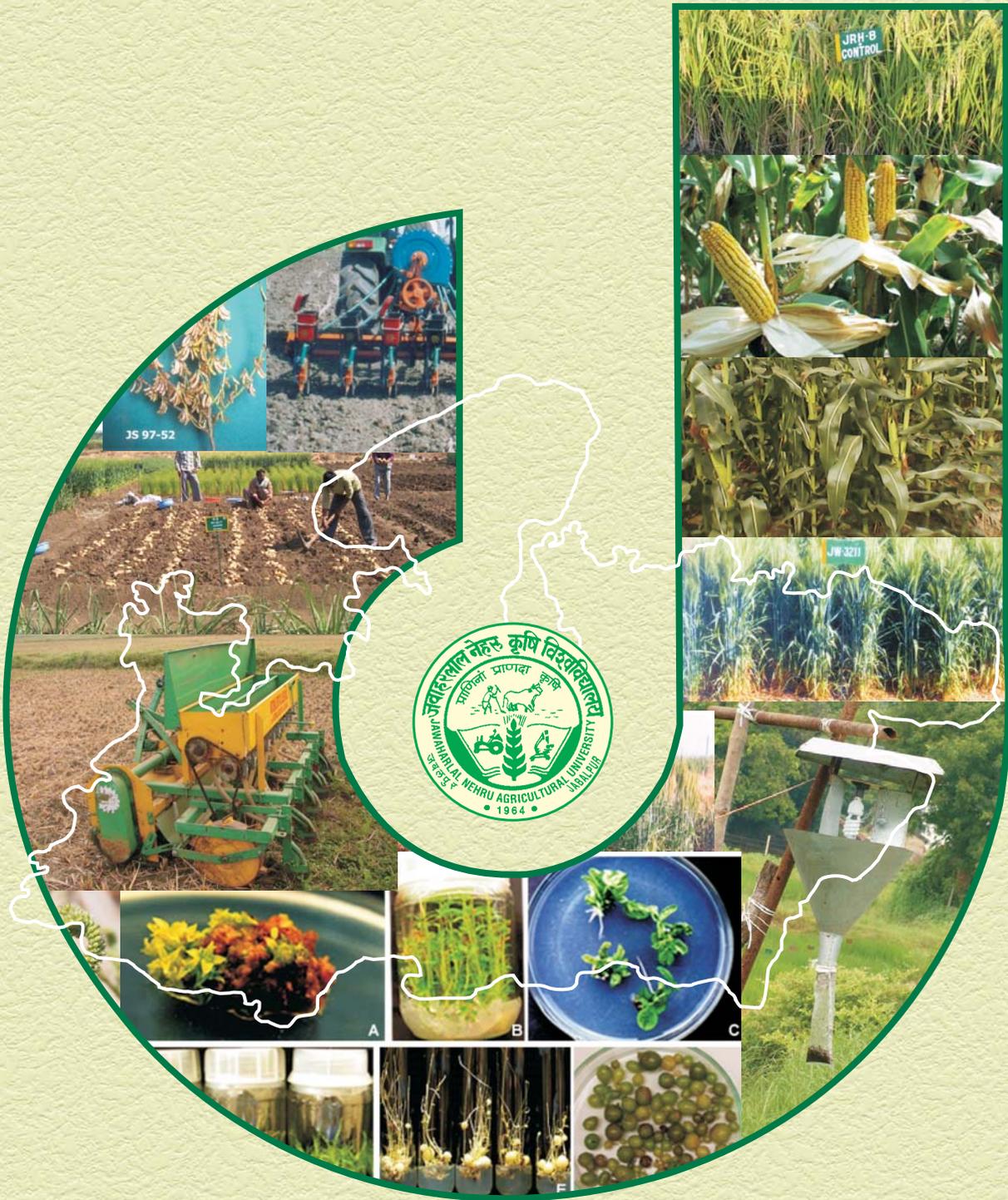


Research Highlights 2009



**JAWAHARLAL NEHRU KRISHI VISHWAVIDYALAYA
JABALPUR, MADHYA PRADESH**



**JAWAHARLAL NEHRU KRISHI VISHWAVIDYALAYA
JABALPUR (M.P.), INDIA**

Research Highlights 2009



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FOREWORD

Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur has played a decisive role in agrarian growth and development of the state of Madhya Pradesh through three major activities viz. teaching, research and extension. As an important mandate, the research activities have been tuned up with the emerging problems in agriculture. The scientists of faculties namely Agriculture, Veterinary Science & Animal Husbandry and Agricultural Engineering have been directed to put more vigorous efforts to counter the challenges before peasants of the State. Reducing the production costs and enhancing livelihood security are the major thrust for which the research activity milestones have been developed through conducting vigorous review. Efforts have been made to strengthen research on development of new crop varieties, hybrids, hi-tech horticulture, integrated farming system, adaptation to climate change, resource conservation, medicinal plants, dryland horticulture, post harvest and value addition and farm mechanization.

Recently, the University has initiated collaborative research in network form and signed MoU with international and national institutes viz; IARI, New Delhi; ICRISAT, Hyderabad; IRRI, Philippines which will definitely boost up research programme of the JNKVV and also provide an opportunity for the scientists to develop research activities in mission mode. Funding from ICAR, DST, MPCOST, NOVOD, State government, Mandi and other agencies are thankfully acknowledged.

I am quite happy that the scientists of JNKVV, Jabalpur have done commendable job. The biennial "Research Highlights 2009" is the glimpses of the research carried out in JNKVV. The efforts of Dr. S.S. Tomar, Director of Research Services and his team in bringing out "Research Highlights 2009" is highly appreciated.


(Gautam Kalloo)



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PREFACE

India has to sustain 16 per cent of the world's population with 2.4 per cent of the global land area, this imbalance itself shows is our concern for enhancing food grain production on a sustainable manner for long term livelihood food and nutritional security. Although, steady and sustain growth, despite of short shocks due to climate change and uncertainties in the last four-five years has made the State self sustain in food grain and surpluses in oilseeds and pulses for meeting domestic need of the country. This is a most significant achievement for the State of Madhya Pradesh which is depicted as developing State at national level. An excellent network, efficiently organized location specific demand driven research, farmer led extension and knowledge strengthening system along with matching infrastructure development proved way for this success.

The emerging challenges of food crises due to steady decline in total factor productivity, food price inflation, shrinking land holdings due to urbanization and large scale diversion of cereals to other alternative use at global level call for rethinking on demand-supply side of food production. Besides, energy crises, climatic change, depleting natural resources and increasing human population are the other factors that requires a paradigm shift in research from commodity approach to system specific approach and from production oriented to efficiency oriented approach to meet the increasing demand of food at domestic and international level.

Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur for over four decades has endeavoured to develop improved crop varieties and production technologies, relevant to the resource base and socio-economic status of farmers. These efforts aims at sustained agricultural growth for food and nutritional security of ever growing population. The problem oriented location specific research in the State is carried out through 4 Zonal Agricultural Research Stations, 4 Regional Agricultural Research Stations and 4 Agricultural Research Stations spread over 6 agro-climatic zones in the State.

Improved crop varieties with matching production technologies, conservation of natural resources through integrated approach, development of package of practices of medicinal and aromatic plants, integrated pest and disease management, livestock improvement and management, post harvest processing and value addition, nucleus and breeder seed production of important crops and biotechnological approach for crop and live stock improvement are some of the land mark achievement of the Vishwa Vidyalaya.

Looking to the predominance of rainfed pattern of agriculture and large population below the poverty line in the State, there arises an urgent need to strengthen research in soil and water conservation, development of early maturing varieties tolerant to biotic and abiotic stresses, crop diversification, biodiversity conservation, biotechnology, dryland horticulture, live stock production and management technology, organic farming, low cost post harvest technology, and also to develop sustainable integrated farming system modules for small and marginal farmers.

Research Highlights 2009 is the biennial document (seventh in the series) containing significant research achievements of the year 2007-08 and 2008-09.

I hope, the information contained in this issue will be of interest to all those engaged in the promotion of agriculture and allied fields.


(S.S. Tomar)

1. INTRODUCTION

Government of India with the assistance of the State Government established the biggest multi-campus university at Jabalpur, in the heart of India and named after the architect of modern India, Pt. Jawaharlal Nehru based on the recommendations of Radhakrishnan commission (1949) on the concept of establishment of Agricultural University. An approach was envisaged to narrow down the gap between the experts and farmers through Joint Indo-American Team on Agricultural Research and Education in 1954-55 and 1959-60 on the patterns of Land Grant Colleges of USA. On October 2, 1964, Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV) was inaugurated by the then Union Minister for Information and Broadcasting Smt. Indira Gandhi.

The Central Administrative Office of the University is located about 7 km North of Jabalpur town on National Highway no. 7. Under an act of Madhya Pradesh Legislature passed in 1963, six Government Colleges of Agriculture and two Veterinary Science and Animal Husbandry and 26 Research Stations formed the University.

The University had to part with the creation of sister universities Indira Gandhi Krishi Vishwavidyalaya (IGKV) at Raipur in 1987 and Rajmata Vijayaraje Scindia Krishi Vishwavidyalaya, Gwalior in 2008.

At present, the University holds an area of about 1544 ha of land. The area under the University jurisdiction contains alluvial, deep black, medium black, shallow and light black, mixed red and black, mixed red and yellow and skeletal or gravelly soil. It is low to medium in available nitrogen and phosphorus, and medium to high in available potassium.

At present, JNKVV encompasses four colleges of Agriculture (Jabalpur, Rewa, Tikamgarh, Ganjbasoda); one Agricultural Engineering (Jabalpur); two colleges of Veterinary Science & Animal Husbandry (Jabalpur & Rewa);

4 Zonal Agricultural Research Stations (ZARS) (Jabalpur, Powarkheda, Tikamgarh, Chhindwara); 4 Regional Research Stations (Rewa, Sagar, Waraseoni, Dindori); 4 Agricultural Research Stations (ARS) (Navgaon, Garhakota, Sausar, Tendini) and 20 Krishi Vigyan Kendras (KVK) (Badgaon, Betul, Chhattarpur, Chhindwara, Damoh, Dindori, Harda, Jabalpur, Katni, Mandla, Narsinghpur, Panna, Powarkheda, Rewa, Sagar, Seoni, Shahdol, Sidhi, Tikamgarh, Umaria) representing 6 agro-climatic zones spread over 25 districts.

Over four decades, JNKVV has created a base for scientific research and education in a wide spectrum of areas. The university has emerged as a leading research organization having a major stake in the agricultural development of the State. Presently, the University is catering to the needs of the farmers of the State through intensive research programmes spread over seven agro-climatic zones under the jurisdiction of the University as under:

1. Chhattisgarh Plain (Balaghat district).
2. Northern Hill Zone of Chhattisgarh (Mandla, Dindori, Shahdol, Anuppur and Umaria).
3. Kymore Plateau & Satpura Hills (Jabalpur, Katni, Seoni, Panna, Rewa, Sidhi, Singroli and Satna).
4. Vindhyan Plateau- Partially (Sagar, Damoh, Raisen and Vidisha districts only).
5. Central Narmada Valley (Narsinghpur, Hoshangabad and Harda).
6. Bundelkhand Zone- Partially (Tikamgarh and Chhattarpur).
7. Satpura Plateau (Betul and Chhindwara).

The research programmes are mainly related to crop improvement, production practices, conservation practices, biotechnology, nutrient management, crop protection, horticulture, agro-forestry, socio-economic studies, medicinal and aromatic plants and veterinary science.

