg/ha)	Value of yield (Rs/ha)	Increase in yield over control (kg/ha)	Value of increase yield (Rs/ha)	Cost of treatment including labours charge (Rs/ha)	Net profit	Cost benefit ratio
Neem 5%	1 litre	741.00	33345.00	231.00	10395.00	670.00	9725.00	1:14.51
Lantana 5%	1 litre	688.00	30960.00	178.00	8010.00	670.00	7340.00	1:10.95
Ipomoea 5%	1 litre	678.00	30510.00	168.00	7560.00	670.00	6890.00	1:10.28
Akua 5%	1 litre	667.00	30015.00	157.00	7065.00	670.00	6395.00	1:9.54
Dhatura 5%	1 litre	663.00	29835.00	153.00	6885.00	670.00	6215.00	1:9.27
Parthenium	1 litre	659.00	29655.00	149.00	6705.00	670.00	6035.00	1:9.00
Custard apple 5%	1 litre	652.00	29340.00	142.00	6390.00	670.00	5720.00	1:8.54
Control		510.00	22950.00					

in comparative effectiveness were Parthenium 5% (659.00 kg/ha.) and Custard apple 5% (652.00 kg/ha.) that was *at par* with each other. The lowest yield (510.00 kg/ha.) was recorded from the untreated control plot.

Economics

Gross return from coriander due to different phyto extracts applications varied from Rs 29,340/ha. To Rs 33, 341/ha as against only Rs 22, 950/ha in the untreated control. However the value of increased yield over control was maximum Rs 10, 395/ha with Neem 5% application. Cost benefit ration (1:14.51) was with Neem 5% application. Our result is conformity with the result of Gupta and Pathak (2009). They reported that the incidence of *H. coriandri* was reduced to the lower extent with a maximum yield and net profit in the crop treated with Neem oil 1% (983 kg/ha and Rs 12165/ ha).

वर्ष 2009-2010 के रबी मौसम में धनिया के माहों कीट पर सात जैव कीटनाशको का प्रयोग जबलपुर जिले के ग्राम- अमखेरा में कृषक प्रक्षेत्र पर किया गया।

जैव कीटनाशकों का प्रयोग दो बार दो अलग-अलग चरणों में किया गया जो सार्थक रूप से धनिया में माहो के प्रकोप को कम करता हैं।

उपचारों का धनिया माहों पर प्रभावशीलता का क्रम था नीम 7 लैन्टाना 7 आईपोमिया, अकुआ, धतुरा, गाजरघास 7 सीताफल 7 अनियंत्रित उपचार पाया गया।

विभिन्न उपचारों का धनिया के उपज पर सार्थक प्रभाव रहा हैं। अधिकतम उपज (741 कि.ग्रा./हे.) नीम 5: द्वारा उपचारित से प्राप्त हुआ, जो अन्य उपचारों की तुलना में सार्थक रूप से प्रभावशाली पाया गया। न्यूनतम उपज (510 कि.ग्रा./हे.) अनुपचारित नियंत्रण से प्राप्त हुई। माहों कीट से प्रभावित धनियाँ की फसल में काकसीनेलीड शिकारी कीटों को अधिक संख्या में पाया गया। सभी उपचार सार्थक रूप से काकसीनेलीड कीट के जनसंख्या को प्रभावित करते हैं।

काकसीनेलीड कीट की प्रति पौधा संख्या का तुलनात्मक अध्ययन करने पर उपचारित फसल की अपेक्षा अनुपचारित नियंत्रित फसल में काकसीनेलीड शिकारी कीट की प्रति पौध संख्या अधिक होना पाया गया।

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Effect of insecticidal seed treatment on pearl millet seed viability during storage

Y.H. Ghelani, K.K. Dhedhi, H.J. Joshi, K.L. Raghvani and **C.J. Dangaria**
Seed Technology Research Unit, Pearl Millet Research Station
Junagadh Agricultural University
Jamnagar 361 006 (Guj.)

Abstract

To evaluate the newer insecticide molecules against storage insect pests and to assess the storability of the treated pearl millet seed, a laboratory experiment was conducted in completely randomized design with seven treatments (thiamethoxam @ 2 ppm, methyl primiphos @ 4 ppm, emamectin benzoate @ 2 ppm, spinosad @ 2 ppm, lufenuron @ 5 ppm, deltamethrin @ 1 ppm and control) and four repetitions. All the insecticidal seed treatments recorded significantly lower per cent seed damage than control. The seed treatment of emamectin benzoate as well as spinosad were found completely free from seed damage after 9 months of storage. The effect of insecticidal treatments on moisture content of hybrid pearl millet seed was found non-significant. Seed germination was significantly higher in treatment of emamectin benzoate after 9 months of storage. All the insecticidal treatments were found effective in protecting the pearl millet seed from insect damage up to 9 months without any adverse effect on moisture content and germination.

Key words: Pearl millet seed, chemical control, stored grain insect pests

Pearl millet (*Pennisetum glaucum* (L.) R. Br.) is a crop of semi arid tropical regions and forms life line of people and cattle population inhabiting dry land regions especially rural areas. Gujarat, Rajasthan, Maharashtra, U.P. and Haryana account for about 90 % of the total area of about 10 million hectare covered under pearl millet in India. Development of hybrids in pearl millet increased demand for high quality seeds by the farmers for obtaining higher crop productivity. The improved quality seed should possess good germination, optimum moisture content and free from diseases and insect pests as per seed certification standards. Sometimes hybrid seeds are to be stored for more than one season. In such cases deterioration of valuable seeds due to insect pests is major constraints. The primary damage in stored pearl millet seed is mainly by lesser grain borer (*Rhyzopertha dominica,* Fab.), followed by secondary attack of rust red flour beetle (*Tribolium castaneum*, Herbst) and rice moth (*Corcyra cephalonica*, Stainton). Hence, to evaluate the newer insecticidal molecules against storage insect pests and to assess the storability of treated pearl millet seed, the present study was initiated.

Material and methods

A laboratory experiment was conducted at Pearl Millet Research Station, Junagadh Agricultural University, Jamnagar during August, 2007 to 2008. Five new insecticides *viz*; thiamethoxam (Cruiser 70 WS) @ 2 ppm [T_1], methyl pirimiphos (Actellic 50 EC) @ 4 ppm [T_2], emamectin benzoate (Proclaim 5 SG) @ 2 ppm [T_3], spinosad (Tracer 45 SC) @ 2 ppm [T_4] and lufenuron (Cigna 5 EC) @ 5 ppm [T_5] alongwith standard check of deltamethrin (Decis 2.8 EC) @ 1 ppm [T_6] were evaluated against major storage insect pests infesting pearl millet seed during storage. Freshly harvested 1.0 kg certified pearl millet hybrid seed (GHB -558) with high germination (> 95 %) and low moisture content (< 10 %) was taken for each treatment. Required quantity of insecticides was diluted in 5 ml of water to treat one kg of seed for proper coating. After drying in shade, seeds were packed in 2 kg capacity of gunny baglets. Similarly, control was maintained without any treatment for comparison [T_7]. The experiment was conducted in completely randomized design with seven treatments and four repetitions. The temperature and relative humidity of the room was recorded on standard week basis. Observations on seed moisture, seed germination, seed damage and insect population (larvae and adult) were recorded at 3 months interval up to 12 months of experimental period.

Table 1: Effect of insecticidal seed treatments on moisture, germination and seed damage in pearl millet seed during storage

Treatment	Moisture (%)				Germination (%)				Seed damage (%)			
	Months after storage				Months after storage				Months after storage			
	3	6	9	12	3	6	9	12	3	6	9	12
T1	7.55	8.03	8.03	8.65	93.50	90.25	87.00	64.75	0.99 (0.03)	0.99 (0.03)	4.93 (0.74)	12.96* (5.11)#
T2	7.63	8.15	7.83	8.63	93.00	91.00	86.50	64.50	0.99 (0.03)	0.99 (0.03)	6.32 (1.22)	13.71 (5.72)
T3	7.45	7.78	8.18	8.28	93.75	90.50	87.50	64.00	0.99 (0.03)	0.99 (0.03)	0.99 (0.03)	10.29 (3.23)
T4	7.65	7.85	8.08	8.60	93.00	89.75	86.50	61.75	0.99 (0.03)	0.99 (0.03)	0.99 (0.03)	12.01 (4.39)
T5	7.55	8.15	8.10	8.70	93.00	90.25	87.25	63.50	0.99 (0.03)	0.99 (0.03)	4.80 (0.70)	13.86 (5.85)
T6	7.65	7.88	8.13	8.68	92.50	90.50	85.75	61.75	0.99 (0.03)	0.99 (0.03)	7.11 (1.54)	14.72 (6.59)
T7	7.58	8.00	8.38	8.60	85.00	81.25	77.75	46.00	8.38 (2.14)	15.55 (7.36)	18.97 (10.95)	24.50 (18.18)
S. Em.	0.14	0.10	0.12	0.12	0.99	0.75	1.31	2.90	0.45	0.15	0.63	1.11
C.D. at 5 %	NS	NS	NS	NS	2.92	2.20	3.87	8.53	1.33	0.45	1.87	3.26
C.V. %	3.65	2.53	3.08	2.84	2.16	1.68	3.08	9.52	44.01	10.04	20.13	15.20

* Arc Sin transformed value, # Figures in parentheses are retransformed value

Table 2: Effect of insecticidal seed treatments on insect population in pearl millet seed after 12 months of storage

Treatment	Number of adult & larvae / 100 g seed		
	Rhyzopertha dominica	*Tribolium castaneum*	*Corcyra cephalonica*
T1	1.65 (2.23)	1.79 (2.70)	1.18* (0.90)#
T2	1.49 (1.73)	2.03 (3.62)	1.27 (1.12)
T3	1.27 (1.12)	1.92 (3.20)	1.48 (1.68)
T4	1.18 (0.90)	1.73 (2.24)	1.27 (1.12)
T5	1.40 (1.47)	1.80 (2.73)	1.35 (1.31)
T6	1.27 (1.12)	2.00 (3.48)	1.48 (1.68)
T7	2.59 (6.21)	3.23 (9.95)	2.49 (5.70)
S. Em.	0.15	0.12	0.19
C.D. at 5 %	0.44	0.36	0.55
C.V. %	19.21	12.06	24.98

* Square root transformed value $\sqrt{x+0.5}$
# Figures in parentheses are retransformed value

Results and Discussion

Effect on seed moisture

The effect of insecticidal seed treatments on moisture content of hybrid pearl millet seed was found non significant and which was observed below Indian Minimum Seed Certification Standards (10 %) in all the treatments. It clearly showed that none of the insecticides when applied as seed treatment in pearl millet has not any effect on seed moisture content (Table 1).

Effect on seed germination

Germination of pearl millet seed was recorded significantly higher in all insecticidal seed treatments as compared to control after 9 months of storage. Treatment of emamectin benzoate recorded the highest germination (87.50 %) which was found statistically at par with rest of treatments except control (77.75 %). None of the treatments recorded germination percentage above IMSCS (75 %) after 12 months of storage. However, thiamethoxam recorded highest germination (64.75 %). While in control, it was found only 46.00 per cent (Table 1).

Effect on seed damage

The per cent damage in pearl millet seed was noticed significantly lower in all the insecticidal seed treatments than control during storage. The treatment of emamectin benzoate as well as spinosad were found free from the seed damage and were statistically at par with the rest of insecticidal treatments after nine months of storage. After 12 months of storage, emamectin benzoate recorded the lowest seed damage (3.23 %) and was statistically at par with rest of the insecticidal treatments. While in untreated seed, it was observed 18.18 per cent (Table 1).

Effect on insect population

All the insecticidal seed treatments recorded significantly lowest larval and adult population of *R. dominica*, *T. castaneum* and *C. cephalonica* after 12 months of storage. The lowest population of *R. dominica* (0.90) and *T. castaneum* (2.24) was observed in treatment of spinosad while the lowest population of *C. cephalonica* (0.90) was found in treatment of thiamethoxam (Table 2).

The result of the experiment clearly showed that all the insecticides under study were found effective in protecting the pearl millet seed from insect damage up to 9 months without any adverse effect on moisture content and germination. The effectiveness of deltamethrin has been reported in literature (Bareh *et al.* 1989) and cleared by WHO and FAO as a safe seed and grain protectant (Anonymous 1982). Study conducted at various centers of National Seed Project showed that spinosad, emamectin benzoate and thiamethoxam (all @ 2 ppm) were found equally effective as deltamethrin @ 1 ppm and provided appreciable control of storage insects infesting cereal seeds *viz*; wheat, pearl millet, maize and paddy under different agro climatic conditions for six months (Anonymous 2008)

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इमेंक्रिन बेजोनेट (दो पीपीएम दर से) तथा स्पीनोसेड (दो पीपीएम दर से) बाजरे के बीजों का उपचार करने से नौ महिने तक भडारगभभह में कीट प्रकोप में कमी पायी गयी । उपरोक्त कीटानाशकों के उपचार से बाजरे के बीजों को नौ महिने तक कीट प्रकोप से सुरक्षित पाया गया ।

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Extent of participation of tribal farm women in decision making process related to agriculture operations in Seoni district Madhya Pradesh

Trupti Gokhe and **N.K. Khare**
Department of Extension Education
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Jabalpur 482004 (MP)

Abstract

Majority of tribal farm women (57.14%)had moderate participation in decision making process towards agricultural operations in Kurai block of Seoni district (MP).

India has one of the largest concentrations of tribal population in the world. According to 2001 census. Tribal are the traditional bound people with apathetic attitude towards the change and development. Women are said to be originator of agriculture. They not only give stability to the life of nomadic habitat, but simultaneously made agriculture a way of life. The rural households are slowly depending on agriculture and farming has become a family enterprise where each member could participate in production process. Men's role is dominant and authoritative while that women's subtle and persuasive. Anita kumari (2002). However, the decision making role of farm women seems to have changed considerably over the years mainly two reasons, firstly the joint family system is breaking and secondly the introduction of modern agricultural technology has resulted in higher income and better standard of living which has brought about a change in outlook and attitude of rural people, especially the women. There is an increasing evidence of women's participation in decision making activities vis-a-vis farm are related enterprises.

Material and Method

The study was conducted in tribal dominated(48%) block of Seoni district of Madhya Pradesh. The block comprised of 183 villages, out of which 5 villages were selected randomly for the study. To select the respondents, a list of tribal farm women from each village was prepared. From the list, 15 per cent tribal farm women were chosen randomly. Thus, total sample comprised of 105 tribal farm women distributed in 5 villages. The eight steps of decision making process are:

Desire for change :

Measured in 3 point scale 1. strong desire 2. Moderate desire 3. least desire.

Getting initial information :

Divided in 3 levels 1. very much. 2. much 3. little

Recognition of the problems:

Measured in 3 point scale 1. Most important 2. important 3. Not important

Getting additional information:

Divided 3 point scale 1. needed 2. Some what needed 3. Not at all needed

Consideration of alternative means:

Divided 3. point scale 1. always 2. Some times 3. Never

Consideration of resources :

Measured in 3 levels 1. Satisfied 2. partially Satisfied 3. not at all satisfied.

Table 1. Extent of participation of tribal farm women in decision making process related to agricultural operations

(N=105)

Steps of Decision making process	Practice	Crop selection (%)	Seed selection (%)	Seed treatment (%)	Use of weedicides (%)	Use of fertilizers (%)	Plant protection measures (%)	Improved method of storage (%)	Time of selling farm produce (%)
Desire for change	Strong desired	52.38	57.14	28.57	10.47	38.09	20.00	34.28	51.42
	Moderate desire	38.09	38.09	55.23	45.71	46.66	39.04	57.14	36.19
	Least desire	9.52	4.76	16.19	43.80	15.23	40.95	8.57	12.39
Getting initial information	Very much excitement	57.14	46.66	38.09	24.76	27.61	20.95	50.47	40.95
	Much excitement	37.14	47.61	45.71	39.04	57.14	32.38	43.80	44.76
	Little excitement	5.71	5.71	16.19	36.19	15.23	46.66	5.71	14.28
Recognition of problem	Most important	48.57	41.90	36.19	20.95	35.23	10.47	35.23	39.04
	Important	35.23	47.61	40.00	42.85	52.38	42.85	50.47	51.42
	Not important	16.19	10.47	23.80	36.19	12.38	46.66	14.28	9.52
Getting additional information	Needed	48.57	43.80	36.19	19.04	25.71	9.52	35.23	49.52
	Some what needed	35.23	39.04	38.09	43.80	49.52	41.90	54.28	40.95
	Not at all needed	16.19	17.14	25.71	37.14	24.76	48.57	10.47	9.52
Consideration of alternative means	Always	34.28	41.90	29.52	16.19	47.61	16.19	45.71	35.23
	Sometimes	40.95	49.95	48.57	35.23	40.95	33.33	43.80	50.47
	Never	24.76	24.76	21.90	48.57	11.42	50.47	10.47	14.28
Consideration of resources	Satisfied	44.76	34.28	29.52	9.52	29.52	16.19	31.42	41.90
	Partially satisfied	40.95	46.66	46.6	36.19	50.47	37.14	53.33	43.80
	Not at all satisfied	14.28	19.04	23.80	54.28	20.00	46.66	15.23	14.28
Consideration alternative of uses of means		-	-	-	-	-	-	-	-
Decision	Yes	78.09	68.57	46.66	27.61	53.33	21.90	65.71	71.42
	No	21.90	34.42	53.33	72.38	46.66	78.09	34.28	28.57

Consideration of alternative uses of means:

1 score was given to each level for each Agricultural operation

Decision:

The data were collected according to their response 1. Yes 2. No.

Result and Discussion

Extent of participation at different steps of decision making process related to agricultural operations.

Out of the total respondents 57.14, 52.38, and 51.42 per cent were having strong desire for change in seed selection, crop selection and time of selling farm produce respectively. 57.14, 50.47 and 46.66 per cent of respondents had very much excitement for getting initial information about crop selection, improved method of storage and seed selection. Majority of tribal farm women realized that the problem pertaining to the crop selection, seed selection and time of selling farm produce were the major problem (Table 1).

It is about 49.52 and 48.57 per cent of respondents that needed addition information related with time of selling of farm produce and crop selection. Out of total respondents 47.61 and 45.71 per cent considered alternative means for the practice use of fertilizers and improved method of storage respectively. Majority(44.76%) of tribal farm women were satisfied with the income resources for crop selection, in technical advice for time of selling farm produce, in knowledge resources for time of selling farm produce and their skill involved resource in time of selling farm produce. All the respondents considered all alternative uses of means.

It was realized that 78.09, 71.42 and 68.57 per cent tribal farm women took part in decision for crop selection, time of selling farm produce and seed selection respectively. However, 78.09, 72.38 and 53.33 per cent of tribal farm women did not take decision for use of plant protection measures, use of weedicides and seed treatment methods (Table 1).

Rank order of tribal farm women in decision making process related to Agricultural operations

Majority of 78.09% of tribal farm women took decision for crop selection were placed rank I, where as 72.38% and 71.47% took decision for use of weedicides and time of selling farm produce and were placed in rank II & III respectively. Other practices perceived by tribal farm women according to percentage are seed selection, improved method of storage, use of fertilizer seed treatment and plant protection measures were placed in rank IV. V.VI, VII respectively. (Table 2).

Extent of participation of tribal farm women in decision making process

Out of the total respondent 21.91% had low, 57.14% had moderate and 20.95% had high role in decision making process. Therefore, it can be inferred that majority (57.14%) tribal farm women had moderate participation in decision making process. (Table 3)

Table 2. Rank order of tribal farm women in decision making process related to agricultural operations

Practices	Decision making process	Rank
Crop selection	78.09	I
Seed selection	68.57	IV
Seed treatment	55.33	VII
Use of Weedicides	72.28	II
Use of fertilizers	57.14	VI
Plant protection measures	50.47	VIII
Improved method of storage	60.71	V
Time of selling farm produce	71.42	III

Table 3. Extent of participation of tribal farm women in decision making process

Categories	Frequency	Percentage
Low	23	21.91
Moderate	60	57.14
High	22	20.95
Total	105	100.00

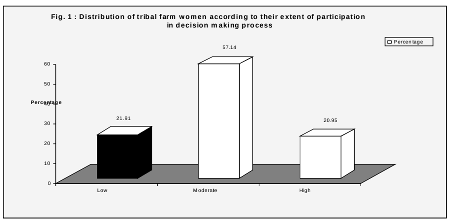

Fig. 1 : Distribution of tribal farm women according to their extent of participation in decision making process

Majority 78.09% of tribal farm women took final decision regarding crop selection. Maximum 57.14 of tribal farm women had moderate participation in decision making process.

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Effect of dates of sowing on growth and heat use pattern of wheat cultivars

Nirmala Singh, R.K. Tiwari and **Sanjay Singh**
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Krishi Vigyan Kendra
Rewa (MP)

Abstract

A field experiment on effect of dates of sowing on growth and heat use pattern of wheat cultivars was carried out during 2008-09 and 2009-10. The study reveals that early planted wheat varieties produced more number of productive tillers/ plant (9.90), maximum panicle length (10.22 cm), more number of grains /panicle (55.03), high test weight (43.78 g) and highest grain yield (66.48 q/ha) as compared to late sowing. The reduction in grain yield was 16.17% when the crop was sown on 1st December. The wheat variety GW 366 gave maximum yield 68.26 q/ha followed by GW 322 and GW 273. While the wheat variety DL788-2 gave poor yield. The heat use efficiency was more under timely sown condition as compared to late sown condition. The heat use efficiency for grain yield was highest (40.12 q/ha/GDDx10^{-3}) for wheat variety GW 366 and lowest (31.40 q/ha/GDDx10^{-3}) for wheat variety DL 788-2.

Keywords: Wheat, dates of sowing, heat use efficiency (Pattern)

Wheat is a staple food crop of Madhya Pradesh which occupies an area of 40.45 lakh hectares with the total production of 73.3 lakh tones and productivity1812 kg/ ha. The major wheat growing area is under rice-wheat cropping system. Late harvesting of rice causes delay in sowing of wheat. In case of late sowing, high temperature during ripening phase shortens the growing period and reduces grain yield. Wheat crop is sensitive to photoperiod, temperature and date of sowing. Hence, the phenology of growth pattern differs greatly with the change in latitude. In past, degree day techniques have been variously applied to correlate the phenological development of crops to predict maturity dates (Nuttonson 1955). However the phenology, ambient temperature interaction of wheat varieties under different sowing dates has not been studied in Rewa region of Madhya Pradesh. Hence, present investigation was under taken.

Material and methods

The experiment was conducted on sandy loam soil of College of Agriculture Research Farm, Rewa during Rabi season of 2008-09 and 2009-10. The soil was neutral in reaction (pH 7.1), low in available nitrogen (235 kg/ha) and phosphorus (9.6 kg/ha) and high in available potash (461 kg/ha). The maximum temperature was recorded 40.00c and minimum temperature was 3.10c during crop period. The treatment consisted of two dates of sowing viz. 15th Nov. and 1st December and six varieties of wheat (GW 366, GW 322, GW 273, MP 3269, JW 3020 and DL 788-2) with three replications. The experimental design was RBD. The fertilizer dose was kept 100 kg N, 60 kg P_2O_5, 40 kg K_2O/ha. All the recommended package of practices were adopted. The maximum and minimum temperature and sunshine hours were recorded at the College Farm observatory located inside the field.

The growing degree days were calculated using 50c as base temperature and accumulated for different growth stages i.e. from sowing to crown root initiation (CRI), sowing to tillering and sowing to maturity stages (Nuttonson 1955) and Sastry and Chakravorty (1982). Photo thermal unit were calculated by multiplying growing degree days to day length. Heat use efficiency (HUE) for different varieties were evaluated at maturity for both the dates of sowing, by using above ground biomass and yield. The phenothermal index was also calculated by following Nuttonson (1955) and Sastry and Chakravorty (1982). Yield and yield components such as plant height, number of tillers /plant, panicle

Table 1. Growth characters of different wheat varieties as influenced by date of sowing (2 years pooled data)

Treatment date of sowing	Plant height (cm)	No. of productive tillers/plant	Panicle length (cm)	Grains/panicle	Test weight (g)	Biomass (q/ha)	Grain yield (q/ha)	Harvest index (%)
15 Nov	85.03	9.90	10.22	55.03	43.78	166.83	66.48	39.84
Ist December	79.56	8.58	9.16	50.96	41.48	142.60	55.73	39.08
SEM +	1.23	0.11	0.09	1.15	0.56	1.40	0.85	0.47
CD at 5%	3.62	0.33	0.28	3.39	1.64	4.30	2.49	1.52
Wheat varieties								
GW366	90.65	12.15	11.65	50.10	48.14	168.39	68.26	40.53
GW 322	88.50	9.35	9.90	75.85	40.43	163.53	66.29	40.53
GW 273	72.10	8.90	9.65	41.90	40.76	160.12	62.51	39.03
MP3269	80.90	8.60	9.20	37.00	43.11	154.79	58.82	37.99
JW 3020	86.20	8.30	8.96	72.20	39.41	144.49	56.61	39.06
DL788-2	75.45	8.21	8.75	40.95	43.93	136.53	54.12	39.63
SEM +	0.71	0.06	0.05	0.66	0.32	0.81	0.49	0.29
CD at 5%	2.09	0.19	0.16	1.95	0.95	2.38	1.44	0.87

Table 2. Days, GDD, HUE, Photothermal unit and Phenothermal index of wheat crop as influenced by date of sowing (2 years pooled data)

Treatment date of sowing	Duration days			GDD at different stages			Photothermal unit at different stages			HUE (q/ha/GDDx10^{-3})		Phenothermal index at
	CRI	Tillering	Maturity	CRI	Tillering	Maturity	CRI	Tillering	Maturity	Grain yield	Biomas	maturity
15 Nov.	20.26	68.41	129.60	275.60	958.55	1686.18	1800.53	5815.66	12210.63	39.54	99.15	12.96
Ist December	17.71	66.10	125.00	236.30	854.10	1690.83	1932.52	5880.78	12866.90	32.95	84.42	13.52
SEM +	0.73	0.82	0.80	1.46	4.87	7.66	11.21	7.94	738.52	0.58	0.72	0.17
CD at 5%	2.15	2.41	1.13	4.28	14.28	22.49	32.88	23.30	2166.14	1.71	2.12	0.51
Wheat varieties												
GW 366	18.00	68.30	128.00	248.45	937.70	1702.00	1806.56	5906.01	12752.02	40.12	98.98	13.20
GW 322	19.90	73.10	127.50	267.65	942.40	1692.50	1946.56	6481.56	12639.69	39.22	96.88	13.26
GW 273	19.30	74.20	126.50	255.00	949.40	1672.50	1890.70	6617.12	12472.56	37.37	95.40	13.22
MP3269	18.20	63.40	125.50	241.85	877.40	1654.60	1755.74	5425.14	12313.07	35.53	93.48	13.18
JW 3020	20.25	61.80	126.50	274.30	859.30	1672.50	1993.11	5289.17	12472.56	33.83	86.49	13.22
DL788-2	18.55	62.60	130.00	248.40	871.50	1739.20	1806.56	5370.39	13082.68	31.40	79.50	13.38
SEM +	0.42	0.47	0.46	0.84	2.81	4.42	6.47	4.58	426.38	0.33	0.41	0.09
CD at 5%	1.24	1.39	1.36	2.47	8.24	12.98	18.98	13.45	1250.62	0.99	1.22	0.29

length, number of grains/pencil and test weight were recorded at the time of harvesting.

Results and Discussion

Effect on yield and yield components

Data presented in Table 1 reveal that the earlier the sowing date the higher the number of productive tillers /plant, panicle length, number of grains/panicle, test weight and final grain yield. Grain yield of 15th Nov. sowing was significantly higher by 19.28% as compared to late sown condition (i.e. 1st December). Average reduction of grain yield was 16.17% when the crop was sown on 1st December. Low yield under late sown condition was due to stress caused by higher temperature during grain filling period in the moth of March, Ishag and Ageeb (1990) also reported similar results.

Yield components likes number of productive tillers/plant (12.15) panicle length (11.65 cm), test weight (48.14 g), biomass yield (168.39 q/ha) and grain yield (68.26 q/ha) were maximum in wheat variety GW 366 followed by GW 322. Number of grains/panicle were maximum in wheat variety GW 322 (75.85) followed by JW 3020 (72.20) but these varieties recorded lowest test weight 40.43 and 39.41 g, respectively. The minimum grain yield (54.12 q/ha) was recorded in wheat variety DL 788-2.

Phenology

Data pertaining to accurance of phenological events of wheat crop varieties under different sowing dates is presented in Table 1. The higher number of days for crown root initiation was recorded for wheat variety JW 3020 (20.25 days) followed by GW 322 (19.90 days) and GW 273 (19.30 days). The minimum number of days for crown root initiation was recorded for variety GW 366 (18 days). The maturity days was maximum (130 days) for variety DL 788-2 followed by GW 366 (128 days). The early maturity by(130 days) for variety DL 788-2 followed by GW 366 (128 days). The early maturity by (4.6 days) was observed under late sown wheat planted on 1st December. The results are in agreement with the findings of Maurya and Kushwah (1993).

Energy Summation indices during crop growth period (GDD)

Data presented in Table 2 regarding the GDD reveals that both calendar days and GDD were higher at maturity for variety DL 788-2 (130 days maturity) and 1739.20 (GDD) followed by GW 366 (128 days, 1720 GDD). The requirements of GDD under different dates of planting were not much different among the varieties tested.

Photo thermal unit (PTU)

The photo thermal unit for different growth stages is presented in Table 2. The requirement of PTU ranged from 12313.07 to 13082.68 for maturity stages. It was maximum for variety DL788-2 and minimum for MP3269.

Heat use efficiency (HUE)

The heat use efficiency for grain yield and biomass at maturity stage are presented in Table 2. The significant difference for HUE was observed among the varieties at both the dates of sowing. Maximum HUE value for grain and biomass yield (40.12 and 98.98 q/ha/GDD x 10^{-3}) was noted for wheat variety GW 366 and minimum (31.40 and 79.50 q/ha/GDDx 10^{-3}) for DL 788-2. This reflects that variety GW 366 is more suitable for late planting than variety DL 788-2. Similar results were reported by Khare et al. (1989).

कृषि विज्ञान केन्द्र रीवा द्वारा रबी मौसम 2008–09 एवं 2009–10 मे धान के बाद गेंहू की फसल बोने से बढ़ते तापमान का उपज पर प्रभाव देखने के लिए 15 नवंबर और 1 दिसंबर को गेंहू की छः किस्मों को बोया गया । अध्ययन में पाया गया कि 15 नवंबर को बोनी करने पर गेंहू के पौधों में उत्पादन देने वाले कल्लों की संख्या, प्रति पौधा बालियों की संख्या तथा बालियों में दानों की संख्या एवं 1000 दानेां का वजन अधिक पाया गया जिसके कारण गेंहू की उपज में 19.28 प्रतिशत की वृद्धि हुई । 1 दिसंबर को बोनी करने पर विभिन्न किस्मों की हीट यूज ईफिसियंसी (उष्मा उपयोग क्षमता) में कमी पायी गयी तथा गेंहू की उपज 16.17 प्रतिशत घट गई । अध्ययन में यह भी पाया गया कि गेंहू की किस्म जी.डब्ल्यू 366 को देरी से बोने पर सबसे अधिक उष्मा उपयोग क्षमता पायी गई जिसके कारण इस किस्म की उपज सबसे अधिक उपज 68.26 क्विंटल/हेक्टेयर प्राप्त हुई । सबसे कम उपज गेंहू की देर से पकने वाली किस्म डी.एल. 788–2 से प्राप्त हुई ।

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Impact of Information Technology to enhance the agriculture productivity in India

A.K. Rai, Bharati Dass, A. Khare, A. Bisen and **C.P. Kushwaha**
Instrument Development and Service Centre
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Jabalpur 482 004 (MP)

Abstract

India is an agricultural country. Most of the populations are living in rural areas (Villages) and agriculture is their main source of earning. The agricultural sector in India is currently passing through a difficult phase. Unfortunately almost all of them are not familiar with the terms "Information Technology" or "e-Agriculture" and other related issues that can make a dramatic change to their day to day life. India is moving towards an agricultural emergency due to lack of attention, insufficient land reforms, defective land management, non-providing of fair prices to farmers for their crops, value addition, inadequate investment in irrigational and agricultural infrastructure etc. India's food production and productivity is declining while its food consumption is increasing. The proper utilization of modern Information technologies, especially e-Agriculture can provide them a global identity that can drastically change the usual life of rural agricultural community. "e-Agriculture" is an emerging field in the intersection of agricultural informatics, agricultural development and entrepreneurship, referring to agricultural services, technology dissemination, and information delivered or enhanced through the internet and related technologies. In our country food production and productivity may be increased by an effective use of IT for agricultural purposes.

Keywords: Information Technology, e-Agriculture, Productivity, Farmer, Entrepreneurship

With the grand success of green revolution in India, agriculture has evolved from sustainable farming into a complex and profit oriented business, which requires accumulation and integration of knowledge and information from diverse sources. An increasing population coupled with mining of natural resources requires application of new technologies to maintain sustainable food and water supply without environmental degradation. Presently the costs of the planting material/seeds, nutrients, pesticides, water, power and labour are increasing enormously; where as increase in crop productivity is at low pace. Farmers are more concerned about the choice of crops that are appropriate for the changing environmental conditions and more conscious location-specific crop management so that the input costs are minimal and less risk prone (Swaminathan 2001).

Information technologies particularly the Internet, are transforming all human activities dependent on information, including rural development and food security, it plays a crucial role in improving the efficiency of inputs as water, nutrient and pesticide use (Ananda and Vijayanand 2003). Modern tools such as Remote Sensing and Geographic Information System (GIS) are helpful to estimate area and production under agricultural crops. Other models such as decision support system, Bio-Informatics, Precision Agriculture, Rural Networking etc can be achieved by aligning Information Technology with agriculture (Kumar and Sailaja 2006). Combining the satellite technology with tools of IT, farmers in a remote village can demand and get the following information's:

- Land use planning for crops for farmers field based on integrated information on soil water, weather, fertilizer and pest management models.
- How and where to get seeds or good quality nursery plants of crops?
- Interactive exchange of information for planning and day-to day operations by farmers.
- e-Procurement

Role of IT in Agriculture

In the context of agriculture, the potential of information technology can be assessed broadly under two heads : (a) as a tool for direct contribution to agricultural productivity and (b) as an indirect tool for empowering farmers to take quality decisions which will have positive impact on the way agricultural and allied activities conducted. Precision farming, popular in developed countries, extensively uses IT to make direct contribution to agricultural productivity. The indirect benefits of IT in empowering Indian farmer are significant and remain to be exploited. The Indian farmer urgently requires timely and reliable sources of information inputs for taking decisions. At present, the farmer depends on trickling down of decision inputs from conventional sources which are slow and unreliable. The changing environment faced by Indian farmers makes information not merely useful, but necessary to remain competitive (Mittal 2004)

Application of IT in Agricultural

IT should be used on demand and monitoring the supply of agricultural impacts in the fields. Based on the annual crop plan, the demand for the agro inputs can be estimated and accordingly supply can be monitored. The information on availability of seeds, fertilizers and pesticides in different region can be made available to the farmers. This will help them in fast procurement of inputs at a cheaper rate. Information on availability of quality planting material of horticultural species at various government nurseries and Agriculture Universities should also be regularly posted on the website. Agriculture Universities and other National Institutions are regularly releasing improved varieties of various crops. The important features of these varieties such as its performance, disease resistance and adaptability should be made known to farmers through the website. The prompt identification and control of pest and diseases of the cash crops is essential in reducing further damage to the crop. Audio-visual clips of the causative organism and affected/diseased plant part with its control measure should be displayed on the website. This would assist the farmers in remote areas to identify the pest/disease and take corrective action. Weather plays a major role in incidences of certain pest and diseases. A disease-forecasting module for advance intimation on likely occurrences of pest and diseases and preventive measures to be taken needs to be developed to reduce the economic losses. The micro level data can be of use in preparing an interactive module for the farmers which will take into consideration the local agro climatic conditions and suggest them an alternative crop plan. Suitable software can be developed for effective monitoring of the crop plan by various officials at different levels and update them with the latest situation. GIS technology will enable the policy makers to assess the area and production of crops. This will help to frame the short term and long term market/credit policy. Use of satellite imaging data analysis for forecasting agriculture related information should be adopted for forecasting rainfall, area under different crops, yield estimations and soil properties. Interactive module needs to be prepared to assist the farmer in preparing crop budget, which will help him in documenting data on cultivation cost and make them aware of the profitability.