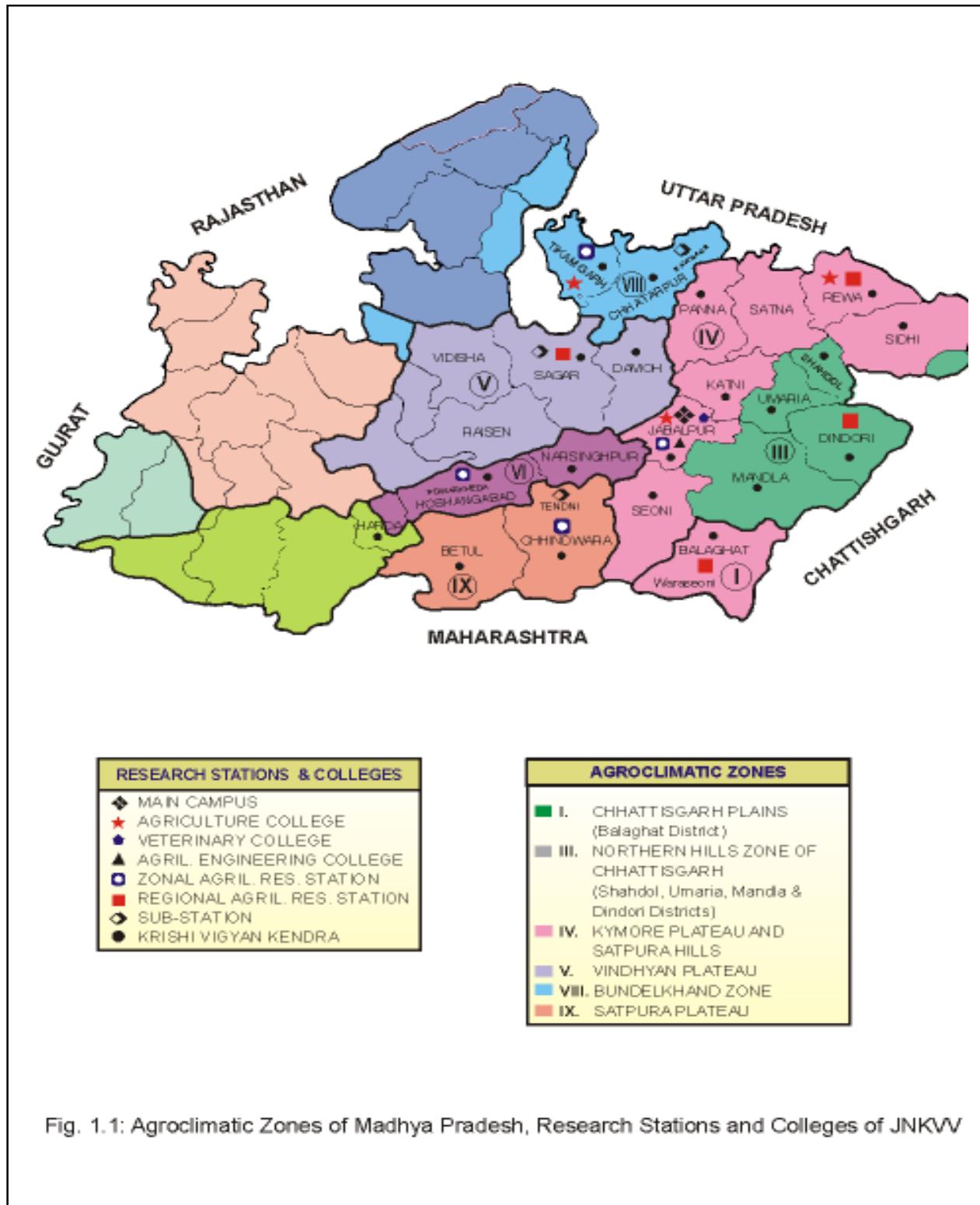


Fig. 1.1: Agroclimatic Zones of Madhya Pradesh, Research Stations and Colleges of JNKVV

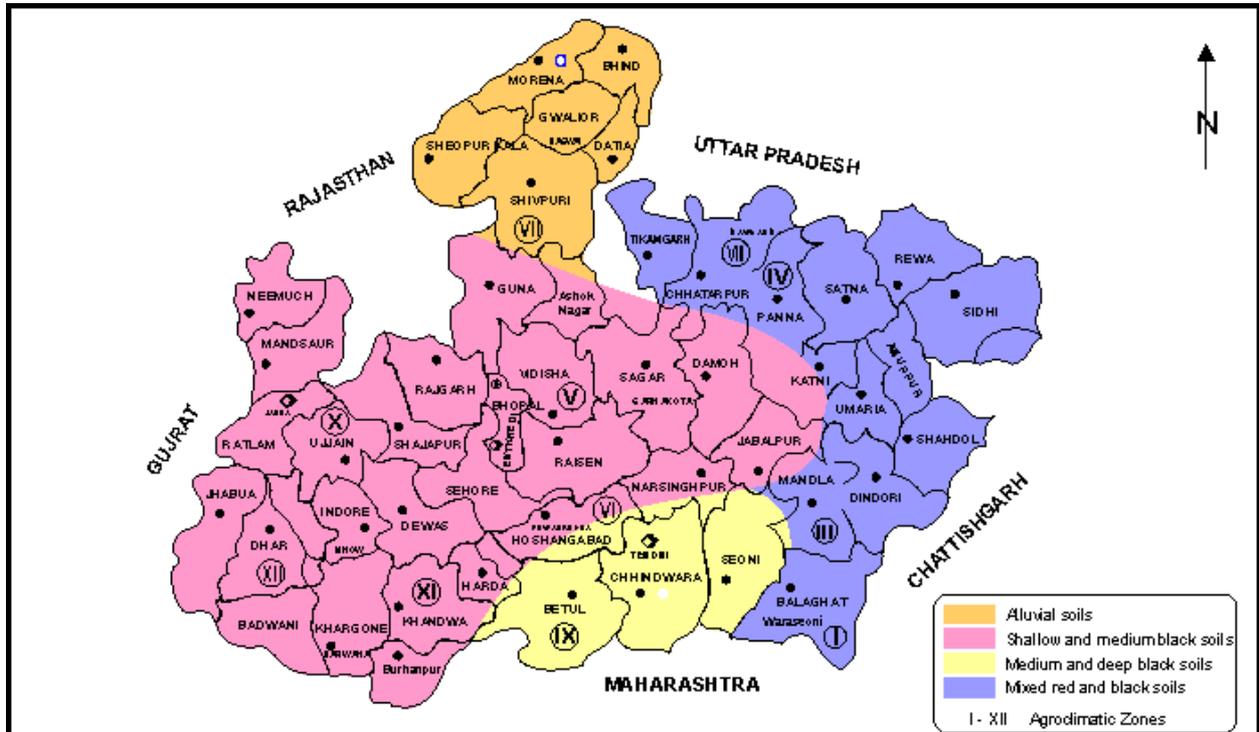


Fig. 1.2: Soil type and their distribution in Madhya Pradesh

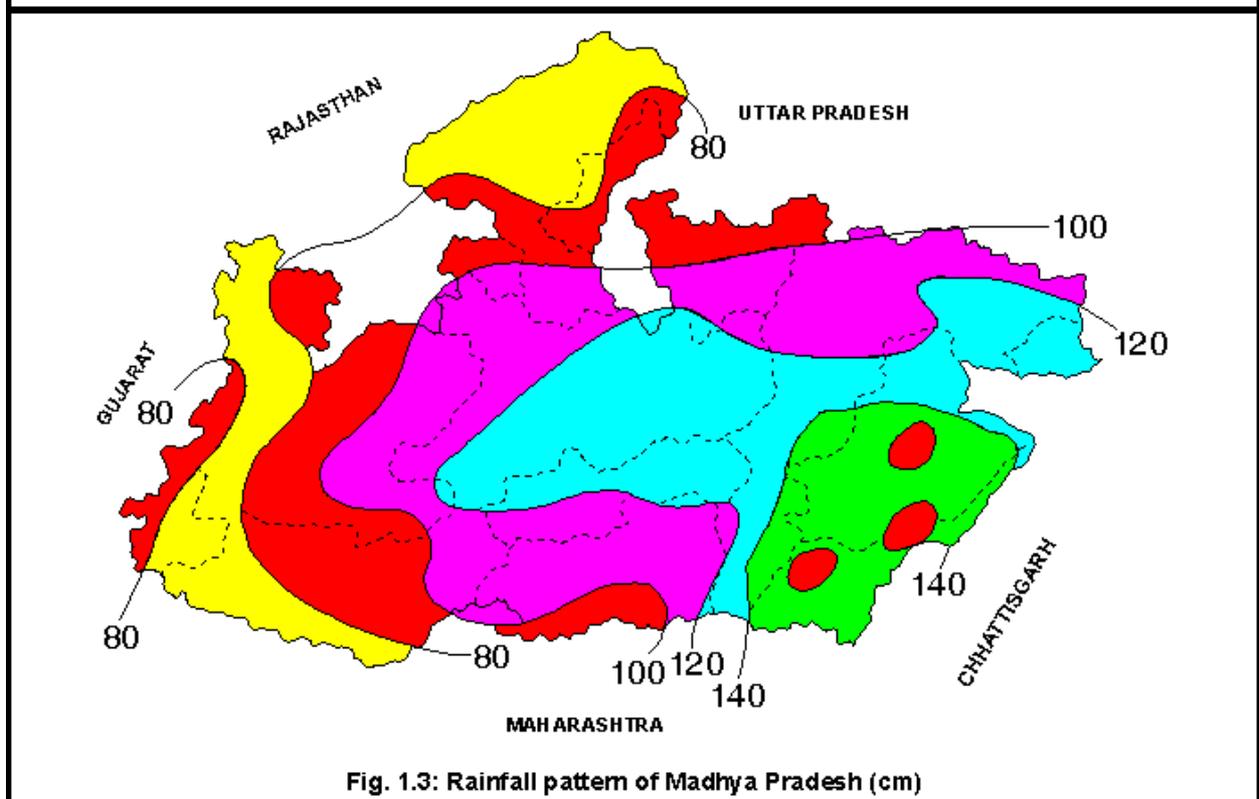
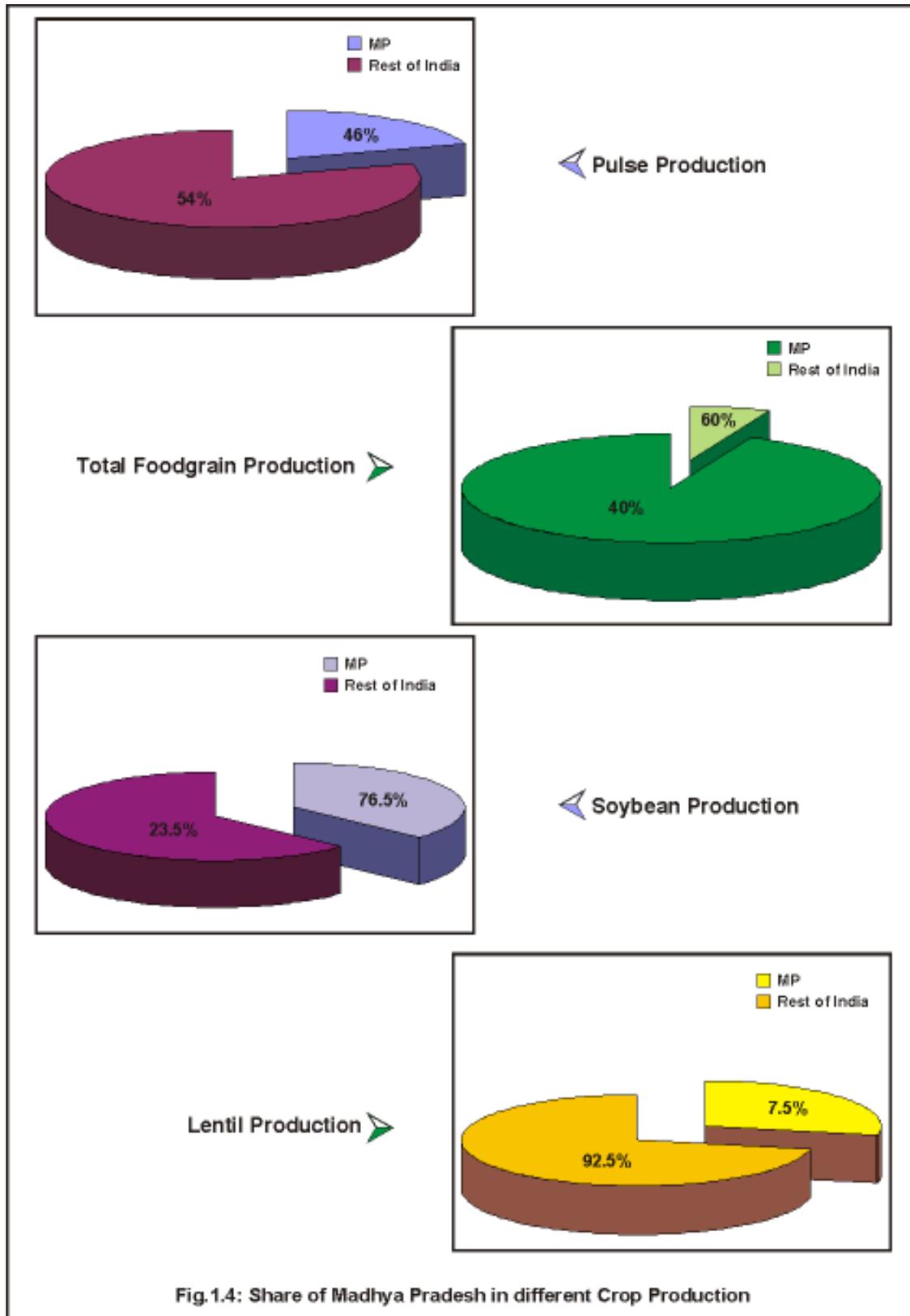