To enhance the productivity it is essential that the latest information on production and post harvest production aspects of various economic crops be made available to the farmers. There is an urgent need to prepare a crop guide containing reliable and authentic information on important varieties, cultivation practices, recommended fertilizer doses, types of pest and diseases and its control, harvesting methods and post harvest practices including primary processing at the farmer's field. This information being dynamic should be kept updated. Information Technology for agricultural extension is going to receive high priority in future. While developing any system of IT for Agriculture technology, the farmer should be kept in focus as a player, generator and user of the knowledge. Extensive use of modern information technology should be promoted for two way communication between scientists, extension workers and farmers to transfer technologies and information more cost effectively. Taking into consideration the individual agriculture management by the farmers, some useful software packages should be developed and made available on the website. Some of the software which need urgent consideration are Micro irrigation (Drip designs), Green House design, Cropping Pattern, Farm Accounting and Management. The Agriculture Department and private sector should be encouraged to develop multimedia based extension material in local language. Multimedia CDs on various topics would be of great utility to the farmers (Chaudhuri et al. 2001).

Constraints and Remedies for Effective Dissemination

Some of the major constraints delaying the spread of e-Agriculture revolution to rural India are listed below

Haphazard development

It is observed that some initiatives have already been made to provide IT based services to agricultural community. However, duplication of efforts is witnessed as most of the services revolve around limited subjects. Keeping in view the giant task involved, it is necessary to form a coordinated mechanism to strive for a concerted effort to support farming community in the country.

User friendliness

The success of this strategy depends on the ease with which rural population can use the content. This will require intuitive graphics based presentation. Touch screen kiosks are required to be set up to encourage greater participation

Local languages

Regional language fonts and mechanisms for synchronization of the content provide a challenge that needs to be met with careful planning.

Restrictions

Information content based on remote sensing and geographical information systems can provide timely alerts to the farmers and also improve the efficiency of administration. These applications can have a major impact on the farmers and help them to appreciate the potential of information technology. However, government's map restriction policies often threaten to stifle the optimal utilization of these tools.

Power Supply

In most of the rural India, power supply is not available for long hours. This will reduce the usefulness of the intended services. Since almost entire country receives sunshine for most part of the year, it is useful to explore solar power packs for UPS as well as for supply of power. The Ministry of Non-conventional Energy Sources may pay special attention in this area which can be a major contributor to the growth of IT in villages.

Connectivity

Despite the phenomenal progress made in the recent years, the connectivity to rural areas still requires to be improved. Reliable connectivity is a prerequisite for a successful penetration of IT into rural areas. Many private ISPs are setting up large networks connecting many major towns and cities. Since some of these networks pass through rural areas, it is possible to provide connectivity to a large number of villages. Several technologies exist that can be utilized for connecting rural areas. Cable network is a possible medium for providing the last mile connectivity to villages.

Bandwidth

Even in areas where telephone and other communication services exist, the available bandwidth is a major constraint. Since internet based rural services require substantial use of graphics, low bandwidth is one of the major limitations in providing effective e-services to farmers. As already stated, networks with high bandwidth are being set up by several companies passing through rural segments which can be utilized. Until this materializes, a two pronged strategy of storing static information at the kiosks and providing dynamic information from remote locations can be examined. The graphic oriented content which does not change frequently, such as, demonstration clips for farmers, can be stored on the local drives at the kiosks and arrange for periodic updating of this information over the network during non-peak hours may be adopted. The dynamic information which changes more frequently can be accessed from remote locations to obtain the latest status.

Dissemination Points

Mass deployment of information kiosks is critical for effective use of the Internet based content and services. In order to ensure that the information kiosks are economically feasible, it is necessary to make the proposition sustainable and viable. This requires a major focus on a viable revenue model for such kiosks. In the new information era, the kiosks should be designed to become electronic super markets that can, in addition to being information sources, handle other services of use to the people living in rural areas.

Recommendations for successful implementation of e Agriculture

The following recommendations should be considered for successful implementation of e Agriculture

Networks Online

The agricultural communities should take the initiative to take on IT rather than waiting for the government to provide the technologies to them. This could be achieved by fostering extension of new agricultural practices through farmer-to-farmer networks and links with research and extension services, and bringing local experience and knowledge to the attention of these services. They should also aim to start developing content to improve their

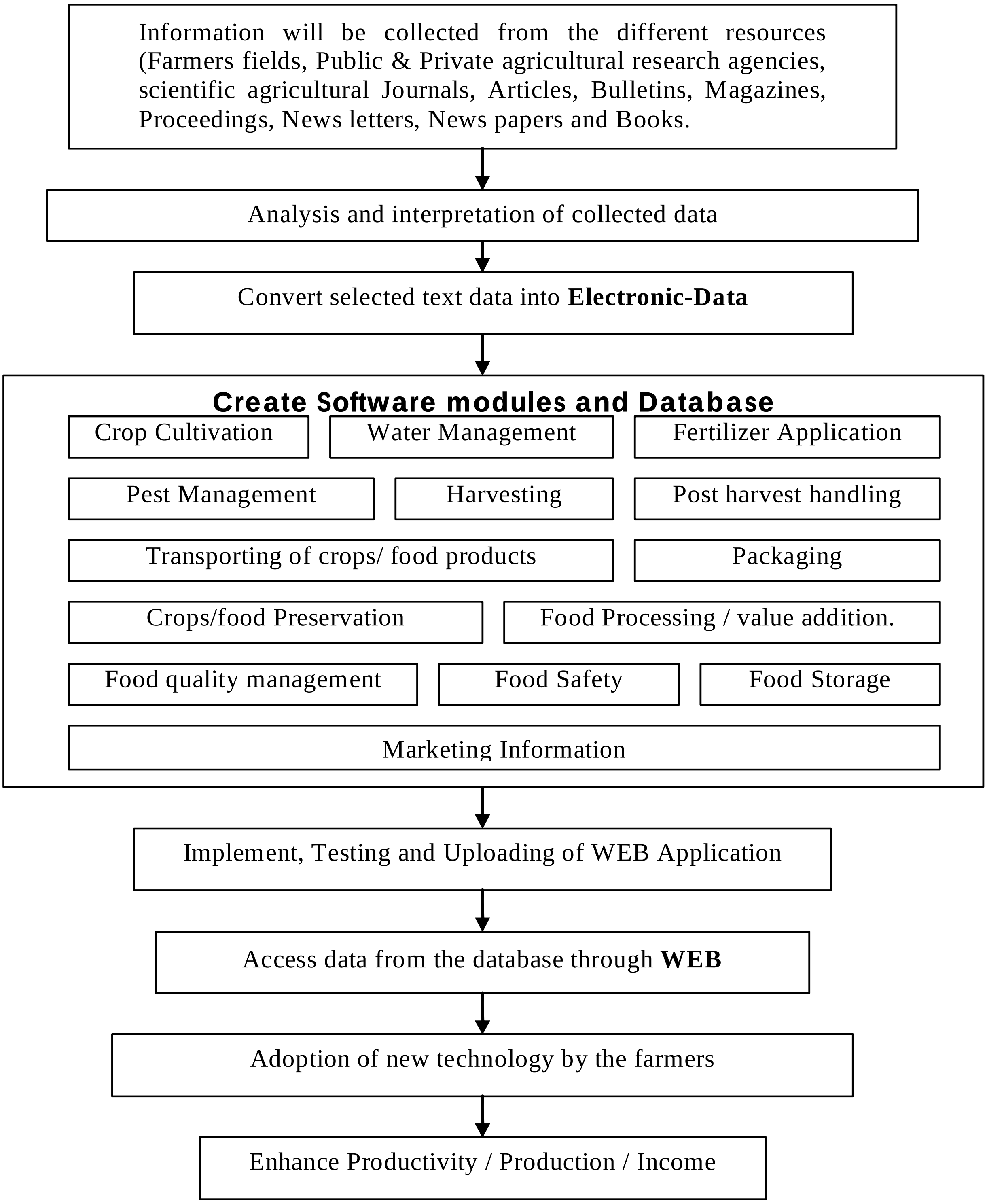

Figure 1: Conceptual Architecture of an Agricultural Information Dissemination System for Users

livelihoods, and in language understand by the rural people.

The government, non-governmental organizations, private sector and rural communities must collaborate to develop rural telecenters or information kiosks into integrated service outlets for agricultural information dissemination, covering such issues as land title certification, credit, marketing, skill development, education and other topics, depending on the needs of the agricultural communities.

Indian governments may take advantage of this by introducing and strengthening initiatives that support the widening of space for exchange of information and a competitive culture of debate of ideas that could concretize the current information-based development wave.

Indian Governments and other agricultural stakeholders should be creative in adapting to these waves, as this could be the road to sustainable progress. With imagination and creativity regional information systems will deliver where other approaches have failed.

Website content developers should facilitate access and enhance the relevance of IT use in Agricultural communities by developing content that can be understood and implemented, that is in local languages and that deals with local issues. Using internationally adopted standards such as UNICODE should be promoted.

Technologies used to develop the online database

Agricultural Development Networks Online can be developed using three free software tools or standards available on the Worldwide Web, namely PHP, MySQL and HTML.

PHP (Hypertext Preprocessor) is a server-side scripting language designed specifically for web applications. The PHP code can be embedded in HTML pages and is executed every time the page is visited. PHP is an open source product downloadable from the Internet at www.php.net. MySQL is a relational database management system (RDBMS) that enables users to efficiently store, search, sort and retrieve data. The MySQL server controls access to the data and ensures that many users can work concurrently on the database, and provides fast access to the database. It is available under an open source license but commercial licenses are available if required. HTML (Hypertext Markup Language) is a document-layout and hyperlink-specification language. It defines the syntax and placement of special embedded directions, which are not displayed by the browser but tell it how to display the contents of the document including text, images and other support media. The language also makes a document interactive through special hypertext links that connect one document to another and with other Internet resources such as file transfer protocols.

The information on database can be indexed by different main phases of the agricultural fields such as Crop cultivation, Water management, Fertilizer Application, Fustigation, Pest management, Harvesting, Post harvest handling, Transporting of food/food products, Packaging, Food preservation, Food processing/value addition, Food quality management, Food safety, Food storage, Food marketing (Fig.1). All farmers of agricultural field need information and knowledge about these phases to manage them efficiently. Any system applied for getting information and knowledge for making decisions in any agricultural sector should deliver accurate, complete, concise information on time. The information provided by the system must be in user-friendly form, easy to access, cost-effective and well protected from unauthorized accesses (Reddy 2002).

The Indian farmer and those who are working for their welfare need to be e-powered to face the emerging scenario of complete or partial deregulation & reduction in government protection, opening up of agricultural markets, fluctuations in agricultural environment and to exploit possible opportunities for exports. The quality of rural life can also be improved by quality information inputs which provide better decision making abilities. IT can play a major role in facilitating the process of transformation of rural India to meet these challenges and to remove the fast growing digital divide. It can be rightly stated that though Information Technology in the agriculture is in growing stage in the Indian context, it has just started to spread its shoots, but with its immense potential to standardize and regulate the agricultural processes and solve the problems, it is sure that IT will be one of the most important areas in the near future for agricultural development. It is hoped that Information Technology will bring a highly developed agriculture by its worthwhile contributions to the society by narrowing down the enormous gap between the researchers and farmers. It is suggested that the farmers are to be made aware of the utility of the Internet and other related information regarding Information Technology (Phougat 2006).

भारत एक कृषि प्रधान देश है । जिसकी अधिकतर जनसंख्या ग्रामीण क्षेत्रों

में रहती है एवं कृषि उनकी आय का मुख्य स्त्रोत है। कृषि व्यवसाय इस समय कठिन परिस्थिति से गुजर रहा है। दुर्भाग्यवश भारत के किसान सूचना तकनीक/ई - कृषि से अनभिज्ञ है। जिसका मुख्य कारण जागरूकता का आभाव, कृषि भूमि में कमी होना, मूल्यसंवर्धन का विकास न होना, त्रुटिपूर्ण भूमि प्रबंधन, किसानो को उनके उत्पाद के लिए उचित मूल्य न मिलना, सिंचाई एवं कृषि आधारभूत संरचना के लिए उचित निवेश का न होना आदि है। भारत की खाद्रय उत्पादन एवं उत्पदकता में कमी हो रही है जबकि इनकी आवश्यकता बढ़ रही है। सूचना प्रौधगिकी का कृषि में उपयोग करने पर भारत को विश्व स्तर पर पहचान प्राप्त होगी, कृषि उत्पादन को बढ़ाने में सहायता मिलेगी एवं किसानों को उच्च्य मूल्य प्राप्त हो सकेंगा।

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Technological gap in chickpea production technology among tribal farmers of Mandla district Madhya Pradesh

Ragini Varme and **A.K. Pande**
Department of Extension Education
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Jabalpur 482004 (MP)

Abstract

The study indicate that out of 120 respondents majority of chickpea tribal growers (88.33%) had medium to high technological gap in practices of chickpea in Mandla block of Mandla district of Madhya Pradesh.

Keywords : Chickpea, tribal farmer

Chickpea (*Cicer arietinum* L.) is the major pulse crop used in diet of vegetarians in India and is a good source of protein. In India chickpea occupies an area of 7.49 million ha with production of 6.33 million tones with productivity of 845 kg/ha. Chickpea occupies about 38 per cent of area under pulse and contributes about 50 per cent of the total pulse production in India (Anonymous 2007). The area of chickpea crop is 2.84 million ha. with production of 2.79 million tones with productivity of 981 kg/ha. in Madhya Pradesh (Anonymous 2009). The average grain yield of chickpea as per the recommendations of scientist's of Jawaharlal Nehru Krishi Vishwa Vidyalaya is 14 q/ha. Thus it warrants the decrease in through increasing the yield potential at farmer's field by adopting scientist's recommended production technologies. Therefore, a study was conducted to ascertain the existing technological gap in tribal growers of Mandla district who are altogether different in characteristics as compared to the general farmers and the factor associated with.

Material and methods

The present study was conducted in Mandla district of Madhya Pradesh.

The district is situated in between 22°.22" to 23°.22" North latitude and 80°.18" to 81°.50" East longitude. The geographical area of the district is 8771 sq/km with a population of 7,86,648 out of which 5,11,798 are tribal population. Among the nine blocks one block was selected purposively on account of large tribal population (57.23%) and chickpea growers as well as large area 761 ha. and less production 578 tones under chickpea crop as compared to other blocks. Out of total 174 villages of block 10 villages were taken on random basis after preparation of list of chickpea growing villages and 12 farmers from each village were selected on random basis. Thus, a total of 120 tribal respondents were considered for the study as per the procedure adopted by Mishra (2009).

Technological gap in adoption of scientific chickpea production technologies was considered as dependent variable for the study and to measuring this, an adoption index was prepared. The technological gap in different package of practices was worked out by using following mentioned formula as advocated by Bhoite (1983).

Formula

$$\text{Technological gap index (TGI)} = \frac{R - A}{R} \times 100$$

Where,

R = Maximum possible adoption score that a respondent could get

A= Scores obtained by a respondent by virtue of his adoption of given technology

The production practices, viz., field preparation and management, seed management, fertilizer management, irrigation management, weed management, plant protection management, harvesting management and storage management were considered for determining the technological gap. The data were collected with the help of pre-tested structured interview schedule. Percentage and Chi-square test were used for statistical analysis and interpretation of results as recommended by Snedecor (1959).

Result

Distribution of respondents on the basis of technological gap

All the respondents were grouped into low, medium and high categories of technological gap. It was observed that 61.67 per cent respondents belong to medium level of technological gap followed by low technological gap 11.67 per cent (Table 1). More than one-fourth of total sample population (26.66%) did not adopt any recommendation which was considered as high level of technological gap in adoption of chickpea production technology. It was recorded that 11.67 per cent respondents adopted the recommendations of chickpea production technology. The work of Badodia et al. (2002) and Mishra (2009) also reported that maximum numbers of respondents were having medium level of technological gap about chickpea cultivation. The wide gap (88.33%) can be minimized through education and other education programmes.

Table 1. Distribution of tribal growers on extent of technological gap in chickpea production technology N=120

Technological Gap	Frequency	Percentage
Low (1- 33 score)	14	11.67
Medium (34- 66 score)	74	61.67
High (67 – 100 score)	32	26.66

Extent of technological gap in different package of practices of chickpea

The technological gap of package of practices of chickpea was worked the data are presented in (Table 2). The maximum percentage of technological gap was recorded in seed management (60.48%) followed by plant protection management (57.60%), fertilizer management (57%) and weed management (51.80%). The least technological gap was recorded in field preparation (35.83%) and irrigation management (34.12%).

This wide gap in field preparation may be attributed to the common practice and lesser requirement of irrigation in chickpea crop. The maximum technological gap in case of seed management, plant protection management, fertilizer management and weed management must be minimized through educating the farmers by imparting training, conducting result demonstrations and field visits.

Table 2. Mean technological gap in package of practices N=120

Package of practices	Mean	Rank
Seed management	60.48	I
Plant protection management	57.60	II
Fertilizer management	57.00	III
Weed management	51.80	IV
Storage management	40.41	V
Harvesting management	36.94	VI
Field preparation	35.83	VII
Irrigation management	34.12	VIII

Association between socio-economic, psychological and communicational attributes of chickpea tribal growers with technological gap

Out of 15 independent variables, 11 variables, namely, education level, size of land holding, farm power, material possession, scientific orientation, marketing orientation, knowledge level and adoption level had significant and positive association with the technological gap (Table 3). Other 4 variables namely, age, social participation, mass media exposure and contact with extension agencies had non-significant and did not show any relationship with the technological gap.