Fig. 1.3: Rainfall pattern of Madhya Pradesh (cm)



2. AGRICULTURE

2.1 Crop Improvement

2.1.1 Genetic improvement of cereals

Wheat

JW 3173: It matures in 125 days. Suitable under rainfed as well as limited irrigation and tolerant to drought. Yield potential is higher than C 306 and Lok-1 under rainfed (23-25 q ha⁻¹) and limited irrigated conditions (37-40 q ha⁻¹). It is non lodging and non shattering. Grains are lustrous and bold, tolerant to drought and rusts, good chapati coupled with other nutritional attributes. It has ability to sustain irrigations and responsive to fertilizers



MP 1203: Resistance against brown and black rust in the variety is mainly due to major and minor genes and therefore, likely to be durable. The variety has higher level of resistance in comparison to checks against other diseases, superior or at par with GW 173, DL 788-2, GW 366 and HD 2932 in agronomical trials also. It has higher number of grains and ears m² under late sown conditions indicating its suitability for the condition. Highest protein content (13.23%), highest Cu content (6.14 ppm) and parallel to checks for other micronutrients. There is no other example that aestivum wheat is having such a higher level of protein content (13.23%).



MP 1202: It has maturity period of 105-110 days with yield potential of 45 q ha⁻¹. It is tolerant to all the three rusts and other diseases of wheat. It is an early maturing variety with high protein content and bold grain and will fetch the market.



MP 1215: This variety of durum wheat is suitable



for timely sowing, It matures in 118-120 days. High protein content, rust resistant and average production is 55 to 57 q ha⁻¹. This variety is recommended for whole of MP especially in Central region.

JW 3211: It matures in 115-120 days, seeds are bold, umber and plants are semi dwarf. Parents are SKAUZ/2/FCT. Resistant to drought. Best for chapati. Suitable for partial irrigation (1-3). Gives 40-45 q ha⁻¹ yield under 2 irrigations. Quality wheat spreading fast in MP.

Barley

JB 1 : It has maturity period of 120 days with yield potential of 43 q ha⁻¹. It is resistant to aphids and tolerant to rust and covered smut.

Paddy

Hybrid Rice (JRH 8): Marching towards the profitable hybrid rice programme, JRH 8 has been developed that matures in 105 days. As compared to any variety, JRH 8 has 40-45% more yield with long slender grain having intermediate amylose content. This hybrid yields 75-80 q ha⁻¹ and may be best suited to the areas growing Kranti and IR 64 with potential to enhance productivity in irrigated situations with tolerance to stress, resistance to lodging and fertilizer responsiveness are the major features.



2.1.2 Genetic improvement of pulses

Jawahar Gram 14 (JG 2000-14) : It matures in 100-105 days with an average yield of 18-19 q ha⁻¹ under late sown condition. Plant is semi erect having attractive pods. Seeds are brown, angular, medium bold (21g/100 seed). It is better in milling due to its high dal recovery and is resistant to Fusarium wilt moderately resistant to dry root rot and shows less incidence of pod borer.

Jawahar Gram-6 (JG 6) : It matures in 113 days with an average yield of 20-21 q ha⁻¹. Seeds are angular, smooth surfaced, dark brown and large (24.9 g/100 seed). Plant type is semi spreading, semi-dwarf with profuse branching, low anthocyanin and pink flower. The variety has resistance to Fusarium wilt, moderately resistant to dry root rot, and tolerant to infestation by pod borer and resistant to lodging and shattering.

2.1.3 Genetic improvement of oilseeds

Soybean

Jawahar Soybean (JS 97-52) : In continuation of world fame JS series, the variety, JS 97-52 has been released. It has a maturity period 98-102 days with yield potential of 25-30 q ha⁻¹. Plants attain medium height (58-60 cm) with test weight of 9-10 g/100 seed. Seeds contain balance amount of quality protein (40%) and edible oil (20%). Seeds of JS 97-52 possess excellent germinability, field emergence and longevity during storage. JS 97-52 is resistance to yellow mosaic virus disease, root rot, bacterial pustule, charcoal rot, cercospora leaf spot and target leaf spot, insect pests and excessive moisture stress.



Groundnut

JGN 23 :This variety matures in 140 days with an average yield of 16-18 q ha⁻¹ of dry pod and 11 q ha⁻¹ of kernel t ha⁻¹ about 10-15% higher yield than existing varieties. Kernels are cylindrical with tan coloured seed coat (testa). The variety is tolerant to Tikka disease.



Sesame

PKDS-12: It has maturity period of 80 days with yield potential of 6 q ha⁻¹. Summer crop is free from diseases and it is moderately resistant to capsule borer. White and bold seeded and has high oil content.

PKDS-14: It has maturity period of 81 days with yield potential of 11 q ha⁻¹. Summer crop is free from diseases and it is resistant to antigastra. Oil recovery is good and it is responsive to irrigation.

TKG-308: It has maturity period of 82 days with yield potential of 7 q ha⁻¹ and oil content 49.6%. Under field conditions the variety is moderately



resistant to *Macrophomia*, *Cercospora*, bacterial leaf spot and leaf curl. It is resistant to antigastra insect at capsule stage.

Linseed

Jawahar Linseed-67 (JLS-67): It is a short statured variety, flowers in 38-48 days, early maturing, medium white flowers are star shaped. Seed colour is light brown. It is moderately resistant to powdery mildew and rust and moderately susceptible to wilt and *Alternaria* blight diseases. It is also moderately susceptible to bud fly. Its average yield potential is 12 to 13 q ha⁻¹ under rainfed conditions and is capable to give 23 q ha⁻¹ under high fertility and irrigated conditions. It contains 40.16% of oil.



2.1.4 Genetic improvement of millets

Kodo

Jawahar Kodo 106 (JK 106): Small millets are predominantly grown in less fertile land with low cost input. The variety JK 106 is the selection from local variety and having average grain yield of 19.47 q ha⁻¹. This variety is suitable for M.P. particularly for tribal areas where kodo is under cultivation. It has 56 cm height, matures in 100 days, 1000 grain weight is 5.0-5.6 g and resistant to head smut and shoot fly. Sole crop and intercropping gave 43.5% and 45.2% more yield than the check variety.



Kutki

Jawahar Kutki 36 (JK 36) : Newly released Kutki variety has plant height of 91.7 cm, matures in 76 days, 1000 grain weight 2.1 g and tolerant to grain smut and shoot fly. This variety is suitable under sole cropping as well as in intercropping and average yield is 10 q ha⁻¹.



2.1.5 Genetic improvement of forage crops

Oat JO 2003-91: It has been developed from a cross between OS6 x JHO822 and has performed well in different locations of India.

2.1.6 Salient features of crop varieties released during 2007-08 and 2008-09

S.No.	Crop /Variety	Maturity (days)	Yield (q ha ⁻¹)	Features
1.	Wheat JW 3173	125	23-24 (rainfed) 37-40 (irrigated)	Suitable under rainfed as well as limited irrigation and tolerant to drought. Yield potential is higher than C-306 and Lok-1. It is non lodging and non shattering. Grains are lustrous and bold, tolerant to drought & rusts, good for chapati coupled with other nutritional attributes. It has ability to sustain irrigations and is responsive to fertilizers
2.	MP 1203	105-110	45-47	Variety is resistant against brown and black rust mainly due to major and minor genes and therefore likely to be durable variety, has higher level of resistance in comparison to checks against other diseases. Superior or at par with GW 173, DL 788-2, GW 366 and HD 2932 in agronomical trials also. Higher number of grains and ears/m ² under late sown conditions showing its suitability for the condition. Highest protein content (13.23%), highest Cu content (6.14 ppm) and parallel to checks for other micronutrients. None of the aestivum wheat has such a high level of protein content.
3.	MP 1202	105-110	45-47	It is tolerant to all the three rusts and other diseases of wheat. It is an early maturing variety with high protein content and bold grain and will fetch the market.
4.	MP 1215	118-120	55-57	This variety of durum wheat is suitable for timely sowing. It has high protein content and rust resistant, this variety is recommended for whole of MP especially in Central region.
5.	JW 3211	115-120	40-45	Bold seeded, umber and plants are semi dwarf. Parents are SKAUZ/2/FCT. Resistant to drought. Best for chapati. Suitable for partial irrigation (1-3). Gives yield under 2 irrigations. Quality wheat spreading fast in MP.
6.	Paddy Hybrid Rice JRH 8	105	75-80	Marching towards the profitable hybrid rice programme, the JRH 8 has been developed. As compared to a variety, the hybrid rice JRH 8 has 40-45% increase in yield with long slender grain having intermediate amylose

S.No.	Crop /Variety	Maturity (days)	Yield (q ha ⁻¹)	Features
				content. This hybrid may be best suited to the areas growing Kranti and IR 64, has potential to enhance productivity in irrigated situations with tolerance to stress, resistance to lodging and fertilizer responsiveness are the major features.
7.	Gram Jawahar Gram 14 (JG 2000-14)	100-105	18-19 (late sown)	Plant is semi erect having attractive pods. Seeds are brown, angular, medium bold (21g/100 seed). It is better in milling due to its high dal recovery and is resistant to Fusarium wilt, moderately resistant to dry root rot and shows less incidence of pod borer.
8.	Jawahar Gram JG 6	113	20-21	Seeds are angular, smooth surfaced, dark brown and large (24.9 g/100 seed). Plant type is semi spreading, semi-dwarf with profuse branching, low anthocyanin and pink flower. The variety has resistance to Fusarium wilt, moderately resistant to dry root rot, and tolerant to infestation by pod borer and resistant to lodging and shattering.
9.	Soybean Jawahar Soybean JS 97-52	98-102	25-30	In continuation of world fame JS series, the recent variety, JS 97-52, has been released. Plants attain medium height (58-60 cm) with test weight of 9-10 g/100 seed. Seeds contain balance amount of quality protein (40%) and edible oil (20%). Seeds of JS 97-52 possess excellent germinability, field emergence and longevity during storage. The variety has resistance against yellow mosaic virus disease, root rot, bacterial pustule, charcoal rot, carpospores leaf spot and target leaf spot, insect pests and excessive moisture stress.
10.	Groundnut JGN 23	140	16-18	The variety matures in 140 days with an average yield of 16-18 q ha ⁻¹ of dry pod and 11 q ha ⁻¹ of kernel; about 10-15% higher yield than existing varieties. Kernels are cylindrical with tan coloured seed coat (testa). The variety is tolerant to tikka disease.
11.	Sesame PKDS 12	80	06	Summer crop is free from diseases and it is moderately resistant to capsule borer. White and bold seeded and has high oil content.

S.No.	Crop /Variety	Maturity (days)	Yield (q ha ⁻¹)	Features
12.	Sesame PKDS 14	81	11	Summer crop is free from diseases and it is resistant to antigestra. Oil recovery is good and it is responsive to irrigation.
13.	Sesame TKG 308	82	7	Under field condition the variety is moderately resistant to Macrophomia, Cercospora bacterial leaf spot and leaf curl. It is resistant to Antigestra insect at capsule stage. Liked by farmers particularly for preparing sweetmeats.
14.	Linseed Jawahar Linseed 67 JLS 67	107-114	12.52	It is a short statured variety flowers in 38-48 days, early maturing, medium white flowers are star shaped. Seed colour is light brown. It is moderately resistant to powdery mildew and rust and moderately susceptible to wilt and Alternaria blight diseases. It is also moderately susceptible to bud fly. It is capable to produce 23 q ha ⁻¹ under high fertility and irrigated conditions. It contains 40.16% oil.
15.	Kodo Jawahar Kodo 106 JK 106	100	19	Small millets are predominantly grown in waste land or less fertile land with low cost input. The variety is the selection from local variety. This variety is suitable for M.P. particularly for tribal areas where kodo is under cultivation. It has 56 cm height, 1000 grain weight is 5.0 - 5.6 g and resistant to head smut and shoot fly. Sole crop and intercropping gave 43.5% and 45.2% more yield than the check variety.
16.	Kutki Jawahar Kutki 36	76	10	Newly released Kutki variety has plant height of 91.7 cm, 1000 grain weight 2.1 g and tolerant to grain smut and shoot fly. This variety is suitable under sole cropping as well as in intercropping.
17.	Barley JB 1	120	43	It is resistant to aphids and tolerant to rust and covered smut.
18.	Sugarcane COJN 86-600	144-168	120-130t	The sucrose content in juice is 17 per cent. It is resistant to smut and wilt red rot. Very good for jaggery. This variety is recommended for sowing in whole of Madhya Pradesh.

The green fodder yield is about 475-525 q ha⁻¹ and dry matter yield 100-115 q ha⁻¹. It has medium duration (82-87 days for 50% flowering and resistance to leaf blight, root rot and powdery mildew disease under field conditions with productivity of seed yield about 18 - 20 q ha⁻¹.

Sugarcane:

COJN 86-600: It has maturity period of 12 - 14 months. Its yield potential is 120 - 130 t ha⁻¹. The sucrose content in juice is 17 per cent. It is resistant to smut and wilt red rot. Very good for jaggery. This variety is recommended for sowing in whole of Madhya Pradesh.

2.2 Seed Technology

Storage of seeds with lower seed moisture (8 per cent) in poly-lined gunny bag and Tyvek bag expressed better storability in terms of germination and vigour.

Standardization of seed coating technique with synthetic polymers and additives

Maize

Seedling emergence and field emergence was significantly faster in seeds coated with thiram @0.25 per cent and polykote followed by vitavax (2 g kg⁻¹).

Sequential coating of seeds with fungicides, insecticide and polykote and their storage in 700 gauge polythene bags exhibited maximum germination and vigour index.

Soybean

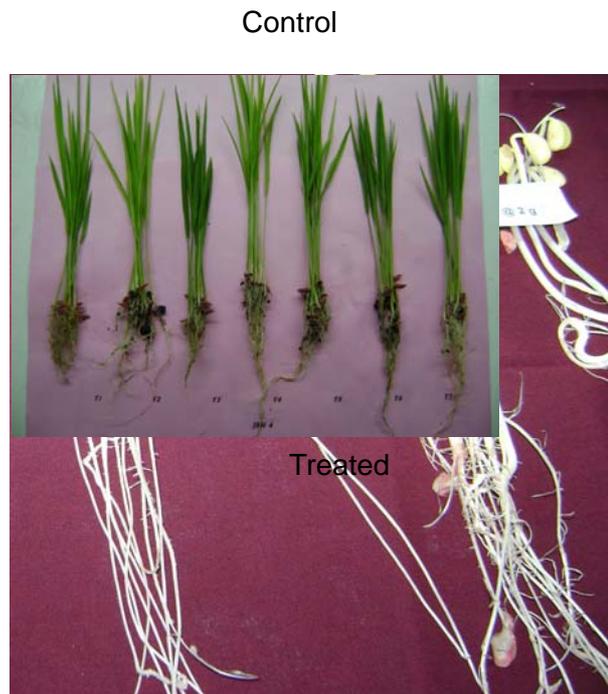
Seedling growth rate of seeds coated with thromothoxum was higher than the untreated ones

Storage of coated seeds in 700 gauge

polythene bag maintained seed quality up to 4 months of storage in terms of germination and vigour

Nursery management for SRI

Seedling dry weight, seedling growth rate and total chlorophyll was observed to be maximum when sown in growing media



containing 25% FYM, 25% Vermicompost and 50% soil followed by 50% soil and 50% FYM and 50% soil and 50% Vermicompost.

Characterization of crop varieties for implementation of PPV and FR Act based on National Test Guidelines for DUS testing

Crop	Varieties	Characteristics
Lentil	25	14
Field pea	29	19
Linseed	71	17
Sesame	65	20
Vegetable pea	16	19
Kodo millet	08	21

Correlation between ODV with genetic purity in GOT

The seeds sorted out as genetic impure based on expression at seed level by seed analyst in sesame has positive and significant correlation with genetic impurity at plant level in Grow Out Test. However, apart from genes expression of seed coat colour of testa is also influenced by other stresses in sesame.

Out-crossing in field pea

The genetically pure seed of field pea can be produced with the recommended isolation distance of 10 and 5m for Foundation and Certified seed category, respectively in MP,

Excessive moisture tolerance in soybean

Genotype JS 76-205 (black) and JSM 127 may tolerate submergence at the time of germination upto 48 hrs with only 50 per cent reduction in germination.

Based on ability to form adventitious roots for survival of plant under excessive moisture stress, genotype JS 95-60, JSM 258, JSM 290, JSM 115, JSM 238 and JSM 175 were found to be the best.

Selection on the basis of grain yield performance under excessive moisture stress, genotype JS 95-60, JSM 115, JSM 202, JSM 189 and JSM 248 have been found to be tolerant.

2.3 Resource Management

2.3.1 Rainwater Management

Enrichment of ground water bank through haveli recharge: Haveli cultivation is an indigenous practice of *in-situ* harvesting of rain water within the fields and growing rabi crops on conserved moisture in vertisols. Estimated potential haveli area is indicative of its extent up to 28% to 64% of cultivated area in different districts of Kymore plateau and Satpura Hills (KPSH) Zone.

Blocks, namely, Budwara (25405 ha), Nagod (33163 ha), Lakhnadon (27529 ha), Shahpura (34533 ha), Rampurnaiken (47593 ha) and Hujur Rewa (35888 ha) possess maximum haveli area under districts; Katni, Satna, Seoni, Jabalpur, Sidhi and Rewa, respectively. Rainfall amount, its distribution and occurrence along with antecedent rainfall affects amount of recharge and haveli storage.

Soil biodiversity at Haveli field of Kymore and Satpura Hills and Narmada Valley Agro climatic zones of Madhya Pradesh: Haveli' fields are the good example of indigenous rain water management prevalent in deep black soils of Madhya Pradesh.

It has been observed that availability of N, P and K, dehydrogenase, N mineralization, alkaline and acid phosphatase activities and context of soil microbial biomass carbon were found to be significantly better at 3rd stage (i.e. after release of water and at sowing of rabi crops).

Similarly B-D glucosidase activity was found highest at 4th stage (i.e. after harvest of rabi crops). While, soil respiration was maximum at 2nd stage, on the contrary microbial counts (total bacteria, actinomycetes, fungi, azotobacter, phosphate solubilizing bacteria and pseudomonas) declined at submergence state of soil but counts was found to be increased rapidly soon after getting favourable aerobic conditions that ultimately resulted in increased in the productivity of microbial biomass carbon content.

All these activities were observed highest at 3rd stage of sampling which further declined progressively as part advances to the maturity or harvest of the crops.

Response of raised and sunken bed: Raised bed and sunken bed system prepared in 1:1 ratio at width of 6.0 to 7.5 m is suitable for conserving the soil water and nutrients efficiently in improving the crop productivity. Raised-sunken bed technology is economically viable in rainfed areas of black soils region of central India.

2.3.2 Nutrient Management

AICRP- STCR project on the nutrient requirement (kg q⁻¹) and per cent efficiency to utilize nutrients in soil and FYM and the nutrients applied through fertilizer indicated that these values have been used for calculating fertilizer doses for target yields of chandrasur.

Nutrient requirement of chandrasur and percent contribution from soil, FYM and fertilizer nutrients at Jabalpur.

On-farm verification trials were conducted each on Urid (LB-6) , Mustard (Pusa Bold), Pea (JP 885), Lentil (JL-23), Gram (JG 315), Soybean (JS 97-52), Maize (JM 12) and Onion (Agrifound light red) at Jabalpur revealed that yield target

were achieved in all the crops with 10% deviation. The profits calculated for each crop were found higher in case of targets with FYM (IPNS) as compared to GRD and STCR approaches.

Particulars	N	P ₂ O ₅	K ₂ O
Nutrient requirement (kg t ⁻¹) seed	3	0.48	5.69
Contribution from soil as % of its available nutrient	9	7	10
Contribution from FYM as % of its nutrient content	60	3	83
Contribution from fertilizer as % of its nutrient content	32	7	46

The fertilizer adjustment equations developed with the help of basic data is presented here:

$$FN = 9.26 T - 0.27 SN - 1.04 FYM-N$$

$$FP_2O_5 = 10.94 T - 3.07 SN - 0.51 FYM P_2O_5$$

$$K_2O = 10.93 T - 0.22 SK - 1.04 FYM - K_2O$$

and where, FN, FP₂O₅ and FK₂O = Fertilizer Nutrient Requirement (kg ha⁻¹)

T = Target Yield (q ha⁻¹)

SN, SP and SK = Available soil test values of N,P and K (kg ha⁻¹) and FYM-N,

FYM-P and FYM-K = N, P and K applied through FYM (kg ha⁻¹)

Frontline demonstrations based on Soil Test Crop Response studies conducted on farmer fields demonstrations on linseed (JLS 23) and gram (JG 130) at different villages of Jabalpur district. The soil on which the trials were conducted were hypothermic Typic

haplustert deep black taxonomically fine soil montmorillonitic. The targeted yield of gram and linseed were achieved within $\pm 2\%$ to $\pm 36\%$ from affixed target. The target of 1.5 t ha^{-1} with 5t FYM at Bilgawon, Keymori villages, achieved the target in gram with variation in yield ranging from -5% to $+3\%$ respectively.

It is interesting to note that when targeted yield approach coupled with IPNS, i.e. inclusion of 5t FYM the target yield enhanced in all experiments by 10% over affixed target. Based on relative magnitude of Yard Stick Values (YSV), given out by the application of different methods of fertilizer recommendations, revealed the sequence as: $\text{STCR} > \text{IPNS} > \text{GRD}$ trend holds good in case of gram and linseed.

It can be concluded that, in linseed and gram, IPNS was responsive and remunerative than that of STCR approach. Under STCR approach, YSV kg per kg of nutrients applied was more than that of IPNS approach of fertilizer prescription.