Table 3. Chi-square between the attributes of tribal growers with technological gap N=120

Socio-economic, psychological and communicational attributes	Chi-square Value
Age	1.34
Education level	14.89**
Size of land holding	6.79*
Farm power	7.963*
Material possession	9.18*
Social participation	0.198
Annual income	5.591*
Socio-economic status	6.475*
Mass media exposure	3.009
Contact with extension agencies	2.979
Extension participation	6.008*
Scientific orientation	14.771**
Marketing orientation	6.070*
Knowledge level	23.48**
Adoption level	10.95**

* Significant at 5 per cent level of significance
** Significant at 1 per cent level of significance

It indicates that these variables did not play any significant role in explaining the technological gap. The variables with Chi-square value high reveal that the variables are associated with the technological gap.

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Evaluation of major characteristics towards yield of rice crop using ANCOVA technique

K.S. Kushwaha and **Sharad K. Jain**
Department of Mathematics and Statistics
Jawharlal Nehru Krishi Vishwa Vidyalaya
Jabalpur 482004 (MP)

Abstract

Analysis of Covariance (ANCOVA) technique has been used to sort out the covariance effect assignable to different causes under investigation about paddy crop. Analysis reveals that the yield attributing characteristics of paddy, viz. number of tillers/hill, number panicles/hill, length of the panicle and number of grains/panicle have been found significant cofactors (covariates) in increasing the yield of the crop.

Keywords: Analysis of covariance, Analysis of variance, Regression analysis, Adjusted and unadjusted yield, Randomized complete block designs

Rice (*Oriza sativa*) is the most important staple food crop in India. It is cultivated in 44.6 million ha and covers the largest acreage under the crop in the world. Rice production accounts for about 43% of the total food grain production and 55% of the total cereal production in the country. Major advances have occurred in rice production during last four decades due to adoption of green revolution technology.

The average yield of rice in Madhya Pradesh is 1.06 tones ha^{-1}. The national average is 2.20 ton ha^{-1} (Statistics 2003) with currant growth in rice production. The productivity of rice in the State is about 1.0 tone ha^{-1} which is lesser than that of national productivity level.

In Madhya Pradesh, rice in grown in the area of about 1.64 million hectares with production of 1.34 million tones and productivity 12.05 q ha^{-1}, which is below than that of national average. 20.05 q ha^{-1}. The productivity of high yielding inbred varieties of rice has almost reached to a plateau with the present level of management in rice growing areas of Madhya Pradesh Introduction of hybrid in rice crop has opened the door of productivity to break the barriers of low productivity in rice growing areas.

In agriculture, the necessary conditions for the field trials is the uniformity of soil condition and culture so that some valid conclusions may be drawn about various treatments applied in study. It is not possible to get an ideal piece of land as is expected for conducting a field experiment and, therefore, the complete randomized block design has been used to meet the need of treatment comparisons with a desired precision up to some extent. It can be possible only with the adoption of proper experimental trial to get reliable data along with the use of suitable statistical methodology and interpretation of such data.

In an ANOVA technique, we sort out the variance components attributable to different sources of variation like blocks, treatments, error etc. But ANCOVA is a statistical technique which controls the variability when experimental control (blockings) fails to meet out the required needs. It is a methods (i) to reduce experimental error through application of a covariate, and also (ii) to minimization of effect an extraneous source of variation in the observations taken. The concept of statistical control is attainable through the use of a co-variate along with the response variable. The ANCOVA makes use of joint applicability of (i) ANVOA and (ii) Regression analysis simultaneously.

An investigation was carried out to achieve the following objectives:

(i) to investigate the presence of of correlation between yield and some important covariates

(ii) to see the effect of some selected covariates which actually regulate the yield of crop

(iii) to see the significance of rice yield of different varieties under unadjusted and adjusted effects of covariates on yield through the use of regression model.

(iv) to search out the better variety amongst varieties considered in the study to give maximum yield in optimized way for recommendation to the farmers.

Methodology for statistical Analysis

The present study is confined to the State of Madhya Pradesh, which is ranked 13th position in the total production of rice in the Indian Union. To fulfill the specific objectives, the study requires the data, viz. number of tillers/hill, number of panicle/hill, length of panicle, number of grains/panicle and grain yield/plot in kg. The data were collected from the Department of Physics and Agrometerology, College of Agricultural Engineering, JNKVV, Jabalpur. Data pertains to rice crop during Kharif season, 2008.

Following Steel and Torrie (1980), the linear statistical model in "Randomized Complete Block Design (RCBD) for ANCOVA", has been utilized for analysis work which is written as

$$y_{ij} = \mu + t_i + \alpha_j + \beta \ (x_{ij} - \bar{x}..) \qquad ... (1)$$

where (i=1,2,3,4...t, j=1,2,3,...,r)

(y_{ij}, x_{ij}): are the values (yield) on ith treatment of rice and jth character of covariate, respectively.

($\bar{x}$.., μ) : Grand mean of covariate x and general mean of response variate y

(t_i, a_j) : Effect of ith treatment and jth block, respectively

b, e_{ij}) : Regression coefficient of y on x and error terms distributed as

$e_{ij} \sim N(o, \alpha_i^2)$

$T_i = \bar{y}_i - \bar{y}... - b(\bar{x}_{i}. - \bar{x}..)$

$\alpha_j = \bar{y}._j - \bar{y}.. - b(\bar{x}._i - \bar{x}..)$

$\beta = b = E_{xy}/E_{xx}$

$\alpha^2_x = \alpha^2_{y.x} = E_{yy} - E_{yy}/E_{xx}$ ...(iv)

Here, E_{xx}, E_{xy} and E_{yg} and adjusted SS, and SP for error respectively and fe is the error d.f. We have to adopt the strategy that the deviation of any treatment mean on response variate y (yield) from grand mean y.. must be adjusted by the quantity b (x_i - $\bar{x}$..). This adjustment removes any attributable effect of covariate x on response variate y. It is adjusted variety means that are comparable in a valid and efficient way.

We have to test the following statistical hypotheses:

H_{01}: There is no significant correlation between yield and its attributing characters at α% level of significance.

H_{02}: Experimental error is non-significant at α% level of significance.

H_{03}: Different varieties have significant effect on crop yield at a% level of significance.

The structure of ANCOVA table for R.C.B.D. and at the same time, illustrates the general procedure (Table 1).

The logic of procedure depends on fitting model by multiple regressions where total SS (adjusted) is partitioned into components attributable to regression and residual. This must be done for the full model i.e. under

Table 1. Structure of Analysis of Covariable in R.C.B.D

Testing adjusted treatment means, ANOVA for the RCBD					Adjusted		
	Sum of products						
Source	d.f	XX	XY	YY	d.f.	$\Sigma(y - \acute{y})^2$	M.S
Treatment adjusted					(t-1)	$S_{yy}-(S^2_{xy}/S_{xx})$ $E_{yy}-(E^2_{xy}/E_{xx})$	M.S(T, adjusted)
Blocks	r-1	R_{xx}	R_{xy}	R_{yy}			
Treatment	t-1	T_{xx}	T_{xy}	T_{yy}			
Error	(r-1) (t-1)	E_{xx}	E_{xy}	E_{yy}	(r-1) (t-1)-1	$E_{yy}-(E^2_{xy}/E_{xx})$	$s^2_{y.x}$
Treatment + error	r(t-1)	S_{xx}	S_{xy}	S_{yy}	r(t-1)-1	$S_{yy}-(S^2_{xy}/S_{xx})$	
Total	r(t-1)	$\Sigma(X-\bar{X})^2$	?(X- $\bar{X}$)^2 (Y - $\bar{Y}$)	$\Sigma(Y-\bar{Y})^2$			

H_1 and again for the reduced model, i.e. under H_0. Finally, we have M.S.E.= $\$^{2}y.x$ for full model and partial regression coefficient of Y on X is given as $b = E_{xy}/E_{xx}$. which estimates β.

Table 2. The correlation matrix of various covariates with response variate Y (yield)

	Y	X_1	X_2	X_3	X_4
Y	1.000				
X_1	0.085	1.000			
X_2	0.203	-0.390	1.000		
X_3	0.204	-0.435	0.937**	1.000	
X_4	0.092	0.937**	-0.124	-0.136	1.000

** Correlation is significant at 1% level of significance (two tailed).

Pair wise correlation coefficient is worked out for combination of all characters under study using the expression

$$r_{xg} = \frac{\sum_{i}^{n} x_i y_i - \sum_{i}^{n} x_i \frac{\sum_{i}^{n} y_i}{n}}{\sqrt{\left(\overset{n}{\Sigma} x^2 - \left(\frac{\overset{n}{\Sigma}}{n} x\right)^2\right)\left(\overset{n}{\Sigma} y_i^{\,2} - \left(\frac{\overset{n}{\Sigma}}{n} y_i\right)^2\right)}}$$

Results and discussion

Silva et al. (1988) explained regression analysis to estimate the relation between rice yields in Sao Paulo and monthly water deficits, Wu (1989) suggested the ANOVA and ANCOVA for agronomic traits with

Table 3. Analysis of variance for unadjusted yield of rice with different covariates separately

Covariance	Source of variance	d.f.	Mean sum of square	Fcal	Ftab 5%
No. of tillers/hill	Replication	2	3.475	1.735	
	Treatment	7	372.32	235.6	3.23
	Expt. error	14	1.58	0.489	1.72
	Sampling error	96	3.22		
	Total	119			
No. of panicles/hill	Replication	2	2.80	0.60	
	Treatment	7	325.57	43.10	3.23
	Expt. error	14	7.55	0.071	1.72
	Sampling error	96	2.45		
	Total	119			
Length of panicle	Replication	2	0.209	0.094	
	Treatment	7	29.2	13.28	3.23
	Expt. error	14	2.198	0.72	1.72
	Sampling error	96	3.02		
	Total	119			
No. of grains/panicle	Replication	2	1404.7		
	Treatment	7	24204.22	3.58	
	Expt. error	14	391.30	61.88	3.23
	Sampling error	96		0.488	1.72
	Total	119			
Grain yield/plot	Replication	2	16.69	3.16	3.75
	Treatment	7	15.75	2.99	2.77
	Expt. error	14	5.269		
	Sampling error	96			
	Total	119			

Table 4. Treatment means with various covariates

Treatments	Means				
	No. of litters/hill	No. of panicles/hill	Length of panicle	No. of grains/ panicle	Grain yield/......
T_1	4.925	3.600	9.950	88.320	18.830
T_2	5.15	2.900	10.375	118.200	19.330
T_3	7.62	6.75	9.025	76.700	22.000
T_4	7.225	6.475	9.625	73.700	16.000
T_5	2.42	2.175	9.525	79.220	17.33
T_6	2.57	2.300	9.525	85.050	20.000
T_7	4.77	4.200	9.025	73.250	21.500
T_8	4.825	3.770	9.175	73.570	16.160
C.D.	0.56	0.795	0.292	8.930	4.029

Table 5. ANCOVA for unadjusted and adjusted yield of rice with different covariates

Covariates average No. of tillers/hill	Treatments (varieties)	Average yield Unadjusted	Average yield Adjusted
13.13	A	18.83	18.78**
13.73	B	19.80	20.06**
20.06	C	22.00	18.24*
19.04	D	16.00	11.93
6.46	E	17.33	7.17
6.86	F	20.00	10.05
12.8	G	21.00	14.34
12.86	H	16.16	9,03
	C.D. at 5%.=17.54		
9.60	A	18.83	9.16
7.73	B	19.80	9.95
18.00	C	22.00	13.34**
11.20	D	16.00	6.55
5.80	E	17.33	7.26
6.10	F	20.00	9.97
11.20	G	21.55	12.06**
10.13	H	16.16	6.59
	C.D. at 5%.=8.564		
26.50	A	18.83	27.47**
27.60	B	19.80	29.91**
24.06	C	22.00	27.53**
25.66	D	16.00	23.85
25.40	E	17.33	24.59
25.40	F	20.00	27.26
23.93	G	21.55	26.87
24.46	H	16.18	22.21
	C.D. at 5%=4.769		
235.53	A	19.83	226.12**
315.40	B	22.00	1824.50**
204.50	C	16.00	-414.10
196.50	D	17.33	-403.30
211.22	E	17.00	-209.50
206.40	F	20.00	-338.30
195.40	G	21.55	-601.00
196.60	H	16.16	-432.80
	C.D. at 5%=11.599		

unbalanced data in hybrids of Indian rice. Lin (1992) explained the cultivation methods for producing the highest yield for rice c.v. Shamyou 63 were modeled. Wu Liang Huan et al. (1995) provided explanation based on data from 84 fertilizer application experiments with rice and obtained equations for regression analysis of factorial experiments with limited replications. Rao, et.al. (1998) conducted a field experiment at the ICRISAT, Hyderabad, India, over 6 years period to study the run off from Alfisola under numbers of tillage without amendments. Becker, and Johnson (2001) found that much of the rapidly growing demand for rice in West Africa will be met from production in island valley swamps which are abundant and relatively robust with regard to cropping intensification. Mahto, R.N. and Mohan (2003) proposed the regression analysis of 26 early maturing upload rice genotypes conducted in a field experiment in Ranchi, Jharkhand, India, during the Kharif season of 1995.

There was no significant correlation between yield and its attributing character at 1% level of significance. But there is significant positive correlation between No. of tillers/hill and number of grains/panicles and same is between length panicle and No. of panicle/hill (Table 2).

The experimental error is non-significant and hence sampling error is pooled with experimental error to see the significance of variety means (Table 3).

The treatment T_2 and T_3 are significant and are also more superior, but T_3 is formed most superior and hence it is the best variety (Table 4).

On comparison of adjusted variety difference values with C.D., value, the variety B is the highest tiller/yield among varieties followed by variety A and is significantly different from others (Table 5).

In case of comparison of adjusted means difference values with C D values, the variety C has highest No. of panicle / hill among the varieties followed by variety G. and significantly different from other varieties.

In case considering length of panicle, the variety "B" has the highest length of panicle yield among varieties followed by variety C and is significantly different from other varieties.

In case of considering yield for number of grain / panicle, the variety B has the highest grain yield among verities followed by A and is significantly different from other varieties.

Finally, we come to a conclusion that variety B is the best variety for Kharif season.

धान पर किये गये परीक्षण के दौरान ।छब्ट। तकनीकी के द्वारा ब्वअंतपंदबम के विभिन्न घटकों का अध्ययन किया गया है । धान के विभिन्न लक्षणों के विश्लेषण के पश्चात पाया गया कि धान की पैदावार पर जपससमत की संख्या प्रति ीपससए चंदपबसम की संख्या प्रति ीपससए चंदपबसम की लम्बाई एवं दाने की संख्या प्रति चंदपबसम को फसल की पैदावार बढ़ाने वाले सार्थक एवं प्रभावी संघटक ;ब्वअंतपंजमद्ध के रूप में पाये गये ।

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Non-linear model for prediction of area under wheat crop in Madhya Pradesh

R.B. Singh, Ramkesh Meena, K.B. Tiwari and **Mahesh Patidar**
Department of Mathematics and Statistics
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Jabalpur 482004 (MP)

Abstract

The study is concerned with diagnostics analysis of the non-linear models for the forecasting of area under wheat crop in Madhya Pradesh. The four non-linear models were employed. Two models Gompertz followed by Logistic were found best suitable because they fore cost the area very well.

Keywords: Non-linear models, Logistic, Gompertz, Monomolecular, Richards, residuals, statistic, goodness of fit, growth

Wheat (*Triticum aestivum*) is the important staple food crop. It is cultivated over an area of about 215 m ha. with the production of 584mt grain. Wheat production of India jumped from 6.40 million tones in 1950-1951 to a record figure of 80.80 million tones in 2010-11 (Agriculture Statistics at a glance).

A number of studies have been undertaken to understand the growth pattern of area under wheat crop in Madhya Pradesh. Statistical tool and techniques ranging from graphs, charts and diagrams to regression analysis were employed. But the potential of the area was unanswered. Hence, the study of the growth process of area employing sound statistical techniques was undertaken.

Various important nonlinear deterministic growth models viz. Logistic, Gompertz, Monomolecular and Richards are fitted.

Logistic Model

Let x (t) denote the variable under study like production or productivity or area of wheat at time t. also, let A (>0) denote the intrinsic growth rate and C the carrying capacity of the environment. Thus the model is represented by

$$X(t) = C / [1+B \exp(-At)]$$

Where
$B=[C-X(0)] / X(0)$ and $X(0)$ is the value of $X(t)$ at t=0.

Gompertz Model

Gompertz model is another sigmoid growth model. It is represented by

$$X(t) = C \exp[-B \exp(-At)].$$

Monomolecular model

The model describes the progress of a growth situation in which it is believed that the rate of growth at a particular time t is directly proportional to the amount of growth yet to be achieved. The model is represented by the equation

$$X(t) = C- (C-B) \exp(-At)$$

Richard's model

Like mixed influence model, Richard's model has a four-parameter growth model. It is proposed by Richards (1959) and is represented by

$$X(t) = C / [\{1 \pm B \exp(-At)\}^{1/D}]$$

Where,

$B = [\{C^D-X^D(0)\}/X^D(0)]$ is the constant of integration.

The upper sign within the brackets is applicable when D is positive and the lower sign when D lies in the Range $-1 \le D < 0$. Richards model is a generalization of logistic (when D=1), Gompertz (when D=0), and monomolecular (when D= -1) models.

Material and methods

Test for randomness of residuals

To test whether the successive observations are random are not, we examine residuals. Replace a residual by "+" or "-"sign according as it was positive or negative. Let n1 be the number of pluses and n_2 was the number of minuses in the series of residuals. The test was based on the number of runs (r); where a run was define as a sequence of symbols of one kind separated by symbols of another kind. We test the null hypothesis

H_0: the test of residuals is random,

Against

H_1: the test of residuals is not random.