Agronomic evaluation, under irrigated condition reveals that application of 20: 60:20 kg NPK ha^{-1} to soybean and 120: 60:40 kg NPK ha^{-1} to wheat resulted in higher production and net profit in soybean-wheat cropping sequence.

Application of 80: 40:20 kg NPK ha^{-1} to pearl millet and 120:60:40 kg NPK ha^{-1} to wheat was found optimum fertilizer dose for increasing total production (6.33 t ha^{-1}) and net profit (Rs 18,705) from pearl millet-wheat cropping system in medium black soils of Tikamgarh.

Application of S 25 kg ha^{-1} and Zn 5 kg ha^{-1} through ZnSO_4 along with RDF in soybean-wheat cropping system increased the productivity and net profit of soybean-wheat based cropping systems.

2.4 Crop Production

2.4.1 Cropping Systems

Kymore plateau and Satpura hills zone

Early medium rice cv. IR-36 - potato cv. K. Sindhuri - wheat cv. Lok-1 cropping system produced maximum wheat equivalent yields ($11.17 \text{ t ha}^{-1} \text{ yr}^{-1}$) with the net monetary return (NMR) of Rs. 57352 ha^{-1} and B:C ratio of 2.79. Cropping sequence of early rice-vegetable pea-wheat ($9.67 \text{ t ha}^{-1} \text{ yr}^{-1}$), green manuring-rice-wheat ($9.47 \text{ t ha}^{-1} \text{ yr}^{-1}$) and early rice-toria-wheat ($9.22 \text{ t ha}^{-1} \text{ yr}^{-1}$) also proved better yielder than existing rice-wheat system ($9.09 \text{ t ha}^{-1} \text{ yr}^{-1}$).

Integrated nutrient management in rice-wheat cropping sequence

Application of 50% NPK through fertilizers + 12 t FYM or green manures ha^{-1} to rice followed by 100% NPK to wheat gave significantly higher total productivity and net profit than those obtained with application of 100% NPK through fertilizers to both crops.

Central Narmada valley agro-climatic zone

Ten crop sequences were evaluated for their productivity and economic viability. among the sequences tested, soybean - potato - sesame produce the maximum SEY 112.83 q ha^{-1} per year and fetched the highest net monitoring return (Rs. $1,15,760 \text{ ha}^{-1} \text{ yr}^{-1}$) with B:C ratio 4.1.

Integrated farming system

Forage crops

Irrigated

Growing crop sequence of jowar+cowpea in kharif, berseem+sarson in rabi and maize+cowpea in summer proved superior for

getting maximum tonnage of green fodder (1763 q ha⁻¹ yr⁻¹) and net monetary returns of Rs. 57443 ha⁻¹ yr⁻¹. However, the per day productivity (4.83 q ha⁻¹) of green fodder was found higher under this crop sequence as compared to other cropping sequences.

Rainfed

Growing of fodder sorghum as an intercrop with pigeonpea gave the maximum gross returns (Rs. 46,268) as well as net returns (Rs. 30,268) when two rows of fodder sorghum was sown in between two rows of pigeon pea sown at 75 cm apart.

Utera cultivation

In paddy growing areas especially under transplanted situation it has been observed that normal sowing of berseem crop is usually delayed by 20-25 days. Under such situation a technology has been generated for timely sowing without reduction in fodder tonnage. The technology involves direct seeding in standing paddy crop increasing by seeding rate 33 percent (40 kg ha⁻¹) 15 days prior to harvest. It is also advised that surplus stored water may be drained out from the field before sowing operation. This practice gives one additional cutting over normal sowing after paddy harvest.



Soybean - Potato - Sesame

2.4.2 Tillage Management

Tillage and planting management in rice-wheat cropping systems

Direct sowing of rice in line sowing followed by strip till drilling of wheat produced maximum wheat equivalent yield (7.05 t ha⁻¹ yr⁻¹), net monetary return (Rs. 52,283 ha⁻¹ yr⁻¹). Sowing of rice by transplanter followed by strip till drilled wheat in a system was comparable to it. These two sowing practices proved most identical in terms of labour requirement and economics.

2.4.3 Nutrient Management

Low cost technology using micro nutrients

Response of micronutrients: In a field trial, rice and wheat crops grown on a vertisol, application of Zn @ 5 kg ha⁻¹ increased the yield by 17 and 19 per cent, respectively. The application of Zn fertilizer at RDF also resulted in the improvement of zinc status in the soil from 0.5 to 1.5 mg kg⁻¹ that also resulted in improving the productivity in successive crops too. The application of sewage and sludge before sowing of rice crop and its residual effect was evaluated on wheat. It revealed that application of sewage and sludge increased the yield by 16-17 percent and also increased the nutrient content to a



Intercropping of Pigeonpea and Jowar chari

considerable extent in comparison to soils treated without application.

In an evaluation pertaining to the application of heavy metals, it has been suggested that conjoint use of Zn @ 10 kg ha⁻¹ with FYM @ 5 t ha⁻¹ increased the yield of garlic to a remarkable extent and also overcome the toxic effects of cadmium content available in the soil. It has been established that being heavy metal cadmium exerts toxicity when present in higher amounts and that cadmium was found to decrease the growth and yield to a considerable extent.

Evaluating the effect of Zn enriched organic manure (@ 5 kg Zn ha⁻¹ + 200 kg FYM ha⁻¹) in soybean suggested that the yield of

soybean was found to increase by 30 per cent as against 5 kg Zn ha⁻¹ while around 20 per cent higher yield of wheat was also recorded as a residual effect when recommended dose of fertilizer was applied.

Micronutrient deficiencies

- Studies conducted under AICRP on Micronutrients revealed that In Madhya Pradesh 71 per cent of 18000 soil samples analyzed, indicated deficiency of Zn. The deficiency of Fe and Mn was noted in 7.0 and 2.4 per cent soil samples respectively, whereas soils were found to be sufficient in available copper. Similarly, the deficiency of S was noticed in about 40.6 per cent of 10900 samples.



Integrated application of Zn (5 kg/ha) with FYM (10 t/ha)



Application of Zn (5 kh/ha)



Application without Zinc

Response of Zn application in Wheat grown on Black Soils

- Investigation on Multi-micronutrient deficiency under Jabalpur Nutrient Index Domain (AESR 10.1) observed that in the soil accounts to be Zn + S 30.1 per cent Zn + B15.8 per cent nutrient deficiency.
- To ameliorate Zn deficiency, application of 10 kg Zn ha⁻¹ to heavy clay soils and 5 kg Zn ha⁻¹ to light textured soils have been recommended.
- The residual effect of applied Zn indicated that 10 kg Zn ha⁻¹ persisted up to 6 crops in soybean-wheat sequence giving the response as 51.3, 34.3 and 17.9 per cent in soybean and 11.4 to 13.6 per cent in wheat. However, response reduced to 5 per cent in 8th crop. Available Zn increased from 0.26 to 2.45 mg kg⁻¹ after 1st crop and then decrease gradually to 0.40 mg kg⁻¹ after 8th crop.
- Zinc and iron deficiency in standing crops can be corrected by the foliar application of 0.5 per cent and 2 per cent of ZnSO₄ and FeSO₄ respectively at an interval of 10 to 15 days.
- In case of sulphur deficiency application of 20 kg S ha⁻¹ to cereals and 40 kg S ha⁻¹ to pulses and oilseed crops every year gave the optimum yields.
- Application of sewage effluent to vegetables indicated higher contents of Cd and Pb which could be found to hazardous to animal and human health.
- The yield of Garlic decreased with increasing levels of Cd from 19.63 g⁻¹ pot at control to 11.75 g⁻¹ pot at 32 mg kg⁻¹ Cd. The application of FYM @ 5 t ha⁻¹ minimized the detrimental effect of Cd on yield of garlic which increased from 15.76 to 18.13 g/pot with FYM. The absorption of Cd is also reduced by the application of FYM @5 t ha⁻¹.
- The application of sewage sludge increased the yield of rice and wheat to an extent of 20-25 per cent in black soils. Zn in post harvest soils also increased due to application of sludge from 0.52 to 0.84 mg kg⁻¹.
- The application of organic matter (OM) increased the yield of paddy and wheat. However, poultry manure (PM) proved better in increasing the yield of paddy and wheat in black soils of Jabalpur. Available Zn status in post harvest soils was found to be higher in PM then that over other OM.

Soil microbes

- Under Network Project on Soil Biodiversity and Biofertilizers, despite continuous cultivation of inoculated soybean on same field (vertisols) for 7 years there was significant response of Bradyrhizobium inoculation on yields (average increase by 11 per cent) indicated that seed inoculation was found to be mandatory every year and there was residual benefits added by soybean about 20-30 kg N ha⁻¹.
- In Madhya Pradesh soils soybean rhizobial strain biodiversity characterization indicated the predominance of *Bradyrhizobium japonicum* and *B. elkanii* which are slow growing species while fast growing species *Sinorhizobium fredii*, *S. xinjiangensis* and *B.liaoningensis* are absent
- Under BARC project Integration of Rhizobium and PSB bio-inoculants with 50 per cent RD of NPK (20:50:20 kg ha⁻¹)

Soil Testing

The soil testing status of Indore district was evaluated under soil testing scheme programme and it was found that the soil was safe with respect to the salinity while organic carbon was determined to be in the medium category of status. Most of the represented areas fall in available N status, medium in available P status while medium to high in available K status. Based on the soil testing data, the soil fertility maps have been prepared and recommendations given to the farmers of Indore district.

Soil quality and crop productivity

The productivity of crops and fertility of soil was monitored under long term fertilizer experiment at Jabalpur. It was observed that balanced use of fertilizer was found to be essential for higher productivity of soybean and wheat as well as for maintaining the fertility of soil. The integrated application of recommended dose of fertilizer along with FYM @ 15 t ha⁻¹ to soybean appeared to achieve sustainably higher productivity as well as resulted in remarkable improvement in soil health. However, continuous use of imbalanced fertilizer viz. devoid of P (Urea alone) or S (addition of DAP) on the other hand resulted in the depletion of fertility of the soil. The results indicated that P seems to be the key input

was found significantly superior in registering higher grain yield (770.4 kg ha⁻¹) of mung bean in comparison to other treatments except 100 per cent RD of NPK and integration of vermi-compost (2 t ha⁻¹) with 50 per cent RD of NPK.

Three years study conducted at Zonal Agricultural Research Station Tikamgarh (2006-2008) indicated application of NPK @ 60:40:20 kg ha⁻¹ in conjunction with 25 t FYM + 20 kg ZnSO₄ + 25 kg FeSO₄ was found superior as compared to recommended doses of fertilizer. These results clearly indicated that under the agro climatic conditions of Tikamgarh, the use of organic manures along with chemical fertilizer improved the production potentials of crop on soil of Tikamgarh.

Evaluation of fertilizers, organic manure and biofertilizer in different combinations



Fertilized un-inoculated control 3 DAS



GPR treated plot at 3 DAS

influencing crop productivity in black soil. Use of balanced application of fertilizer along with FYM helps improving available status of carbon in the soil.

Field trial results of field demonstrations conducted on different pulses showed improvement in the yield of crops due to RDF along with seed inoculation with beneficial microorganisms over RDF alone and farmer's practice (imbalance nutrition) without seed inoculation. While inoculation with indigenous isolates increased the average seed yields of different rabi pulses by 33% as compared to JNKVV inoculants accounts for about 44 %.

Agricultural microbiology

Bio-fertilizer based IPNS

Soybean Rhizobial diversity : The Rhizobial strain isolated from soybean root nodule was distinct from the standard strain *B. japonicum* (USDA 6), *B. elkarrii* (USDA 76) and *S. fredii* (USDA 205) introduced in to nitragin of USA. It was inferred that MP soils might harbour either *B. japonicum* or *B. elkarrii* and not any fast growing species with a population count less than 100 cells per gram soil, which indicated the need of regular inoculation.

BNF exploitation under soybean-wheat cropping sequence: Under soil biodiversity, regular inoculation with biofertilizers increased the soybean yield by 10-12 per cent. This practice resulted in saving of N about 20 to 30 kg ha⁻¹ for succeeding Rabi crops when seed inoculation was done with Rhizobium for soybean and Azotobacter for wheat. On the other hand, microbial biomass carbon content was also found to be enriched that favourably improved the fertility of the soil in many fields.

The microbial activity of bacteria, actinomycetes, fungi, PSB and Pseudomonas

were observed highest at early and flowering stage of the crop (45 DAS), while the microbial population declined at second stage of crops growth (20 DAS), but increased at 3rd and 4th stages of crop (flowering and grain setting at 45 and 75 DAS) respectively.

- Integration of Bio-inoculants with inorganic and organic sources of nutrients for yield maximization of sesame result on the basis of three years studies (2006-08), showed that the application of 60:40:20 kg ha⁻¹ NPK with 2.5 t ha⁻¹ vermi-compost/ FYM + Azospirillum 5 kg ha⁻¹ + PSB 5 kg ha⁻¹ + *Trichoderma viridae* 2.5 kg ha⁻¹ + *Pseudomonas fluorescens* 2.5 kg ha⁻¹ was found to produce higher yield and net return in sesame grown in medium black soils.
- In tribal areas IPNS practice (inorganic fertilizer + FYM + Azotobacter + Azospirillum + PSB) resulted in substantial increase in productivity of kodo, kutki and niger crops (100-230 per cent) over farmer's practice (without any input) in skeletal soils of Dindori district .
- Status of plant growth promoting rhizobacteria along with fertilizer application (recommended NPK) indicated that soybean, wheat and chickpea seed germination was found to be increased and which may improved the seed yield (average 15-20 per cent) over fertilized uninoculated control.

2.4.4 Salinity and Pollutants

Response under salinity and alkalinity soils:

Delineation of saline alkali soils and preparation of map at various scale using Remote sensing data and ERDAS Imazine 8.7 software revealed total salt affected area of 19,547 hectare in Sheopur district. Similarly, extensive survey

and mapping on GIS platform showed that poor quality ground water problem was more severe in Bhind district where 48% samples were categorized as poor quality water, while, only 13% samples of Sheopur district categorized under poor quality water.

As regards to the measures for reclamation of black alkali soils, use of spent wash @ 5.0 cm was found to be the most efficient under meager paddy-wheat cropping system. Use of sand along with gypsum in plough layer creates favourable soil conditions for germination, crop establishment which leads to higher productivity of the crops in soils.

Use of perforated vertical PVC pipes (110 mm diameter) in vicinity of fruit trees like Aonla for irrigation was found to be suitable and cheaper alternative to drip system for saving of irrigation water to a remarkable extent in strong alkali soil.

Nutrient management in medicinal and aromatic plants

Amongst the suitable medicinal crops Babchi (*Psoralea conifolia*) Sadabahar (*Catharanthus roseus*), Muskadana (*Abelmoschus moschatus*) Isabgol and Chandsoor have been identified to be most suitable for cultivation on soil categorized under slight to moderate black alkali soil group.

Under Medicinal and Aromatic Plants application of Urea @ 2 g plant⁻¹ in lemongrass (genotype OC 19) was found to enhance plant height, plant spread, number of tillers, leaf area and herb yield (357.1 g plant⁻¹) over control (62.86 g plant⁻¹). On the other hand application of Urea @ 1.50 g⁻¹ plant was found to be associated with maximum oil yield (1.07%).

Urea application through ring method in

Lemongrass (variety RRL 16) in different seasons showed that maximum herbage yield was produced (2.39 kg ha⁻¹) when urea was applied @ 1.25 g plant⁻¹ followed by 2.3 kg plant⁻¹. Maximum oil (0.28 per cent) was found in treatment where 1.75 g Urea plant⁻¹ followed by (0.26 per cent) in 2 g urea plant⁻¹ was applied.

2.4.5 Weed Management

Rice-wheat sequence

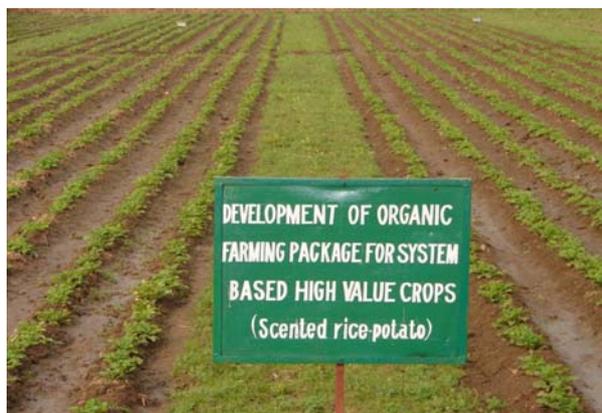
Pre emergence application of Benthicarb @ 1.5 kg ha⁻¹ to rice and Isoproturon @ 1 kg ha⁻¹ as post emergence to wheat under rice wheat sequence proved as good as to two hand weeding in terms of yield and profit.

Pre emergence application of Butachlor 1.5 kg ha⁻¹ to rice and pre or post emergence application of Isoproturon @ 1 kg ha⁻¹ to wheat in rice-wheat sequence proved as good as two hand weeding in terms of yield and profit.

2.4.6 Organic Farming

Development of organic farming package for rice (Pusa basmati-1)- potato (Kufri Sinduri) high value crops: Application of 100% NPK through fertilizers to both crop components with additional application of Zn as per soil test values, resulted in the highest productivity of entire cropping systems as rice equivalent yield (7.2 t ha⁻¹ yr⁻¹) followed by 50% NPK adopted through fertilizers+ 50% N through farmyard manure to rice and potato crops.

Integrated nutrient management in rice wheat cropping system: Long term field experiments on nutrient management continued since past 25 years in Rice-Wheat cropping system with treatment receiving 50% NPK through fertilizers+50% N substituted through farmyard manure/green manuring to rice and 100% NPK through fertilizers to wheat, produced



View of Organic Farming experiment on Rice-Potato at Jabalpur

the maximum yield of both crops and total productivity of the cropping system than that of the 100% NPK through fertilizers applied to both the crops. Thus, integrated application of fertilizers with organic manure sustained the productivity of crops as well as improved the fertility of soils.

2.5 Crop Protection

2.5.1 Disease Management

Management of Phyto-nematode

Soil application of neem cake @ 10 g/ sq m along with *Trichoderma viride* @ 2.5 kg ha⁻¹ effectively reduced the population of lesion nematode by 68 and 64 per cent and increased the yield of chickpea by 24 and 23 per cent during 2008 and 2009 respectively.

Soil treatment with *T. harzianum* @ 2.5 kg ha⁻¹ gave 62 per cent reduction in population of lesion nematode, while increased the yield of chickpea by 15 per cent.

Hot water treatment of paddy seeds at 54°C for 10 min. + foliar spray with carbosulfan @ 0.01 per cent at 45 DAT reduced the population of *A. besseyi* by 59 per cent in shoot and 55 per cent in seed. There was 37 per cent increased in yield over control.

Solarized beds coupled with Carbofuran @ 0.3 g sq m were comparatively superior over organic cake which gave 70 and 53 per cent reduction in root knot population while increasing the yield of Tomato by 21 and 64 per cent respectively during the year 2008 and 2009.

Spot treatment of Carbofuran @ 10 g plant⁻¹ in bottle gourd was superior over organic amendment in reducing the root knot population and increasing yield. The yield was increased by 37 per cent while gall index was reduced by 56 per cent.

Nursery bed treatment with *T. harzianum* @ 50 g sq m gave 44 per cent reduction in root knot population and 28 per cent increased in yield of tomato.

Application of *T. harzianum* @ 2.5 kg ha⁻¹ increase the yield of okra by 20 per cent and reduced the gall index to the tune of 60 per cent.

Management of major diseases

Sesame

Seed treatment with *T. viridae* (0.4%) + *P. fluorescens* (0.4%) + soil application of *T. viridae* (2.5 kg ha⁻¹) + soil application of *P. fluorescens* (2.5 kg ha⁻¹) + Foliar spray of

Tridemorph (0.1 per cent) was found most effective in management of major diseases of Sesame.

Soybean

Seed treatment with Thiram + Carbendazim (2:1) 0.25% is superior. Among new molecules SAFF (0.25%) is effective.

P. flourescence and *T. harzianum* @5 g kg⁻¹ seed + soil application @ 5 kg ha⁻¹ after 30 days of sowing is effective against seedling diseases.

Under ITK- seed soaking with cow urine or butter milk (1:10) for 30 second and two sprays of cow urine or butter milk (1:10) 30 and 45 days after sowing

Germination of fungicidal treated (Thiram + Carbendazim 0.2% each) soybean seeds (with initial moisture 10%) can be maintained above minimum seed certification standards (70%) up to seven months of storage in polythene lined bags.

Prior to sowing soybean seeds should be dressed with Thiram + Carbendazim (0.2% each) that eliminates the associated mycoflora responsible for rotting.

YMV management in soybean

Avoid early sowing as well as immediately after first shower. Seed treatment with thiamethoxam (0.3%) followed by one spray of thiamethoxam (0.1%) 35 DAS.

Select early maturing varieties like JS 95-60, JS 93-05 or resistant variety JS 97-52.

Minor millets

Two varieties of kodo millet namely JK 13 (CR) and JK 106 (SR) were released and both

are resistant to head smut.

Early sowing and seed treatment with carboxin or Carbendazim @ 2 g kg⁻¹ seed is recommended against grain smut incidence and higher grain yield in little millet.

Seed treatment with carboxin @2 g kg⁻¹ seed is very effective in controlling (99.3%) the head smut incidence in kodo millet.

Rice

Management of rice bunt can be achieved by two applications of propiconazole (Tilt 0.1%) first at 30-35 days after transplanting and second after 15 day of first application.

2.5.2 Insect Pest Management

Pigeonpea

Syn-A 15397 ZC 15 per cent @ 37.5 g a.i. ha⁻¹ and Pyridalyl 15 per cent + Fenprothrin 20 per cent EC @ 90+120 g a.i. ha⁻¹ recorded minimum grain damage by pod fly, gram pod borer and pigeonpea plume moth and maximum grain yield.

Chickpea

KN-128 15 per cent EC @50 g a.i. ha⁻¹, Avaunt 15 per cent SP @ 50 g a.i. ha⁻¹ and Beta - Cyfluthrin 9 per cent + Imidacloprid 21 per cent @175 ml ha⁻¹ were highly effective in reducing gram pod borer infestation on chickpea and did not have any phytotoxic effect on the crop.

Small seeded varieties are less preferred by *Helicoverpa* larvae (JG130,JG16,JG 63,JG 1-09,ICC-10,lccv-86111.)

Sesame

Intercropping of sesame + black gram in 3:3 rows may be recommended to the farmers

of Bundelkhand Zone to reduce the incidence of major pests (leaf roller /capsule borer at leaf, flower and capsule stages and bud fly at flowering) of sesame.

NSKE 5 per cent or neem seed oil emulsion 3 per cent or Profenophos 50 EC @800ml ha⁻¹ may be used successfully to manage the *Antigastra catalaunalis* and *Dasyneura sesami* in sesame crop.

Soybean

KN-128 15 per cent EC @ 50 g a.i ha⁻¹, Lannate 40 per cent SP @300 g a.i. ha⁻¹ and Profenophos 50EC @625 g a.i. ha⁻¹ were highly effective in reducing the infestation of insect pest complex on soybean had no phytotoxic effect on the crop.