The required statistical test is the one sample run test. The mean and variance of the sampling distribution of r, the number of runs, was given by

Mean (μ) = $[2n_1n_2 / (n_1+n_2)] + 1$

and

Variance (s^2) $[2n_1n_2 (2n_1n_2-n_1-n_2)] / [(n_1+n_2)\ 2(n_1+n_2-1)]$

Therefore, for large samples, the required test statistic was

$$Z = \frac{\left[r + h - \left(\frac{2n_1n_2}{n}\right) - 1\right]}{\sqrt{\left[\frac{\{2n_1n_2(2n_1n_2 - n_1 - n_2)\}}{\{(n_1+n_2)^2(n_1+n_2-1)\}}\right]}}$$

Where,

$h = 0.5$ if $r < 2n_1n_2 / n+1$

and

$h = -0.5$ if $r > 2n_1n_2 / n+1$

Since H_1 does not predict the direction of the deviation from randomness, a two-tailed rejection region was used. Thus H_0 is rejected at level of significance α if

$$|Z| > Z_{\alpha/2}$$

Where

$$Z ?= P(Z > Z_{\alpha}) = \alpha$$

The most widely used method of computing nonlinear least square estimates is Levenberg-Marquadt algorithm (Levenberg 1944 Marquadt 1963) has been used. The method represents a compromise between the linearization (i.e. Taylor series) method and the gradient (i.e. steepest descent) method and combines successfully the best features of both and avoids the series

Goodness of fit of nonlinear statistical models

An important question that arises when a modeler wants to develop model empirically is that of how a specified model fits the given data set. A lot of studies have been conducted for investigating whether a proposed model provides a good description of the data. The widely used method is based on examination of residuals. The usual modeling situation was that a model is adopted because some theory and / or empirical evidence from the use of that model over many data sets indicate that model is appropriate (Ratkowsky 1983).

Coefficient of determination (R^2)

The goodness of fit was examined by using the coefficient of determination (R^2). Kvalseth (1985) examined the different forms of R^2 available in the literature. Eight different forms of R^2 have been mentioned in his paper. One of the main conclusions of the paper was that

$$R^2 = 1 - \text{Residual SS} / \text{Corrected SS} \qquad (1)$$

values of this R^2 was well defined with end points corresponding to perfect fit and complete lack of fit, such as $0 \le R^2 \le 1$, where $R^2 = 1$ corresponds to perfect fit and $R^2 \ge 1$ for any reasonable model specification. For nonlinear statistical models its value can be negative, if the selected model fits worse than the mean (Kvalseth 1985).

Root means squared errors (RMSE)

The RMSE is defined as

$$RMSE = \left[\frac{\Sigma(X-\hat{X})^2}{n}\right]1/2 \qquad (2)$$

The smaller the value of RMSE the better is the model.

(iii) Mean absolute error (MAE) the MAE is defined as

$$RMSE = S\,|X - X|\,/\,n \qquad (3)$$

the smaller the value of MAE the better is the model.

Mean squared error (MSE)

The MSE is defined as

$$MSE = \frac{\Sigma(X-\hat{X})^2}{(n-p)} \qquad (4)$$

In equation (2) to (4) the summation is over all the observed values, n denote the total number of observed values and p denotes the number of model parameters. Ratkowsky (1990) mentioned that MSE is the best goodness of fit statistic as it explicitly considers number of parameters in the definition.

Correlation coefficient between observed and predicted values [$r(X, \hat{X})$]

It is the simple product moment correlation coefficient between observed and predicted values. The greater the value the better is the model.

Results and discussion

Various nonlinear statistical models Logistic, Gompertz, Monomolecular and Richards are considered for modeling total area under wheat in state of Madhya Pradesh (Table 1). In all the four models Logistic and Gompertz fit very well to the data set than the other models, The best fit model is Gompertz, followed by Logistic model for the data set because the other two models showed the higher values of RMSE, MSE, MAE parameter values, hence discard Monomolecular and Richards in comparison of three parameter models that is Logistic and Gompertz. The coefficient of determination was maximum with comparison various goodness of fit of statistic R^2, RMSE, MSE, MAE, and $r(X\,\hat{X})$. Therefore Gompertz model followed by logistics was considered as the best suited models. The difference between the statistics of goodness of fit of these models was negligible. Therefore no difference among these models was noticed. Gompertz and Logistic model well considered for the fore casting of area of wheat in Madhya Pradesh. The illustration of graphs of fitted logistic, Gompertz, monomolecular, and Richards. Models as represented in (Fig 1 a, b, c, d) showed the clear-cut picture that Gompertz and Logistic fit the data best. The result of the observed and fitted value is given in the Table 2.

Table 1. Results of fitting various models to the data sets regarding total area under wheat (in million hectares) crop during 1984-85 to 2008-2009

Constants	Logistic	Gompertz	Mono molecular	Richards
A	0.034	0.026	0.0060	0.0056
B	0.32	0.31	0.35	246.43
C	4702.11	4873.07	7605.60	-88
D				0.074
RSS	2949444.45	2953453.22	2981421.74	3010503.19

Examination of Residuals

	Logistic	Gompertz	Mono molecular	Richards
No. of Runs	6	6	6	6
Z	-2.021	-2.021	-2.021	-2.021

Goodness of fit statistic

	Logistic	Gompertz	Mono molecular	Richards
R^2	0.905	0.906	0.910	0.905
RMSE	343.47	343.71	345.49	347.01
MSE	134066.5	134247.7	135519.5	143357.4
MAE	256.00	256.77	258.93	260.40
r(X, X)	0.434	0.435	0.426	0.418

Table 2. Observed and estimated area (1000 hectares) for the different models

YEAR	Area observed	Logistic estimated	Gompertz estimated	Monomolecular estimated	Richard's estimated
1884-85	3598	3575.25	3580.67	3605.79	3613.47
1885-86	3705	3604.35	3609.34	3629.96	3633.99
1886-87	3502	3633.03	3637.48	3653.98	3654.64
1887-88	3667	3661.28	3665.11	3677.85	3675.4o
1888-89	3667	3689.09	3692.23	3701.58	3696.28
1889-90	3284	3716.46	3718.84	3725.17	3717.28
1990-91	3738	3743.38	3744.94	3748.62	3738.40
1991-92	3458	3769.86	3770.55	3771.92	3759.64
1992-93	3589	3795.9	3795.66	3795.08	378100
1993-94	4053	3821.49	3820.28	3818.11	3802.48
1994-95	4096	3846.63	3844.42	3840.99	3824.09
1995-96	3925	3871.32	3868.08	3863.73	3845.81
1996-97	4235	3895.57	3891.26	3886.34	3867.67
1997-98	4502	3919.37	3913.99	3908.81	3889.64
1998-99	4575	3942.73	3936.25	3931.15	3911.75
1999-00	4670	3965.64	3958.05	3953.35	3933.98
2000-01	3311	3988.11	3979.41	3975.42	3956.33
2001-02	3704	4010.15	4000.33	3997.35	3978.82
2002-03	3382	4031.74	4020.81	4019.15	4001.43
2003-04	4045	4052.9	4040.86	4040.82	4024.17
2004-05	4200	4073.63	4060.49	4062.36	4047.04
2005-06	3785	4093.93	4079.7	4083.77	4070.04
2006-07	4275	4113.81	4098.51	4105.05	4093.17
2007-08	4101	4133.27	4116.91	4126.2	4116.44
2008-09	4010	4152.32	4134.91	4147.22	4139.83

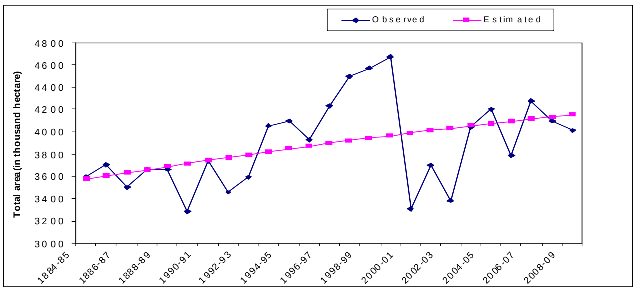

Figure 1(a). Fitted Logistic model to total area under wheat crop for the state of Madhya Pradesh

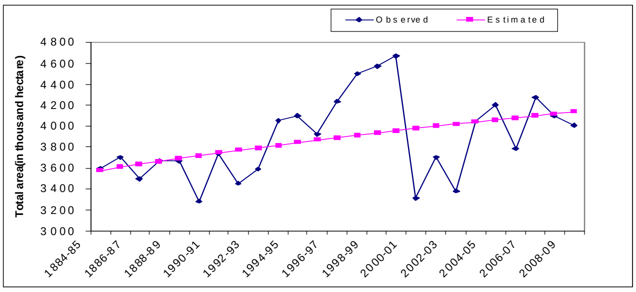

Figure 1(b). Fitted Gompertz model to total area under wheat crop for the state of Madhya Pradesh

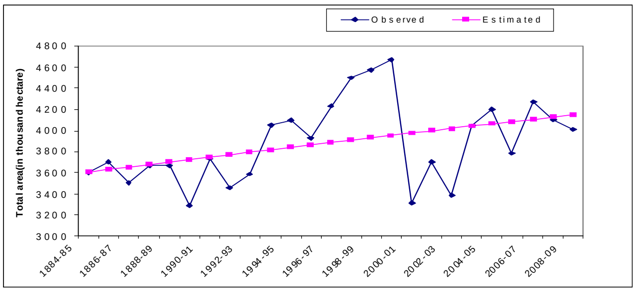

Figure 1(c). Fitted monomolecular model to total area under wheat crop for the state of Madhya Pradesh

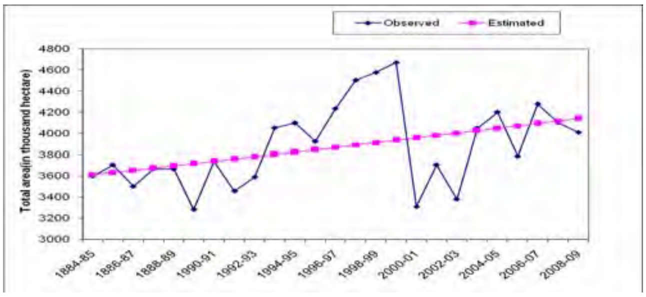

Figure 1(d). Fitted Richards's model to total area under wheat crop for the state of Madhya Pradesh

इस अध्ययन में गेहूँ के क्षेत्रफल के पुर्वानुमान के लिए चार आरेबीच के प्ररूप की पहचान का विश्लेषण किया गया है। यह पाया गया है कि दो प्रारूप गुम्पर्ज एवं लाजिस्टिक उपयुक्त है।

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Studies on land use pattern changes in Betul tehsil during past decade using remote sensing technique

V.K. Verma*, N.K. Khare, D.P. Rai and **K.K. Saxena**
*Programme Coordinator
Krishi Vigyan Kendra, Betul
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Jabalpur 482 004 (MP)

Abstract

During the systematic survey of Betul district, it was observed that a great variety of soils (soil family association) occurs in the region. These soils are found to occur either as a single entity or an association of two to three soil families in a mapping unit of a particular landform and soil portion represents a large fraction of the biological and physical activities necessary for turfgrass growth. It serves as a growth medium, and a source of nutrients and water. It was observed that more than 60 per cent of the districts have no stoniness, while the rest of the area falls under moderate to slight stoniness. The nitrogen content in 54 per cent of soil is medium; in 21 per cent of soil is high and that of 25 per cent of soil is low. This shows that the most of the soils need (low and medium category) the application of nitrogen. As a whole in the district, 105451 ha has low K, 456957 ha has medium K and 441892 ha has high K status indicating the necessity of K fertilization in about 56 per cent (low to medium) area of the district. These lands are grouped under marginal to moderate suitability class for cultivation. About 28 per cent land of the districts falls under class VI-VIII which are not suitable for cultivation. the introduction of canal irrigation has resulted in the development of soil salinity and shallow water table in the arid and semi-arid regions, which have depicted serious negative impact on the agricultural environment in these areas. The Total Forest Area is 4085.043 sq. km (40.67 % of total geographical area of the district) with protected Forest (1245.634 sq. km) and reserved Forest (2839.409 sq. km)

A country is considered to be the social and political stable nation, if it possesses a very sound agriculture base. In India, it is the largest enterprise up holding by more than 10 crore farm holdings. It contributes nearly 14.6 per cent of national GDP and sustains livelihood of more than 65 per cent population, helps in alleviating poverty and provides food to more than 1 billion people. It forms the base for agro processing industries by supplying raw material and contributes to 1/6th of the export earnings.

There is a continuous pressure of growing population and dynamism in human activities resulting in change in agricultural resource pattern and use. A systematic planning is urgently needed to combine the conventional practices with modern to reap the fruits of advancement in science and technology. There is a great concern about decline soil fertility and water level, increasing soil salinity, resistance too many insecticides, pesticides and degradation of irrigation water quality. In many areas of the country due to misuse and improper management of natural resources especially land and water have initiated a process of degradation through loss of soil productivity and environmental quality. This has resulted in soil erosion, silting up to storage reservoirs, rising steam beds, frequent floods, water logging etc. Apart from this, there is a continuous competing demand on land resources which are gradually leading to land scarcity. In many parts, large areas of prime agricultural land lost due to urbanization and developmental activities. Forests are being intruded for agriculture and subjected to heavy pressure of grazing.

In view of the above situation, importance of land, resource for the survival and welfare of the people, economic independence of the country it is imperative to give high priority to promoting optimum land use to maintain and improving soil productivity and to conserve soil resources. The available land of the country is already being put to use due to an increasing demand for various agricultural, forestry and livestock products for consumption and export, it evidently need the planning for its best use. The conventional methods of data collection by simple survey method to systemic land use surveys are generally costly and time consuming. The new scientific ways such as Remote Sensing and Geographical Information System (GIS) proved great significance to record information on cropping pattern changed and agriculture land which is a prerequisite for optimal land use planning.

The advent of remote sensing technology and its potential in the field of agriculture has given new opportunities for improving agricultural statistics. Singh et al. (2003) proposed suitable methodology for estimating crop area by integrated remote sensing and GIS based on spatial sampling approach. Remote sensing is powerful technique for surveying, mapping and monitoring earth resources. Development of remote sensing and Geographical Information System(GIS) technologies have resulted in the betterment of mapping and interpretation techniques as a means of understanding and effective managing the present sources for sustainable. A unique feature of systems is that it allows human logic and intuition through a specifically developed programme for correcting and modifying the discrepant classification arising out of spectral similarity of two or more classes in non forest stratum. The technology combined with GIS which excels in storage, manipulation and analysis of geographic information and socio economic data provide wider application and remotely recorded have been successfully used for a variety of applications in arid and semi-arid regions along the world. Land use and land covering mapping using remotely sense image data involves delineation of the constituent units .Such delineation however, is dependent on wavelength region, in which they are imaged and also the spatial resolution of the image sensor. The visible and infrared bands provide information on common land cover features water, soil and vegetables Goward et al. (1994).

Material and methods

The study was conducted in Betul tehsil of Betul District. Betul tehsil is situated in Satpura Mountain running east to West Satpura hills, Sapura Plateau, Satpura plains. The tehsil is categories under agro climatic zone Satpura Plateau Zone and has basically agriculture oriented economy. It receives monsoon rains during June to October The average rainfall of the district 1083.9 mm in 57 rainy days. Betul tehsil is situated in the south central part of the Madhya Pradesh with head quarter at Betul under Bhopal division. It is bounded northwest by Hoshangabad district in southwest by Khandwa District in the east by Chhindwara district of Madhya Pradesh and in south by Amravati District of Vidarbha region of Maharastra state. The tehsil is located between 210-220 to 220-240 North latitude and 740-04 to 780-330 East latitude the general elevation is 700-800 meters above mean see level (MSL).

An extensive survey of the Tehsil was carried out to collect relevant information for present study. No questionnaire based study was carried out but information was collected through formal interviews of the farmers, local governing bodies and personnel. It included RAEO, Patwaries, Sarpanch and Agriculture Extension Officers etc. Fifty different villages of the Tehsil lying in different direction were randomly surveyed. These villages surveyed were later used for remote sensing studies as well. The information regarding the change in agricultural mechanization, fertilizer and plant protection methods were collected through these villages. Also the causes and concern for these changes was discussed with the farmers and related authorities. Data regarding agriculture Land Use Land Cover (LULC) pattern, crop cultivation, water resources etc. were produced through various government and semi government organization including District planning and Statistic Department, Betul; State Land Record Department, Betul; National Informatics Center, Betul, Agriculture Department, Soil testing Laboratory, Betul.

Result and discussion

In a developing country like India, it is necessary to know and evaluate the changes/transformations of land cover that are going on. Out of several land use practices agriculture is one of them, where man uses the land for growing crops to fulfil his basic food demands. During this practice he transformed the land cover other than agricultural land into croplands. Conventional ground methods of land use mapping are labour intensive, time consuming and are done relatively infrequently. These maps soon become outdated with passage of time, particularly in a rapidly changing environment. Hence, to have knowledge based concrete record of transformation of land cover and the rate of land use practices man had developed modem tools like remote sensing satellite to have a vigilant watch on the changes. Remote sensing satellite is one of the best tools designed by the human being for continuous monitoring of such changes ever taking place on the land cover due to its revisit capacity. The remote sensing sensors data provides better information about the changes. In agricultural applications, remote sensing imagery has been used to identify different crop types, estimate crop area and, predict yield at small (Kanemasu 1974).

The remote sensing and GIS approach not only emphasize on the agricultural practices in the country, it also help to manage the sustainability of agriculture even in the regional area like small or large tehsil of a state district. The tehsil level agricultural crop analysis is possible only through the IRS series satellite data due to its resolution. However, in addition to this, it seems that the analyses based on synoptic data make extrapolations to lower administrative levels difficult (Ocatre 1997). Monitoring of potential yield based administrative aggregates is disadvantageous because of the wide conditions and land use types that may occur within their area.

Remote sensing satellite data helps in sustainable agricultural practices. In order to achieve sustainable agriculture, national planners and decision makers require timely, accurate and detailed information on land resources. Available crop area statistics are disseminated as administrative aggregates in tabular format. The aggregate form of such data is incompatible with data formats that attempt to interpret spatial relationships of factors related to crop distribution and production potential. The traditional notion of thematic mapping presumes that every spot on the ground surface can be labelled as belonging to only one category (Schowengerdt 1997). The landscape is a heterogeneous area consisting of a mosaic of local and interacting ecosystems, which may include forests, cropland, shrub land, open grassland and built up areas (DeFries et al. 1996). However, the identification of object depends on the spatial resolution of the remote sensing imagery (Tomar and Maslekar 1974).

The present study primarily aims at generating detailed agricultural cropping pattern and relevant land cover land use classes of the tehsil maps by using remote sensing and GIS techniques incorporated with expert knowledge to spatially distribute crop areas and other possible land cover /land use classes. For this IRS IA LISS IT and IRS ID LISS III data were chosen as the most efficient satellite data for 1:50000 scale for agricultural and land use land cover pattern changes study applications. Spatial information on the expansion and identification of agricultural production is an important aspect in the generation of spatial agricultural statistics. This present study is based on the observation that there is an increasing need for accurate and timely information on crop area information at national level.

Soil

Soil systems like most natural systems, are in dynamic equilibrium. Most changes are slow and imperceptible particularly when viewed in the time frame of human lifespan. However, catastrophic events such as high intensity storms can accelerate erosion processes resulting in measurable changes. These 'performance-related changes are more important as they can be quantified, particularly in economic value terms (Szabolcs 1994). Soil survey provides an accurate and scientific inventory of different soils, their kind and nature, and extent of distribution so that one can make prediction about their characters and potentialities. It also provides adequate information in terms of land form, terraces, vegetation as well as characteristics of soils (viz., texture, depth, structure, stoniness, drainage, acidity, salinity and so on) which can be utilized for the planning and development. More than ninety percent of world's food production is dependent on soil (Venkataratnam & Manchanda 1997). The scientific documentation of the properties of Indian soils dates back to 1898 when J.W Leather distinguished four major groups of soils namely Indo-gangetic alluvial soils, black cotton or regular soils, red soils lying on metamorphic rocks and lateritic soils (Velayutham 2000). The use of digital image processing for soil survey and mapping was initiated with the establishment of National Remote Sensing Agency and Regional Remote Sensing Service Centres. The initial works carried out by Venkatratnam (1980) and Kudrat et al. (1990) demonstrated the potential of digital image processing techniques for soil survey.

Soils are varied in nature. Their extent and development depends upon the environmental setting in which they have been evolved. The knowledge on the kinds of soils and their extent is very essential for sustainable land use planning. Soil resources inventory provides this kind of information, obtained through a systematic interpretation of remote sensing imageries, photograph, field survey, laboratory characterization and cartography. During the systematic survey of Betul district, it was observed that a great variety of soils (soil family association) occurs in the region. These soils are found to occur either as a single entity or an association of two to three soil families in a mapping unit of a particular landform.

Organic Matter

Soil organic matter is any material produced originally by living organisms (plant or animal) that is returned to the soil and goes through the decomposition process. At any given time, it consists of a range of materials from the intact original tissues of plants and animals to the substantially decomposed mixture of materials known as humus. Most soil organic matter originates from plant tissue. Plant residues contain 60-90 percent moisture. The remaining dry matter consists of carbon (C), oxygen, hydrogen (H) and small amounts of sulphur (S), nitrogen (N), phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg). Although present in small amounts, these nutrients are very important from the viewpoint of soil fertility management. Soil organic matter consists of a variety of components. These include, in varying proportions and many intermediate stages, an active organic fraction including microorganisms (10-40 percent), and resistant or stable organic matter (40-60 percent), also referred to as humus. Radar waves may not be able to penetrate soil if it is moist. On the soil reflectance spectra, this soil moisture will develop parallel curves. Moisture of soil has an equal effect over the spectrum and the ration between the spectral bands. Spectral bands of red and near-infrared bands are independent from the soil moisture. The soil line of the soil reflectance spectra, characterizes the soil type, defines vegetation indices, and corrects the plant canopy reflectance from the optical soil property effects. This soil line also represents the relationship between the red and the near-infrared soil reflectance. Ground radar can also be used in combination with remote sensing, to detect changes of diagnostic soil horizons such as albic, spodic and argillic horizons or soil/rock boundaries. Limitations with ground radar include soils with high salt content/clay/silt/moisture amounts.

Soil particles

The soil particle such as proportion of the sand, silt and clay play an important role for water holding and retentive capacity, response to water management, response to application of fertilizers etc. the soil having almost equal amount of sand, silt and clay are considered as ideal. However, the existences of such soils are seldom. Soils with extreme high content of clay, high content of sand or high content of silt are said to be bad soils in term of particle size classes. Usually the soils are met with different proportion of particles. In view of this the soils of the soils of the district have been categorized as below. The fine soils are accounted to 35 per cent, followed by loamy soil 29 per cent, clayey soils to 16 per cent and loamy skeletal soils to 10 per cent TGA.

In Betul district the soil portion represents a large fraction of the biological and physical activities necessary for turfgrass growth. It serves as a growth medium, and a source of nutrients and water. The interaction nature of soils and water together is the focus of this presentation. Basically the soil particle size, the soil particle size distribution, and the structure of the soil determine the moisture characteristics (soil water relationships) a particular turfgrass soil will have. Soil particles are basically composed of sands, silt, clays and organic matter. Sands include particle sizes which range from 0.05 mm to 2.0 mm in size. This is a very large range of particle sizes Silt particles range in size from 0.05 mm to 0.002 mm, and clay particles are those particles less than 0.002 mm in size.

Clay Mineralogy

Clay minerals (and clay-sized particles) represent the ultimate fate of the crystalline rocks as they interact with surficial environmental conditions, provide the substrate that sustains life (and may even have played an essential role in the creation of life!), are important constituents of the "critical zone", play a key role in global biogeochemical cycling, and are important to humanity with respect to their role in natural hazards (swelling clays, slip surfaces of landslides and faults), as a natural resource, as they impact human health, their importance to civil engineering projects, and topical issues such as nuclear waste repositories. The clay mineralogy of the districts have been studied and concluded that they are closely related to the nature and kinds of parent material/rock. The soils of mixed mineralogy occupy an area of 32 per cent; Smectitic (developed from fine gravels, basaltic rocks - basalt) 38 per cent and that of kaolinitic mineralogy around 29 per cent (coarse nature of parent rock/materials).

Calcareousness of Soil

In general there are two kinds of soils i.e. calcareous and noncalcareous. The calcareous soils having calcium carbonate within 50 cm from the surface. The content of $CaC0_3$ help for crop growth and to some extent improves the quality of fruit crops/grains etc. but it has some reservation. The $CaCO_3$ more than 20% is harmful to the root crops and also uptake of nutrients. Based on content of $CaC0_3$, the soils have been categorized as slight, moderate and strongly calcareous soils. Slightly calcareous soils do not have much problem whereas strongly calcareous soils pose problem for crop production etc.

The land use of calcareous soils is highly variable: it ranges from non-used wastelands (deserts) to intensively cultivated irrigation areas. Calcareous soils develop in regions of low rainfall and must be irrigated to be productive. Therefore one of the main production constraints is the availability of water for irrigation. The quality of the irrigation water is of crucial importance for sustainable agricultural production on calcareous soils. Frequently, the irrigation water is the cause of many management problems. Almost all waters used for irrigation contain inorganic salts in solution. These salts may accumulate within the soil profile to such concentrations that they modify the soil structure, decrease the soil permeability to water, and seriously injure plant growth. Crusting of the surface may affect not only infiltration and soil aeration but also the emergence of seedlings. Cemented conditions of the subsoil layers may hamper root development and water movement characteristics. Calcareous soils tend to be low in organic matter and available nitrogen. The high pH level results in unavailability of phosphate (formation of unavailable calcium phosphates as apatite) and sometimes reduced micronutrient availability e.g. zinc and iron (lime induced chlorosis). There may be also problems of potassium and magnesium nutrition as a result of the nutritional imbalance between these elements and calcium.

Stoniness

The stoniness of surface is the area covered by stones playing an important role for soil crop and water management practices. More the area, the more is the risk of conservation measure and vice versa. The stoniness depends on slope gradients, terrain, management practices, land use, land cover etc. As such in the district three stoniness classes .are noticed. A land having less than 3% stones cover is classified as 'nil'; 3-15% stones cover as 'Slightly stony and 15-40% stones cover as moderately stony. This stoniness provides the hurdle in all sort of (soil, crop and water) management practices leading to low productive area. It was observed that more than 60% of the districts have no stoniness, while the rest of the area falls under moderate to slight stoniness.

Availability of Nitrogen

Nitrogen is an essential plant nutrient and is of a singular importance in influencing crop production. Its unique position in agriculture is due to the fact that its, occurrence in soil in general is low, and in atmosphere enormous. Its requirement by plant is considerable very high. Normally food grain crops need 4-5 kg of N for production of one quintal of grain yield. The entry of atmospheric nitrogen in soil had taken place through series of steps, the front one being the symbiosis fixation of atmosphere elementary nitrogen (78.09%) and through liberation of nitrogen from fundamental rocks as well as reduced forms of nitrogen to elementary form. The nitrogen content in 54% of soil is medium; in 21 % of soil is high and that of 25% of soil is low. This shows that the most of the soils need (low and medium category) the application of nitrogen.

Available Potassium

Available potassium (K) refers to that forms of soil K which remains on exchange complex (exchangeable) and in water soluble form, together these can be extracted easily by plant to meet its requirement. On an average the exchange phase K dominated by 90 per cent and that of solution phase K by 10 per cent to the total pool of available K. The variation in available K status is governed by top sequential occurrence of soil, texture, CEC, K-activity, depth and slope gradient. The value increases with fineness of texture and also with increasing CEC (r=0.561; Y = 5.6 CEC-7.3); K-activity (r = 0.96; Y = 2788 ak-19) and soil depth. The shallow soils usually accompanied by coarser texture occurred at or near the escarpment and are usually associated with relatively low value of available K. Considering the K fertility indices as: less than <150 ppm K as low; 150-300 ppm K as medium, and more than >300 ppm K as high; about 44% of the soils of the districts showed high level of available K status, 45.5% soils showed medium K status and 10.5% soils showed low K status.

As a whole in the district, 105451 ha has low K, 456957 ha has medium K and 441892 ha has high K status indicating the necessity of K fertilization in about 56 per cent (low to medium) area of the district.

Land Capability Classification

Land capability classification is an interpretative grouping of soil mapping units mainly based on inherent soil characteristics, external land features and environmental factors that limit the use of land for agriculture, pasture, or other uses on a sustained basis. Land capability is the potential of the land for its utilisation in specified use. The limitations are the land characteristics which adversely affect its use potential for agricultural production. There are three category of land capability classification namely capability class, subclass, and unit. A capability class is a grouping of land unit that have the same relative degree of limitation or hazard. The classes are indicated by roman numerals. The restriction, kind of land use and management increases from class I to class VIII. Classes I to IV considered for arable uses, while class V to VIII for non-arable uses. The soils, having greatest response to management and least limitation are grouped in class I, and those with little response to management and greatest limitations are grouped in class VIII. In the district, the major area falls under Class 11 contributing about 39% of the district TGA followed by Class III accounting for about 14% and Class IV 19% of TGA. These lands are grouped under marginal to moderate suitability class for cultivation. About 28% land of the districts falls under class VI-VIII which are not suitable for cultivation.

Soil Erodibility

Erosion is the process of detachment of finer soil particles from aggregates and their transportation from one place to the other place through the action of eroding agents like water, wind and human activities etc. It further leads to soil degradation with varying extent and intensity of eroding agents. There are four type of soil erosion namely sheet, rill, gully and stream bank erosion.

Remote Sensing and GIS integrated erosion prediction models do not only estimate soil loss but also provide the spatial distributions of the erosion. Especially, generating accurate erosion risk maps in GIS environment is very important to locate the areas with high erosion risks and to develop adequate erosion prevention techniques. In this study RS and GIS technologies were successfully used for land degradation and erosion mapping. Another study by also indicated that GIS analysis provide satisfactory results in developing erosion surveys and risk maps by using GIS data layers such as DEM, slope, aspect, and land use. The amount of soil erosion is mainly affected by vegetation cover, topographic features, climatic variables, and soil characteristics. The human activities and large-scale envelopments alter the vegetation cover, impacting upon the soil erosion rate. Topographic features such as ground slope, slope length, and shape most affect rill and interrill erosion. The most important climatic variables are rainfall amount and precipitation intensity, which are called rainfall erosivity. Besides, temperature is another important climatic variable since it affects the vegetative materials which are used in mulching to control erosion. Soil erodibility is mainly affected by aggregate stability, texture, depth, organic matter, and stoniness.

Soil Degradation

The soil degradation is defined as the condition of the soil by which soil progressively losses its productive capacity. The assessment of soil degradation plays an important role for taking care of conservation of the natural resources to avoid further deterioration of soil and land quality. For assessing the degradation of the landform, land use, yield potential, the erosion, slope and physio-chemical properties of soils have been considered. The kind, degree, extent and severity of soil degradation were assessed on the district. Assessing the soil erosion rate is essential for the development of adequate erosion prevention measures for sustainable management of land and water resources. Geographic Information System (GIS) technologies are valuable tools in developing environmental models through their advance features of data storage, management, analysis, and display. The Remote Sensing (RS) technology has been used to provide the land use/cover information by using digital image processing techniques. There have been many studies on modeling soil erosion by utilizing RS and GIS technologies.

Land Irrigability

Land irrigability classification is an interpretative grouping of soils based on physical and socio-economic factors in addition to the soil irrigability and is primarily concerned with predicting the behavior of soils when they are brought under irrigation. Development of irrigation network to feed the increasing human population is a worldwide concern. A substantial investment has been made in the country for creating assured irrigation-facilities through major and medium irrigation projects to increase agricultural production. The irrigated area of the country has increased from 21 Mha in 1950-51 to 57 Mha during 1999-2000 (www.agricoop.nic.in). Unfortunately, the introduction of canal irrigation has resulted in the development of soil salinity and shallow water table in the arid and semi-arid regions, which have depicted serious negative impact on the agricultural environment in these areas.

Table1. Forest Resources of Betul District

Total Forest Area	4085.043 sq. km (40.67 % of total geographical area of the district)
Protected Forest	1245.634 sq. km
Reserved Forest	2839.409 sq. km
Per capita Forest Area of the district	0.267
Annual Rate of afforestation	0.19 per cent
Forest Villages	111
Main Species	Teak usually (grade III)
Other species	Haldu, Saja, Dahoa
Minor Forest Produce	Tendu leaves, Chironji, Harra, Aonla etc.

Forest

Forests cover about a third of the Earth's land surface, and they affect the exchange of gases and energy between the atmosphere and the surface. About 80% of the global biomass is contained in forests, and this forms the central component of the stocks and acquisition of carbon in the biosphere. The growth and distribution of forests has a critical impact on atmospheric carbon dioxide concentrations, a central issue in global change research.

Measuring the size and complexity of forest canopies over large areas would enable scientists to better understand these environmental processes. This can be made easier only through the high spectral, spatial and temporal resolution qualities of remote sensing techniques. Indeed, the precise database pertaining to forest cover information is an imperative input of formulating various management plans and also remote sensing technology can be effectively utilized for change detection and monitoring activities (Jessica et al. 2001). Forest boundaries of Betul Forest circle and Betul District are the same. Information regarding forest resources of the region is illustrated in the following table:

बैतूल जिले के क्रमबद्‌ध सर्वेक्षण में विभिन्न प्रकार की मृदाये पाई जो कही कही एक कुल या कही कही दो या तीन कुल का प्रतिनिधित्व करती है बैतूल जिले की मुदा घास वर्गीय पौधों की भौतिक एवं जैविक क्रियाशीलता हेतु उपयुक्त है जो कि फसलों की उचित वृद्‌िध , पोषक तत्व एवं पानी के लिये उचित माध्यम होना सुनिश्चित करती है जिले की 60 प्रतिशत मृदा पथरीली नही है जबकि 40 प्रतिशत मृदा में आंशिक से लेकर मध्यम स्तर तक पथरीलापन मिलता है मृदा की मध्यम सतह में नत्रजन का स्तर 54 प्रतिशत, उपरी सतह में 21 प्रतिशत तथा निचली सतह में 25 प्रतिशत है जो कि मृदा में कुल नत्रजन की कमी को दर्शाता है जिले की मुदा में पोटाश का न्यूनतम स्तर का क्षेत्र 105451 हेक्टेयर, मध्यम स्तर का क्षेत्र 456957 हेक्टेयर तथा उच्च्य स्तर को क्षेत्र 441892 हेक्टेयर है जिले का कुल 56 प्रतिशत क्षेत्रफल पोटाश की कमी को दर्शाता है। केवल 28 प्रतिशत भूमि जो ट्प्.ट्प्प्‌ श्रेणी में आती है खेती के लिये उपयुक्त नही पाई गई है अन्यथा जिले की भूमि सभी प्रकार की सामान्य खेती के लिये उपयुक्त है। बैतूल जिले में नहर सिंचाई प्रारंभ होने से जिले के श्शुष्क एवं अर्धशुष्क क्षेत्राो में मृदा क्षारीयता एवं जल स्तर में कमी देखी गई जिसकी वजह से इस क्षेत्र में कृषि पर नकारात्मक प्रभाव पाया गया। बैतूल जिले में कुल वन क्षेत्र 4085.043 वर्ग किलोमीटर है जोकि कुल क्षेत्रफल का 40.67 प्रतिशत है। जिसमें से 1245.63 वर्ग किलोमीटर प्रतिंबंधित वन क्षेत्र तथा 2839. 40 वर्ग किलोमीटर रिजर्व वन क्षेत्र है

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Hypocholestremic effects of garlic oil on serum and egg yolk of Jabalpur color birds

Shraddha Shrivastava, V.N. Gautam, B.S. Gehlaut and **M.A. Quadri**
Department of Veterinary Biochemistry
College of Veterinary Science and Animal Husbandry
Nanaji Deshmukh Veterinary Science University
Jabalpur 482001 (MP) India

Abstract

The present investigation was undertaken to elucidate the hypocholestremic effect of the garlic oil on egg yolk and serum cholesterol levels in Jabalpur color birds. Twenty four 40-weeks-old Jabalpur color birds were allocated to four dietary treatments. Birds were caged individually and diets were supplemented with 0 (control), 250, 500 and 750 mg garlic oil/kg of feed in group T_1, T_2, T_3 and T_4 respectively for 56 days. There were highly significant (P<0.01) differences in serum cholesterol and egg yolk cholesterol values between intervals within treatments, whereas those between treatments within group were significant (P<0.05). Serum and egg yolk cholesterol concentration decreased with increased level of garlic oil from 0 to 750 mg/kg of feed. It was concluded that garlic oil in the diet of laying hens reduced the serum and egg yolk cholesterol concentration. The better values-for these parameters were obtained in the T_4 group.