Low cost light trap

A low cost (Rs. 700), compact , handy (2.9 kg) fitted with 30 W CFL bulb (withstand voltage fluctuation) is developed that collects insects double the volume in comparison to the conventional Light Trap (SMV Light Trap model-1982) which is costly, bulky fitted high voltage bulbs.

2.6 Horticulture

High yielding varieties/lines of vegetables recommended for cultivation in Kymore Plateau and Satpura Hills of MP on the basis of three year performance.

Double hedge row system of planting technology developed for more production in mango cv. Amarpali and Allahabad safeda.

In mango, Olour root stock was found to be the best root stock for Langra. It is recommended as a grafting root stock

Significantly maximum root yield of carrot 37.70 q ha⁻¹ along with highest net return of Rs. 1.02,151 and BCR 4.10 was found with 30:40:37.5 kg NPK + vermicompost @2 t ha⁻¹ + Biofertilizer.

Crop	Variety/line	Yield (q/ha)
Brinjal	1 BWL 2001-1	185.77
	PB 70	215.64
	PB 67	249.20
	KS 331	229.89
	Pb. Sadabahar	160.23
	Pb. Nagina	220.20
Dolichos bean	Mahabeej 720	252.53
	Jdl 79-1	349.92
	VRBD 1	305.25
Cowpea	BADB 4	363.63
	Arka Garima	47.00
	IV RCP 4	93.00
Garlic	G 189	159.98
	DARL 52	150.42
Onion	No. 335	382.85
	RO 597	288.86
Hybrid tomato	INDAM 531	409.46
	COTH 2	273.02
	ARTH 1023	443.63
Hybrid cabbage	KCH 54	37.93
	Kranti	388.90
Hybrid cauliflower	Hansa	447.42
	Telris 3	51.68
Tomato (BWR)	BT 317	346.44

Nutrient management in horticulture

Result on AICRP on Potato Improvement at Chhindwara revealed that Potato variety Kufuri Surya and K. Pukhraj recorded highest potato tuber yield as compared to early and late dates of planting. Application of crop residue incorporation + Biofertilizers (Azatobactor + Phosphobacteria + culture) decomposed residue along with the FYM @20 ton ha⁻¹ was

found to be suitable for production of organic farming in potato.

2.7 Medicinal and Aromatic Plants

Nutrient management

In Lemongrass genotype OC 19 application of Urea @ 2 g plant⁻¹ was found to enhance plant height, plant spread, number of tillers, leaf area and herb yield (357.1 g plant⁻¹) over control (62.86 g plant⁻¹). On the other hand application of urea @ 1.50 g plant⁻¹ was found to be associated with maximum oil yield (1.07 per cent).

Germplasm evaluation

Among 26 germplasm lines of Ashwagandha evaluated MWS 202 and MWS 222 were found to be superior over check JA 20 for dry root (676.33 kg ha⁻¹, 644 kg ha⁻¹ and 400 kg ha⁻¹) as well as seed yields.

Standards preparation

Aloin from Aloe vera, Beta-asarone from Acorus calamus, Andrographolides from Andrographis paniculata has been prepared.

Value addition

The shelf life of Aloe vera gel and juice is standardized. Khus oil, Amrit Dhara (base mint material), Herbal Balm (base eucalyptus, rosa, turmeric and tulsi), Herbal oil (base material bringraj, brahmi and nagarmotha) and Menthol oil popularized as Brand material.

Herbal garden

The herbal garden of JNKVV is one of the unique ex-situ herbal garden in the country enlisted in national network having a collection of more than 1100 species belonging to 450 genera and 110 families. More than 60 species

of medicinal plants under IUCN categories viz. rare, endangered and vulnerable are conserved in herbal garden. In two hectare of land an arboretum of 60 tree species belong to 25 families have been developed according to Bentham and Hooker system of plant classification.

2.8 Agro-forestry

Agri-horticulture

Growing of Paddy+Guava, i.e. Agroforestry system produce higher monetary return (Rs. 9983 ha⁻¹) as compared to growing of arable crop, i.e. paddy alone (Rs. 5314 ha⁻¹) and fruit crop, i.e. Guava alone (Rs. 6904 ha⁻¹) under rainfed condition.

Kharif crops and guava under different pruning intensities

Heavy pruning (60 cms all sides) in Guava with crops (i.e. Agro forestry system) produced higher monetary return (Rs.14081 ha⁻¹) as compared to moderate pruning (Rs.13705 ha⁻¹), light pruning (Rs.13044 ha⁻¹), no pruning (Rs.10,883 ha⁻¹) as compared to crop alone (Rs.5871 ha⁻¹) and fruit crop alone (Rs.9686 ha⁻¹).

Pruning intensities and fertility levels under agri silvi-cultural system

Pruning intensities

Significantly higher grain yield of wheat was recorded in open condition (2123 kg ha⁻¹) where as no pruning recorded the lowest yield (1409 kg ha⁻¹) and the reduction in grain yield was 34 per cent (due to shade). Among different pruning intensities, 75 per cent pruning recorded maximum yield (2044 kg ha⁻¹) closely followed by 50 per cent pruning (1795 kg ha⁻¹). 25 per cent pruning recorded the lowest yield (1641 kg

Guava based agro-horticulture system

Open condition recorded significantly highest grain yield (647 kg ha⁻¹) of moong as compared to different pruning management and on pruning. Among different pruning intensities, heavy pruning intensity (60 cm) recorded significantly higher grain yield (574 kg ha⁻¹).

Managed agro-forestry system is more profitable (Rs.30416 ha⁻¹) than growing of crop alone (Rs.15009 ha⁻¹) and un managed agro-forestry system i.e. no pruning (Rs. 24475 ha⁻¹). Under managed Agro-forestry system, i.e. growing of crop with different pruning intensities wheat + Sissoo in 25% pruning is more profitable (Rs.32460 ha⁻¹) as compared to 50% pruning (Rs.30485 ha⁻¹) and 75% pruning (Rs.28305 ha⁻¹).



Wheat + Sissoo



Bamboo+Moong

The per cent reduction in grain yield under no pruning, 25 per cent, 50 per cent and 75 per cent pruning as compared to open was 34 per cent, 23 per cent, 15 per cent and 4 per cent respectively.

Fertility levels

Cent per cent fertility levels (i.e. recommended dose of NPK) gave significantly higher grain yield (1920 kg ha⁻¹) closely followed by 75 per cent fertility levels (1808 kg ha⁻¹). Fifty per cent fertility levels recorded significantly lowest grain yield (1680 kg ha⁻¹).

The per cent reduction in grain yield under 75 per cent and 50 per cent fertility levels over 100 per cent was 6 and 13 per cent respectively.



Guava + Moong

Bamboo+Moong+Stylo

Evaluation of bamboo species in agri-silviculture / silvopastoral system of agro-forestry under wasteland conditions of M.P.

(a) Bamboo based agri-silviculture system

Moong when grown with bamboo recorded significantly higher net profit (Rs 10612 ha⁻¹) followed by Til (Rs. 4976 ha⁻¹). Soybean + Bamboo (Rs. 2825 ha⁻¹) and Paddy+ Bamboo (Rs. 2761 ha⁻¹) gave significantly lowest monetary return.

(b) Bamboo based silvopastoral system

Napier grass produced significantly higher green fodder yield during first cutting (3040 kg ha⁻¹) as compared to Guinea grass (1577 kg ha⁻¹) and Anjan grass (1093 kg ha⁻¹). Dicanthium recorded lowest green fodder yield (629 kg ha⁻¹) and which was at par with Anjan and Guinea grass. Growth of Dicanthium grass was suppressed by stylo during first cutting.

Intensities of pruning in D. sissoo at the age of 10th year under Agri-silvi-culture system

Managed agro forestry system is more profitable (Rs.32353 ha⁻¹) than growing of crop alone (Rs.17642 ha⁻¹) and unmanaged agro-forestry system i.e. no pruning (Rs.28439 ha⁻¹). Under managed agro-forestry system, i.e. growing of crop with different pruning intensities wheat + Sissoo in 25 per cent pruning is more profitable (Rs.34105 ha⁻¹) as compared to 50 per cent pruning (Rs.31522 ha⁻¹) and 75 per cent pruning (Rs.31436 ha⁻¹).

Block plantation of multi purpose for biomass study

At the age of 21 years (2009) eucalyptus (2 x 2 m) produced maximum above ground biomass (856.1 t ha⁻¹) whereas, in 3 x 3 m

spacing Shisham produced higher above ground biomass (203 t ha⁻¹).

2.9 Food Science and Technology

Stevia is appropriate for use in conjunction with a variety of herbal teas. Five types of herbal tea i.e. stevia mint tea, stevia ginger tea, stevia lemon grass tea, stevia tulsi and stevia masala tea were developed and standardized by conducting acceptability tests. Herbal infusion developed at 10.25-16.10% level of incorporation of stevia brought to maximum improvement in overall quality of infusions, bright, sparkling and clear conduction of brown colour with pleasant aroma and taste. All protective essential nutrients were present in these teas. The consumption of these tea beverages could be considered best to maintain good health.

The investigations were carried out to optimize the aonla honey spread made from juice and raw papaya hot water extract (50%) for crude protein in the ratio of 5:1. The better quality of honey spread could be obtained at the level of 15% and the developed product was found to contain higher amount of various nutrients. The overall acceptability, spreading quality and taste was good and could be stored for 150 days at ambient conditions.

Seven groundnut varieties and five groundnut products were analyzed for aflatoxin B1 content. It was observed that aflatoxin content was markedly affected during storage in different packaging materials. Shivpuri, Batana, KGH-23 and Gangapuri varieties of groundnut exhibited the aflatoxin content in the range of < 0.002 to 113.56 mg kg⁻¹ whereas, it was totally absent in groundnut products. Roasting was found to be the best dioxifixation method with 72% destruction of aflatoxin B1 at 160°C for 10 minute as compared to drying, microwave heating and radiation.

The osmotic dehydration of pea could be possible on 40% sucrose + 20% tri-sodium citrate under agitated conditions at 60°C with 60 minutes treatment. Pea had better quality with good colour, texture and overall acceptability without nutritional changes. The extruded products made from rice, soybean and potato in the ratio of 80:10:10 had better quality with superior in nutritional quality. The product could be well stored in aluminum foil for the period of 3 months.

Noodles and extrudates were made from water chestnut alone in combination with potato and sweet potato flours. The product developed in the ratio of 60:10:210 (water chestnut, potato and sweet potato) supplemented with 10% skimmed milk powder had better quality in terms of both sensory as well as nutritional qualities as compared to water chestnut alone. The shelf life of the products packed in aluminum foil was good for the period of three months.

Formulation, development and evaluation of baby foods, revealed that malting process was considered the best for development of product. The product developed in ratio of 2:1 (wheat : green gram) was better in term of protein and minerals. Addition of banana powder at the level of 10% further increased the quantity of calcium, iron and protein. The product could be well stored in polyethylene bags for the period of four months.

Development of nutritious sattu revealed that barley could be well supplemented upto the level of 30% with good palatability. It contained 20.40% protein, 3.97% fat, 60.95% carbohydrate, 2.05% ash and 1.18% fibers. The calcium, phosphorus and iron were 42.4, 305.2 and 7.4 mg/100 g sattu. It was further improved by the addition of 10% each, processed soy flour and skimmed milk powder. This highly paustik sattu contained 25.22% protein, 5.28% fat,

55.59% carbohydrates, 2.51% ash and 1.08% fibre. The calcium and phosphorus were 1.5 to 2.0 times higher than traditional sattu. Shelf life of the product was also good for the period of two months.

The value added products from Ber revealed that good quality of ber jam and ber preserve could be made at 0.5% acidity and 70° Brix, respectively.

The development of value added products from watermelon revealed that better quality of watermelon rind jam and tatty fruity could be made at 0.3% acidity and 3% calcium chloride treatments. The products had higher values of vitamin C, TSS, calcium, phosphorus, iron and minimum microbial load. The overall acceptability of products were also good and could be stored upto 4 months.