Keywords: Garlic oil, Jabalpur color birds, serum cholesterol, egg yolk cholesterol

Cholesterol is present in all animal tissues. When its level rises to more than normal limits it may be associated with atherosclerosis, hypertension and coronary heart disease (Satyanarayana 2005). The medicinal values of several plants is well studied for therapeutic properties. Garlic (*Allium sativum)* is used to treat cardiac diseases (Adler and Holub 1997) that contains a variety of organosulphur compounds such as allicin, ajoene, S-allylcysteine, diallyl disulphide, S-methylcysteine sulphoxide and S-allylcysteine sulphoxide (Chi et al. 1982). According to Adler and Holub (1997), allicin is responsible for reducing the level of serum cholesterol that ultimately may be beneficial to cardiovascular diseases.

Egg is a rich source of all the essential amino acids, minerals and vitamins however, in addition to these essential dietary components, it contains about 200-250mg of cholesterol (Griffin 1992) which is considered as a major source of dietary cholesterol. The liver of the layer hen produces most of the lipids found in egg yolk since the lipids are transported to the ovary by serum lipoproteins (Elkin 1997). Hence, a decrease in serum lipid concentration might lead to a decrease in egg-yolk lipids. The current study was planned to study the effect of garlic oil on the serum and egg yolk cholesterol of poultry birds.

Material and Methods

Birds 40-week age were maintained at All India Coordinated Research Project on Poultry Breeding, Adhartal, Jabalpur in individual cages under standard managemental conditions for 56 days. Birds 40-week age were randomly divided into 4 groups having 6 birds each. Group T_1 served as control, whereas treatment groups T_2, T_3 and T_4 were considered as experimental-ones. Diet of the birds of trial groups were supplemented with garlic oil @ 250, 500 and 750 mg/kg of feed respectively. The basal diet consisted of 2700 Kcal ME/kg and 17% protein. Blood samples were collected from all control and experimental birds on days 0, 14, 28, 42 and 56 of the experiment. Serum was separated and used for the estimation of cholesterol by standard diagnostic kit (Erba). Six eggs were collected from each group on days 0, 14, 28, 42 and 56 day of the experiment. Egg yolk total lipids were extracted (Folch et al. 1957) and used for the estimation of egg yolk cholesterol by the standard diagnostic kits (Erba).

Results and Discussion

Data were analyzed using hierarchial analysis of variance (Steel and Torrie 1992). Mean values of serum cholesterol are presented in Table1. The variations in

Table 1. Serum cholesterol (mg/dl) in Jabalpur colour birds under various treatments and durations (mean ± SE; n=6)

Treatments	Days				
	Day 0	Day 14	Day 28	Day 42	Day 56
T_1	$176.62^{b} \pm 0.37$	$176.17^{b} \pm 0.63$	$177.54^{ab} \pm 0.59$	$178.88^{a} \pm 0.49$	$176.56^{b} \pm 0.37$
T_2	$176.06^{a} \pm 0.27$	$167.86^{b} \pm 0.23$	$162.84^{c} \pm 0.13$	$147.16^{d} \pm 0.85$	$130.64^{e} \pm 0.43$
T_3	$177.54^{a} \pm 0.31$	$158.33^{b} \pm 0.22$	$134.36^{c} \pm 0.31$	$125.45^{d} \pm 0.17$	$118.71^{e} \pm 0.25$
T_4	$178.73^{a} \pm 0.30$	$145.51^{b} \pm 0.29$	$123.23^{c} \pm 0.69$	$105.23^{d} \pm 0.51$	$100.53^{d} \pm 0.38$

Mean values with different superscripts in a row vary significantly (P< 0.01)

Table 2. Egg yolk cholesterol (mg/g) in Jabalpur color birds under various treatments and durations (mean ± SE; n=6)

Treatments	Days				
	Day 0	Day 14	Day 28	Day 42	Day 56
T_1	17.47 ± 0.19	17.98 ± 0.39	17.72 ± 0.23	17.68 ± 0.29	17.95 ± 0.20
T_2	$17.40^{a} \pm 0.14$	$16.32^{b} \pm 0.17$	$15.61^{b} \pm 0.13$	$14.71^{c} \pm 0.21$	$13.44^{d} \pm 0.13$
T_3	$17.33^{a} \pm 0.19$	$16.93^{a} \pm 0.24$	$15.36^{b} \pm 0.21$	$14.33^{c} \pm 0.19$	$12.20^{d} \pm 0.32$
T_4	$17.41^{a} \pm 0.15$	$16.86^{a} \pm 0.12$	$15.22^{b} \pm 0.18$	$13.96^{c} \pm 0.28$	$11.21^{d} \pm 0.09$

Mean values with different superscripts in a row vary significantly (P< 0.01)

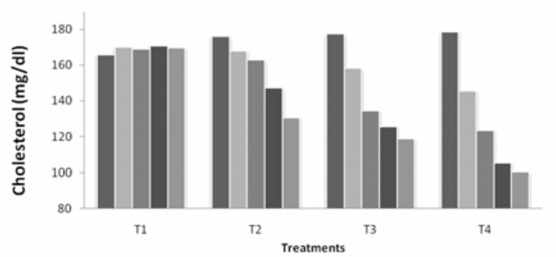

Fig 1. Mean values of serum cholesterol under various treatments and durations

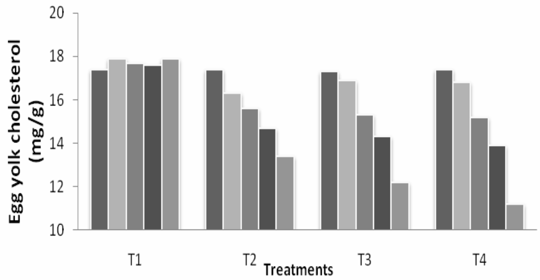

Fig 2. Mean values of egg yolk cholesterol under various treatments and duration

serum cholesterol and egg yolk cholesterol between intervals within treatments were highly significant (P<0.01) whereas those between treatments within group were significant (P<0.05). The reduction in serum cholesterol values was 25.79% for group T_2 whereas it was 33.31% for group T_3 and 43.75% for group T_4 on day 56 of the experiment (Fig. 1). Mottaghitalab and Taraz (2004) showed that the mean serum cholesterol levels were dropped by 14.2%, 21.9% and 12% in the 0.5, 1, 1.5% garlic treated groups in laying hens. Significant reduction in serum cholesterol levels in birds were also reported (Canogullari et al. 2009, Khan et al. 2008, Chowdhury et al. 2002).

Mean values of egg yolk cholesterol are presented in Table 2. Birds fed with garlic oil the percent reduction in egg yolk cholesterol was calculated to be 22.75 in group T_2, 29.60 in group T_3 and 35.61 in group T_4 on day 56 of the experiment (Fig. 2). Similarly Chowdhury et al. (2002) reported 5, 9, 14, 20 and 24% reduction in yolk cholesterol of laying hens on supplementation of 2, 4, 6, 8 or 10% garlic paste in diet. Elangovan et al. (2004) found lower cholesterol levels in egg yolk levels of Japanese quails fed 1% garlic powder in diet. Khan et al. (2008) observed a significant reduction (P<0.05) in egg yolk cholesterol concentration with increasing level of oven dried garlic powder from 0 to 8% in native desi layers for

6 weeks.

Most of cholesterol found in the egg is concentrated in the yolk and is synthesized in the liver of the hen, transported by blood in the form of the lipoproteins (HDL, LDL and VLDL) and deposited in the developing follicles. In the present studies, serum HDL-cholesterol values 42.81±0.12 mg/dl on day 0 were significantly increased to 52.06±0.11mg/dl. On the other hand serum LDL cholesterol values 80.92±0.24 mg/dl on day 0 were significanly reduced to 44.44±0.47 mg/dl on day 56 of garlic oil supplementation of diet. Similarly serum VLDL values also decreased significanly from 52.59^{a}±0.04 to 30.99^{e}±0.05 mg/dl.

The reduction in lipid profile may be due to the fact that garlic reduces the hepatic activities of lipogenic and cholesterogenic enzymes such as malic enzyme, fatty acid synthase, glucose-6 phosphate dehydrogenase (Qureshi et al. 1983) and 3-hydroxy-3-methyl-glutaryl-CoA (HMG-CoA) reductase (Youn et al. 1996).

Hence, it was concluded that use of 750mg garlic oil/kg of feed showed a highly significant hypocholestremic effect (P<0.01) on day 56 and can be effectively used for reducing cholesterol contents in egg yolk and serum of poultry birds. So, therefore, that egg can be consumed safely without the risk of cardiovascular diseases.

कम कोलस्ट्राल वाले अण्डों का उत्पादन केवल पोल्ट्री उद्योग की अर्थव्यवस्था में वृद्धि ही नहीं करता अपितु स्वास्थ्य के प्रति जागरूक उपभोक्ताओं द्वारा ऐसे अण्डों की खपत में वृद्धि भी करता है । इन बिन्दुओं को ध्यान में रखते हुये वर्तमान जांच करने के लिए अण्डे की जर्दी और जबलपुर रंगीन मुर्गियों में सीरम कोलस्ट्राल के स्तर पर लहसुन के तेल के प्रभाव को स्पस्ट किया गया है । 24 मुर्गियों (40 सप्ताह उम्र) को 6-6 मुर्गियों के चार समूह में विभाजित किया गया। प्रत्येक मुर्गियो को अलग पिजडें में रखा गया था । T_1 T_2 T_3 एवं T_4 समूहों में क्रमशः 0, 250, 500, 750, मि.ग्रा. लहसुन का तेल प्रतिकिलो आहार 56 दिनों तक दिया गया । सीरम कोलस्ट्राल और अण्डो में उपचार के भीतर अंतराल में P<0.01 मतभेद थे जबकि समूह के भीतर उपचार में P<0.05 मतभेद थे । सीरम व अण्डे का कोलस्ट्राल लहसुन के तेल का प्रतिशत बढ़ाने के साथ कम पाया गया । इस प्रयोग से यह निष्कर्श निकलता है के मुर्गी के आहार में लहसुन का तेल मिलाने पर सीरम व अण्ड़े दोनों का कोलस्ट्राल कम होता है ।

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Counteracting adverse effect of ochratoxin on relative organ weights of broilers by Mentha piperita dry leaf powder

Anju Nayak, Sunil Nayak, Varsha Sharma and **R.P.S. Baghel**
Department of Veterinary Microbiology
College of Veterinary Science and Animal husbandry
Nanaji Deshmukh Veterinary Science University
Jabalpur 482 001(MP)

Abstract

Hot and humid climate proliferate the growth of *Aspergillus ochraceus* and ochratoxin production. It is considered to be the most toxic mycotoxin and reported to be nephrotoxic, hepatotoxic, teratogenic and immunosuppresive causing a drastic reduction in the lymphoid cell population. The present experiment was designed to study the adverse effect of 2ppm ochratoxin in broilers and anti ochratoxigenic effect of *Mentha pirerita* dry leaf powder. Six groups were maintained with and without ochratoxin and *Mentha pirerita* leaf powder in duplicate having 6 broilers in each replicate. The broilers were sacrificed on day 15th, 25th and 35th. Increase in the weights of liver, kidneys were noted while reduction in the size of lymphoid organs particularly bursa and thymus were observed. *Mentha pirerita* leaf powder partially counteracted the adverse effect of ochratoxin on organ weights in broilers.

Keywords: *Aspergillus ochraceus*, Ochratoxin and *Mentha pirerita*

Poultry is kept primarily to convert feed into meat and eggs. At present, India stands at the third and fifth positions in egg and chicken meat production, respectively with an annual contribution of about rupees 352 billion to the gross domestic product (GDP).The Council of Agricultural Science and Technology (1989) reported that at least 25% of the total world feed supply is contaminated with mycotoxins. During 2004-05 more than 85 percent of feed samples were found positive for mycotoxins (Devegowda et al. 2005). Besides aflatoxin, ochratoxin and T-2 toxins are also found in feed stuffs. Although aflatoxin is the most prevalent, ochratoxin is considered to be the most toxic mycotoxin, being three times more dangerous than aflatoxin. It is reported to be nephrotoxic, hepatotoxic, teratogenic and immunosuppresive, causing a drastic reduction in the lymphoid cell population (Hohler 1998). The toxin is an ever increasing threat to the poultry industry, young birds being more susceptible to it than older birds (Huff et al. 1974). As a natural contaminant of poultry feedstuff it produces detrimental effects on the immune and other systems of broiler chicks. Species of Aspergillus and Penicillium are mainly controlled by synthetic preservatives, most of which are reported to be carcinogenic, teratogenic and leave residual effects in both humans and animals (Foegeding and Busta 1991). The use of herbal agents in controlling the production and spread of mycotoxins in broilers is a recent concept. *Mentha pirerita* has wide geographic distribution, is easily procured and economical. Besides, they are reported to possess antioxidant, antimicrobial, immunomodulatory and antitoxigenic properties (Hitokota et al. 1980, Basilico and Basilico 1999, Renzulli et al. 2004). Effect of ochratoxin on relative organ weights in broilers and counteracting its adverse effect by *Mentha pirerita* leaf powder was studied.

Material and methods

Day old 72 broiler chicks of either sex were procured from M/S Phoenix Hatcheries. Ochratoxin was produced in cereals according to the method described by Trenk et al. (1971). The representative samples of feed were submitted for quantification of ochratoxin by thin layer chromatography (AOAC 1995) at the Animal Feed Analytical and Quality Control Laboratory (A.F.A.Q.C.L.) Veterinary College, Namakkal (Tamil Nadu) and added in broiler diet to give a final concentration of 2 ppm. Nine experimental diets were formulated as per Bureau of Indian Standard (BIS 1992) specification. Six groups were maintained in duplicate with six broilers in each replicate (Table 1). The broilers were sacrificed on 15th, 25th and 35th day of experiment. The organ (liver, spleen, kidney, bursa and thymus) collected at the time of slaughter were weighed and expressed as relative organ weight and examined for any gross abnormal changes.

Results and discussion

The broilers of groups I, III and IV showed normal relative organ weights and were statistically similar.

Liver: In group II broilers receiving 2 ppm ochratoxin, relative liver weight was higher in comparison to control while liver in broilers of group VII was more severely affected in comparison to group II. Marginal improvement in relative liver weight in broilers of group V, VI supplemented with *Mentha pirerita* along with ochratoxin was observed on 15[th] day. Increase in relative weight of liver due to ochratoxicosis were observed by Huff and Doerr (1981), who reported a significant increase in relative weights of liver at 2 ppm ochratoxin in feed. The enlargement and degenerative change in the epithelium of liver may be due to the enterohepatic recirculation and hepatobiliary way of excretion of ochratoxin causing the direct toxic effect (Fuchs et al. 1988).

Spleen: Relative spleen weight was significantly higher only on 35[th] day in group II broilers. While relative spleen weight of group II was at par with control up to 25[th] day of experiment. Supplementation of *Mentha pirerita* along with ochratoxin was not effective at any interval. The findings are in agreement with Bhanuprakash et al. (2006), enlargement in spleen may be due to inflammation.

Kidney: Significantly higher kidney weight was noted in group II in comparison to control during the entire period of experiment. Supplementation of *Mentha pirerita* with ochratoxin (group V and VI) was partially effective in counter acting adverse effect of ochratoxin only up to 15[th] day of study. Increase in relative weight may be due to enlargement of epithelium in kidney as a result of their regenerative activity. The enlargement and degenerative changes of the epithelium cells may be due to the fact that the route of elimination of ochratoxin is kidney (Fuchs et al. 1988). It was due to direct effect on the kidney or due to renal damage involving proximal convoluted tubules.

Bursa: In broilers of group II, reduced weight of bursa of Fabricius was observed in comparison to control during all the intervals of experiment. Broiler of groups V and VI counteracted adverse effects of ochratoxin only on the 35[th] day of experiment. Reduction in the size of bursa is likely to be a consequence of degenerative changes and decreased lymphoid tissue in these organs in ochratoxin

Table 1. Design of experiment for in vivo studies with ochratoxin and *Mentha pirerita* dry leaf powders

Groups	Treatments
Group I control	Only broilers ration
Group II	2 ppm Ochratoxin
Group III	2g *Mentha pirerita* / Kg feed
Group IV	4g *Mentha pirerita* / Kg feed
Group V	2 ppm Ochratoxin + 2g *Mentha pirerita* / Kg feed
Group VI	2 ppm Ochratoxin + 4g *Mentha pirerita* / Kg feed

Table 2. Organ weights (%) of broiler chickens fed 2 ppm ochratoxin with and without Mentha piperita on 15[th] day

Groups	Treatments	Liver	Spleen	Kidney	Bursa	Thymus
I	control	2.56b	0.08a	0.68b	0.29a	0.63a
		(9.28)	(1.81)	(4.80)	(3.14)	(4.44)
II	2 ppm OT	3.38a	0.13a	1.10a	0.20b	0.30bc
		(10.63)	(1.81)	(6.02)	(2.56)	(3.14)
III	2g M. piperita	2.71ab	0.10a	0.76ab	0.29a	0.43b
		(9.46)	(1.81)	(5.13)	(3.14)	(3.63)
IV	4g M. piperita	2.63b	0.09a	0.70b	0.26a	0.47ab
		(9.28)	(1.81)	(4.80)	(3.14)	(4.05)
V	2 ppm OT+2g M. Piperita	3.34ab	0.13a	1.10a	0.22b	0.40b
		(10.47)	(1.81)	(6.02)	(2.56)	(3.63)
VI	2 ppm OT+ 4g M. piperita	2.85ab	0.11a	0.84ab	0.24b	0.43b
		(9.63)	(1.81)	(5.13)	(2.56)	(3.63)
CD	P < 0.05	1.223	0.6318	1.076	0.5471	0.6626
SE		0.3536	0.1826	0.3109	0.1581	0.1915

Values bearing similar superscripts in the same column do not differ significantly (P>0.05)
Values in ( ) brackets are angular transformed values

Table 3. Organ weights (%) of broiler chickens fed 2 ppm ochratoxin with and without *Mentha piperita* on 25th day

Groups	Treatments	Liver	Spleen	Kidney	Bursa	Thymus
I	control	2.38b	0.10a	0.71b	0.26a	0.56a
		(8.91)	(1.81)	(4.80)	(3.14)	(4.44)
II	2 ppm OT	3.34a	0.15a	1.90a	0.18b	0.23c
		(10.47)	(1.81)	(7.92)	(2.56)	(2.56)
III	2g *M. piperita*	2.68ab	0.11a	0.89b	0.25b	0.52ab
		(9.46)	(1.81)	(5.44)	(2.56)	(4.05)
IV	4g *M. piperita*	2.55ab	0.10a	0.97b	0.26a	0.53ab
		(9.10)	(1.81)	(5.74)	(3.14)	(4.05)
V	2 ppm OT+2g M. piperita	3.24[a]	0.15a	1.75a	0.25b	0.32b
		(10.30)	(1.81)	(7.49)	(2.56)	(3.14)
VI	2 ppm OT+ 4g *M. piperita*	2.79ab	0.13a	1.83a	0.23b	0.34b
		(9.63)	(1.81)	(7.71)	(2.56)	(3.14)
CD	P < 0.05	1.223	0.6921	1.548	0.5471	0.7652
SE		0.3536	0.2000	0.4472	0.1581	0.2550

Values bearing similar superscripts in the same column do not differ significantly (P>0.05)
Values in ( ) brackets are angular transformed values

Table 4. Organ weights (%) of broiler chickens fed 2 ppm ochratoxin with and without *Mentha piperita* on 35th day

Groups	Treatments	Liver	Spleen	Kidney	Bursa	Thymus
I	control	2.50b	0.12b	0.82b	0.23a	0.58a
		(9.10)	(1.81)	(5.13)	(2.56)	(4.44)
II	2 ppm OT	3.98a	0.20a	2.16a	0.15b	0.30b
		(11.54)	(2.56)	(8.33)	(1.81)	(3.14)
III	2g M. piperita	2.85b	0.12b	0.91b	0.22a	0.51a
		(9.63)	(1.81)	(5.44)	(2.56)	(4.05)
IV	4g M. piperita	2.96b	0.16a	0.93b	0.25a	0.52a
		(9.97)	(2.56)	(5.44)	(2.56)	(4.05)
V	2 ppm OT+2g M. piperita	3.69[a]	0.19[a]	1.87ab	0.22a	0.40ab
		(11.09)	(2.56)	(7.92)	(2.56)	(3.63)
VI	2 ppm OT+4g M. piperita	3.48a	0.16a	1.90ab	0.19a	0.37ab
		(10.78)	(2.56)	(7.92)	(2.56)	(3.63)
CD	p < 0.05	1.223	0.6834	1.630	0.7511	1.038
SE		0.3536	0.1975	0.5032	0.2503	0.3009

Values bearing similar superscripts in the same column do not differ significantly (P>0.05)
Values in ( ) brackets are angular transformed values

treated chicks (Stoev et al. 2000). Huff et al. (1974) observed significant decrease in size of bursa at 8 ppm ochratoxin in diet.

Thymus: Significantly reduced relative thymus weight was observed in group II in comparison to control during all the three intervals of experiment. Marginal improvement in thymus weight was observed in groups V and VI during all the three intervals of experiment except group VI which was not effective in diluting the adverse effect of toxin on 15th day. Bhunuprakash et al. (2006) observed decrease in size of thymus using 1 ppm ochratoxin. The decrease in size of thymus may be due to degenerative changes and decreased lymphoid tissue in thymus in ochratoxin treated chicks (Stoev et al. 2000).While supplementation of *Mentha pirerita* along with ochratoxin, counteracts the adverse effect of ochratoxin. It may be due to modulating potentials of these herbal powders.

शोध में 72 एक दिवसीय चूजों को 6 समूहों में बांटा गया, प्रत्येक समूह के दो- दो रेप्लीकेट बनाए गए व प्रत्येक में 6-6 चूजे रखे गये। मुर्गियों के आहार में उपस्थित ओकराटाक्सिन का चूजो के विभिन्न अंगों के वजन व उन पर प्रभाव का अध्ययन किया गया। पुदिना की विभिन्न मात्राओं के साथ भी ओकराटाक्सिन का चूजो के विभिन्न अंगों के वजन व उनपर प्रभाव देखे गये। 2 व 4गाम पुदिना प्रति किलो आहार का उपयोग आहार में उपस्थित ओकराटाक्सिन के प्रभाव को कम करता है।

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Effect of rock phosphate without and with aluminium on carcass yields of egg type starters

Sunil Nayak, R.P.S. Baghel and **Anju Nayak**
Department of Animal Nutrition
College of Veterinary Science and Animal Husbandry
Nanaji Deshmukh Veterinary Science University
Jabalpur 482 001 (MP)

Abstract

In order to reduce the cost of mineral mixture in egg type starters, present study was planned to see the utilization of rock phosphate (RP) without and with aluminium sulphate as an alternate to dicalcium phosphate in their mineral mixture In the experiment, four hundred and five day old egg type chicks (WLH) were randomly distributed to 27 replicates of 15 chicks each and were allotted to 9 dietary treatments. Diet one (T_1) was control diet in which DCP was used as a sole source of P. Diets 2, 4, 6 and 8 (T_2, T_4, T_6 and T_8) were same as T1 except that in these diets DCP was replaced @ 40%, 60%, 80% and 100% with rock phosphate on P basis. While, diets 3, 5, 7 and 9 (T_3, T_5, and T_7 and T_9) were same as T_2, T_4, T_6 and T_8 accept the addition of aluminium at a ratio of 0.8 Al: 1 F, in those diets. Experiment was conducted for 0-8 weeks (Starter phase). Use of RP with and without aluminium sulphate on carcass yields (dressed, eviscerated and drawn weights) of egg type starters (0-8 weeks) had significant ($P<0.05$) influence on the dressed, eviscerated and drawn weights of starters. Use of 40% RP instead of DCP did not influence their carcass yield but when it was used at higher level (60%, 80% and 100%) they were reduced significantly. However supplementation of aluminium sulphate with 80% RP instead of DCP did not influence their carcass yield. Hence it was concluded that 40% RP and 80% RP along with aluminium sulphate was beneficial to replace DCP in the mineral mixture of egg type starters. However, supplementation of aluminium sulphate to RP was not economical.

Keywords: Mineral mixture, Alternate phosphorus sources, Dicalcium phosphate, Rock phosphate, Aluminium sulphate, carcass yields, Egg type starters.

The cost of traditional phosphorus (P) supplement i.e. dicalcium phosphate (DCP) in poultry diet is steeply increasing hence use of alternate economical phosphorus supplement without lowering the production performance of birds has become essential. In India, rock phosphate (RP) is available as an alternate economical phosphorus supplement but its use in the poultry diet is limited. Rock phosphate contains lower amount of P and large amount of fluorine (F) in comparison to DCP. Aluminium over a short time period has proved to be an effective alleviator of F toxicity. An Al : F ratio of 0.8 : 1.0 was found effective in eliminating the toxic effect of F in poultry rations. Therefore, the present work was conducted to study the effect of rock phosphate without and with aluminium on carcass yields of egg type starters.

Material and methods

Stock, diet and husbandry

In the experiment, four hundred and five day old egg type chicks (WLH) were randomly distributed to 27 replicates of 15 chicks each and were allotted to 9 dietary treatments. Diet one (T_1) was control diet in which DCP was used as a sole source of P. Diets 2, 4, 6 and 8 (T_2, T_4, T_6 and T_8) were same as T_1 except that in these diets DCP was replaced @ 40%, 60%, 80% and 100% with rock phosphate on P basis. While, diets 3, 5, 7 and 9 (T_3, T_5 and T_7 and T_9) were same as T_2, T_4, T_6 and T8 accept the addition of aluminium at a ratio of 0.8 Al: 1 F, in those diets. Fluorine content in the diets containing 40%, 60%, 80% and 100% RP instead of DCP were 486,729,972 and 1214ppm, respectively. The chicks were vaccinated against MD, ND, IBD, IB and fowl pox as per vaccination schedule. The brooder temperature was maintained at 34±1°C up to 7 days of age and gradually reduced to 26±1°C by 21 days of age after which chicks were maintained at room temperature. The experimental diets were formulated as per ICAR (1998) specification and are presented in Table 1. Each experimental diets were fed ad libitum to 27 replicates of 15 chicks each during experimental period of 0-8 weeks.

Parameters studied

Samples of feed were analyzed for proximate composition using standard procedures of the AOAC (1995) and for estimation of Calcium and phosphorous content method given by Talapatra et al. (1940).

Carcass yield were measured using 2 birds in each replicates at 8th weeks of age. Birds used for carcass yield study were fasted for 12 hours and then were slaughtered using standard procedure.

Statistical analysis

The data obtained during experiment were analyzed statically by using the methods described by Snedecor and Cochran (1989). Differences among the treatments were tested for significance by Duncan's New Multiple Range Test (1955).

Table 1. Composition of diets (%), using RP without and with aluminium sulphate, instead of DCP in MM, fed to egg type starter chickens (0-8 weeks)

Ingredient/diets	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9
Maize (kg	41	41	41	41	41	41	41	41	41
DORP (kg)	20	20	20	20	20	20	20	20	20
SBM (kg)	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.5
DCP (g)	1600	960	960	640	640	320	320	-	-
RP (g)	-	640	640	960	960	1280	1280	1600	1600
LSP (g)	1400	1400	1400	1400	1400	1400	1400	1400	1400
A_{l2} $(S0_4)3$(g)	-	-	480	-	720	-	960	-	1200
Salt (g)	400	400	400	400	400	400	400	400	400
Mn $S0_4$ (g)**	16	16	16	16	16	16	16	16	16
Zn $S0_4$ (g)**	10	10	10	10	10	10	10	10	10
KI (mg)**	150	150	150	150	150	150	150	150	150
Vit. A, D3, K (g)*	25	25	25	25	25	25	25	25	25
Vit. B comp. (g)*	5	5	5	5	5	5	5	5	5
Salinomycin (g)	44	44	44	44	44	44	44	44	44
Total (kg)	100	100	100	100	100	100	100	100	100
Nutrient composition analysed									
CP%	22.21	22.25	22.30	22.33	22.29	22.31	22.22	22.29	22.36
Ca %	1.038	1.078	1.078	1.098	1.098	1.119	1.119	1.138	1.138
Total P %	0.944	0.925	0.935	0.911	0.929	0.922	0.930	0.935	0.939
Nutrient composition calculated									
ME(kcal/kg)	2502	2502	2502	2502	2502	2502	2502	2502	2502
Lysine %	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13
Methionine%	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36
Threonine%	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
Tryptophan%	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
NPP%	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44

*Vitamin premix provided (each 250 g contains): Vit A - 10000000 IU; Vit.D3- 2000000 IU; Vit. B_1 -800mg; Vit.B_2- 5g; Vit.B_6-1.6g; Vit. B_{12}-20.5g; Niacin -12.0g; Calcium D Panthothenate-8.0g; Vit. K3-1.0g; Vit. E - 8.0g; folic acid-800mg.
**Trace minerals premix provided (mg/kg diet) - Manganese- 80; Iron- 80; Copper-11.24; Zinc- 50; Iodine-8

Results and discussion

Effect of use of RP without and with aluminium sulphate on carcass yields (dressed, eviscerated and drawn weights) of egg type starters (0- 8 weeks) is presented in Table 2. Dietary treatments had significant (P<0.05) influence on the dressed, eviscerated and drawn weights of starters.

The treatment means of dressed, eviscerated and drawn weights indicated that increase in the level of RP instead of DCP in the MM reduced the dressed, eviscerated and drawn weights of starters. Among RP diets, maximum and significantly (P<0.05) higher dressed, eviscerated and drawn weights was observed in starters assigned T_2 (40% RP) diet. Afterwards, addition of 60%, 80% levels of RP instead of DCP decreased their dressed, eviscerated and drawn weights significantly (P<0.05). However, statistically (P<0.05) they were comparable. Further, complete replacement of RP instead of DCP reduced their dressed, eviscerated and drawn weights significantly (P<0.05). Minimum and significantly (P<0.05) lower dressed, eviscerated and drawn weights was observed in starters assigned T8 diet (Table 2).

The carcass yield and processing losses in 8 weeks birds were not influenced significantly (P> 0.05) when RP was used at 40% level instead of DCP but use of higher levels of RP (80% and 100%) tend to reduce the carcass yields. These finding were in accordance with that of Abdelhamid (1999) who reported that increase levels of fluorine (0 to 3125 ppm) resulted in decrease relative weights of pituitary, adrenal, heart, spleen, lungs, kidney, gizzard, and changes in intestinal dimensions.

Use of RP up to 80% level (972 ppm F) along with aluminium sulphate produced carcass yields comparable to control (DCP) but when it was added completely instead of DCP led to reduction the carcass yield (Table 2). It was attributed to more processing losses.

Supplementation of aluminium sulphate with 60%, 80% and 100% levels of RP instead of DCP (Table 2) increased dressed, eviscerated and drawn weights of starters significantly (P<0.05). Probably reduction in fluorine content due to supplementation of aluminium sulphate diverted more amounts of nutrients for protein synthesis resulting in to better carcass yield and less processing losses (Hahn and Guenter 1986).

Hence it was concluded that use of 40% RP instead of DCP and use of 80% RP along with aluminium sulphate instead of DCP in mineral mixture of starting (0-8 weeks) egg type chickens was responsible for better carcass yield.

अण्डा देने वाली मुर्गी की प्रांरभिक अवस्था (0–8 सप्ताह) के रखरखाव में 50 से 60 प्रतिशत खर्चा उसके आहार से होता है। मुर्गियों के आहार में ऊर्जा एवं प्रोटीन प्रदान करने वाले अवयवों के अलावा खनिज लवण मिश्रण एक आवश्यक घटक है। खनिज लवण मिश्रण में स्फुर एक अत्यन्त आवश्यक एवं महंगा घटक है। सामान्तयः मुर्गी आहार में स्फुर, डाई कैल्शियम फास्फेट (डी.सी.पी.) नामक स्रोत से प्रदान किया जाता है। अतः यदि स्फुर इसके अतिरिक्त अन्य स्रोतों जैसे रॉक फास्फेट इत्यादि से प्रदान किया जावे तो खनिज मिश्रण में होने वाले खर्चे को कम करके, मुर्गी आहार को सस्ता बनाया जा सकता है। अतः इस शोध में मुर्गियों के आहार में उपयुक्त होने वाले खनिज मिश्रण में डी.सी.पी. को रॉक फास्फेट की विभिन्न मात्राओं (40 प्रतिशत, 60 प्रतिशत, 80 प्रतिशत, एवं 100 प्रतिशत) द्वारा विस्थापित किया गया। एल्यूमिनियम सल्फेट रॉक फास्फेट में उपस्थित फ्लोरीन के प्रभाव को कम करता है। अतः एल्यूमिनियम सल्फेट को रॉक फास्फेट की विभिन्न मात्राओं (40 प्रतिशत, 60 प्रतिशत, 80 प्रतिशत, एवं 100 प्रतिशत) के साथ भी मुर्गियों के आहार में दिया गया। इस प्रकार कुल 9 आहार के प्रकार बनाये गये। एवं इनके प्रभाव मुगैयों

Table 2. Carcass yields (% of live weight) in starters fed mineral mixture containing RP without and with aluminium sulphate (0-8 weeks)

Treatments	F Level ppm	Dressed wt %		Eviscerated wt %		Drawn wt %	
T_1	0	81.25^a		65.85^a		70.08^a	
T_2/T_3	486	80.75^a	81.10^a	65.93^a	65.99^a	70.18^a	70.19^a
T_4/T_5	729	80.14^b	80.80^a	64.52^b	65.90^a	68.74^b	70.13^a
T_6/T_7	972	79.85^b	80.49^a	64.54^b	65.80^a	68.73^b	69.88^a
T_8/T_9	1214	78.83^c	79.91^b	62.66^c	64.30^b	66.89^d	68.36^c
CD		0.7861		0.9158		0.8209	
SE		0.2646		0.3082		0.2763	

में मांस की उपलब्धता पर देखे गये। इस अध्ययन से यह निष्कर्ष निकाला गया कि अण्डा देने वाली मुर्गियों की प्रारंभिक अवस्था (0-8 सप्ताह) में उपयुक्त होने वाले खजिन लवण मिश्रण में डी.सी.पी. को 40 प्रतिशत रॉक फास्फेट द्वारा विस्थापित किया जा सकता है। एल्यूमिनियम सल्फेट रॉक फास्फेट में उपस्थित फ्लोरीन के प्रभाव को कम करता है। अतः एल्यूमिनियम सल्फेट उपयोग करके, खनिज मिश्रण में 80 प्रतिशत डी.सी.पी. को रॉक फास्फेट द्वारा विस्थापित किया जा सकता है।

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