The sev made from sorghum besan blend revealed that the good quality of product was made with besan and sorghum in the ratio of 70:30 having highest amount of protein fat, ash and crude fibres.

The products made from different cultivar of chickpea revealed that there was a significant differences in quality characteristics. Textural analysis of different products showed that JG 218 was found to be best for sponginess, cutting strength and hardness. JG 16 could be considered the best for preparation of sev. Local variety was found to be best for preparation of dhokla and fried dhal.

2.10 Socio-economic Studies

Ailing agricultural productivity in Madhya Pradesh.

The agricultural productivity in economically fragile regions of the state are since long remained ailing although present

uncommon opportunities for becoming fertile crescent. Cropping pattern has remained almost static. Growth in food grain production is consistently growing and yield of major crops during 2000-05 are growing by 2-5% per annum. The forecasts for one decade (2005 - 2015) using ARIMA model shows that food grain production and yield also expected to grow by 1-2% annually. This poses serious questions for the food and nutritional security of poor farmers where population growth is more than 2%.

Factors responsible for ailing agricultural productivity are relatively low priorities of public expenditure in agriculture, technological (seed replacement rate between 5 to 20% depending on crops, slowed down fertilizer consumption growth, volatility in growth of irrigated area), infrastructural (un-surfaced rural roads, poor electricity supply), institutional (lengthy procedure or rule debarring marginal farmers for accessing institutional credit, poor access to extension activities), farmers not getting required benefits of the government schemes etc. These interlocking inequalities need serious overhauling for keeping the food growers in the state afloat.

Farmer's economic capacity largely depends on the public investment in road, research and extension, energy, irrigation, credit, education and health, many of which directly affect the crop productivity and therefore there is an urgent need to improve the synergy among these socio-economic, technological and institutional variables.

Economic Impact of Bt cotton

The visible economic impact of Bt cotton production technology was observed in terms of productivity and profitability which enhanced by 56 and 100% respectively. Marketing efficiency and better resource use efficiency was also observed despite of over 19% increased in cost of cultivation when compared with non-Bt Cotton.

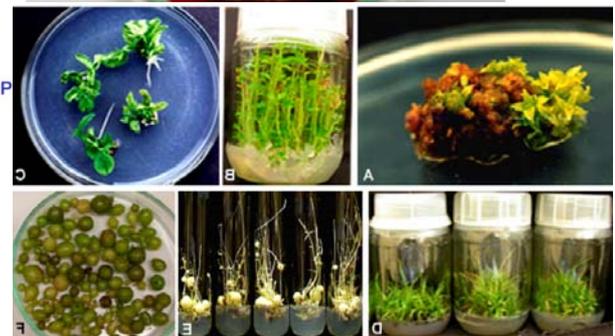
The indirect benefits such as more investment in other inputs, higher female labour participation (16%) and reduction in farmers risk (C.V. reduced by 1.50%) were also observed. Thus, GMO technology is beneficial for meeting out the growing demand for cotton fibre and for safety of environment, if pesticides are used judiciously.

3. Biotechnology

3.1 Agriculture Biotechnology

Tissue culture

- Initiated somatic embryogenesis in soybean and wheat for its further utilization in genetic transformation.
- Identification of genes responsible for male sterility and fertility restoration in wheat.
- Mass production of potato micro-tubers after disease indexing using ELISA and molecular markers.
- Established efficient protocols for mass in vitro propagation of some important medicinal and aromatic plants of Madhya Pradesh including low-cost protocols of *Sesuvium portulacastrum* and *Sesuvium portulacastrum*.
- Developed productive micro-propagation protocols for banana. Sugarcane and papaya.



Mass propagation of *Oryzylum* and *Ravulitia*; C. Regenerants of soybean from somatic embryogenesis; D. Micro propagation of sugarcane; E-F. Microtuber production of potato.

Fermentation Technology

- Mixed substrate fermentation of carbon and nitrogen rich agro by products (rice

Plate 1: Culture plate of strain *Monascus purpureus* MTCC 414

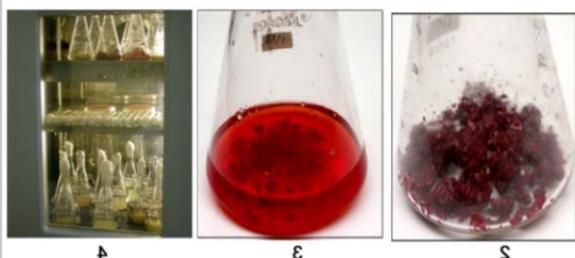
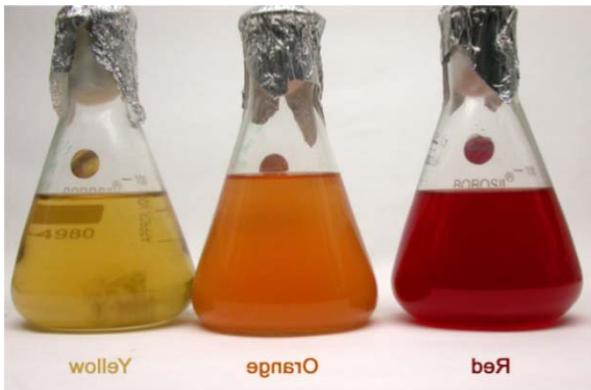
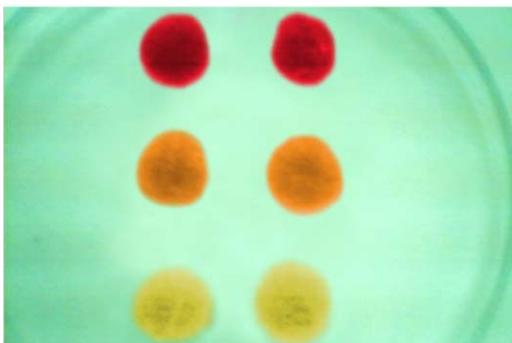


Plate 2: Fermented biomass after fermentation period of 12 days
 Plate 3: Fermented broth after fermentation period of 7 days
 Plate 4: Incubator shaker used in investigation (New Brunswick Scientific Co.)



Extracted microbial pigment obtained from *Monascus purpureus* MTCC 414



Sugar candies (Red, Orange and Yellow) made by incorporation of synthesized microbial pigments



Jellies made by incorporation of synthesized microbial pigments packed in PVC containers

Jellies made by incorporation of synthesized microbial pigments packed in glass containers

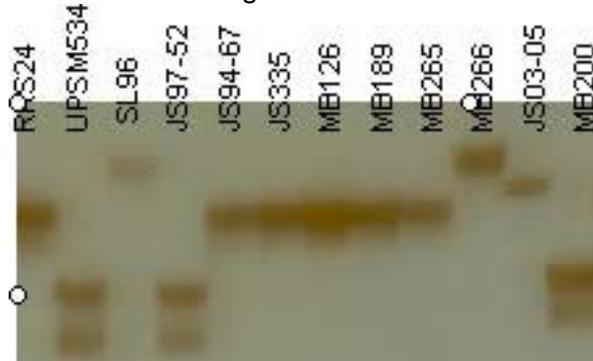
bran, wheat bran, sugarcane biogas, groundnut shells as carbon source and mustard oil cake, sunflower oil cake cottonseed oil cake, niger oil cake as nitrogen sources) using *Aspergillus niger* IARI 363 and *Aspergillus ficuum* IARI, 1461 resulted in better yield of phytase in comparison to single substrate taken individually.

- The combination of chickpea hulls with sunflower oil cake in 1:1 ratio gave the higher yield of phytase using the strain *Aspergillus niger* IARI 1461.
- Development of low cost production technology for better recovery of microbial pigments from various agro by products such as sugarcane molasses, wheat bran, rice bran, as carbon source, cottonseed oil cake, mustard oil cake, sunflower oil cake as nitrogen source using fungus *Monascus perpureus* MTCC 410 strain employing the techniques of solid state and submerged fermentation..
- The combination of rice bran and mustard oil cake in 1.5: 1 ratio resulted in the highest yield of various pigments fraction, i.e. yellow, orange and red. The incorporations of these three pigment fraction in

processed products such as sugar candies and jellies showed the better consumer acceptability with respect to various sensory attributes

Molecular Biology

- Molecular characterization of Ashwagandha (*Withania somnifera*) and Chandrasoor (*Lepidium sativum*) germplasm
- Molecular diversity analysis among soybean cultivars and mutant against root rot and yellow mosaic virus (YMV) disease
- Molecular linkage studies for flag leaf width and leaf hair traits in rice using recombinant inbred lines derived from cross JNPT 89 X IR 64 using SSR markers.



Electrophoretic banding pattern SSR amplification product of soybean varieties

samples. Histology of the biopsy samples revealed 16 per cent increase in the number of muscle fibers.

Embryo Biotechnology

The fibroblast and cumulus cell line of Jamnabai breed has been generated and cryopreserved to create the somatic cell bank for subsequent regeneration studies.

The buffalo and goat IVF embryo production has been standardized and PCR based embryo sexing by specific primers has been done using 8 cell to blastocyst stage of embryos.

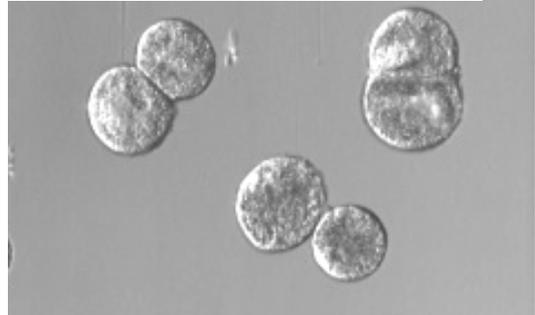
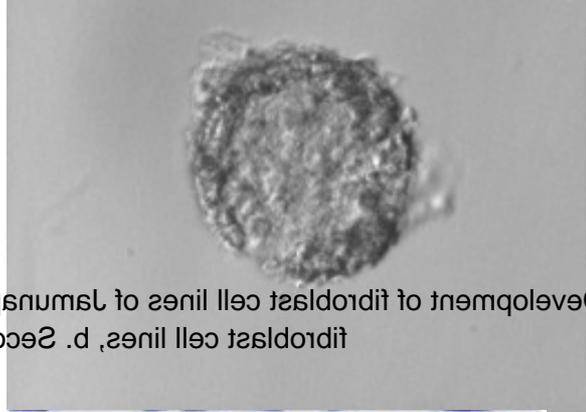
The cloned embryos by SCNT technology

Macrophomina phaseolina isolates of soybean. Characterization and diversity analysis of

3.2 Animal Biotechnology

- Four different anti myostatin shRNA constructs (sh 1, sh 2, sh 3 and sh 4) using p-silencer vector were designed and analyzed for their silencing efficiencies by real time PCR experiments. Transfection experiments using sh 1 construct in fibroblast cell line proved the sh 1 construct to be most efficient for in vitro silencing studies (up to about 90 per cent silencing). The in vivo transfection studies by electroporation using sh 1 construct at 100 µg dose at 200 V, 6 pulses for 30ms revealed 66 per cent MSTN knockdown by real time analysis of the biopsy
-
-

Development of fibroblast cell lines of Jamnabai goat using ear tissue explants. Primary fibroblast cell lines, b. Secondary fibroblast cell lines



Production of cloned embryo by Modified hand made cloning technology. a. Electrofused triplets (enucleated oocytes and cytoplasm), b. Early blastocyst

monitored by laparoscopy and empty collection and transfer was done by laparotomy. The events of oestrus cycle viz. dioestrus, pro-oestrus and oestrus could be tracked by exfoliative vaginal cytology in both the animals. Oestrus was characterized by predominance of cornified cells corroborated with overt signs of oestrus for presentation of post to the buck for ensuring mating. Successful mating was confirmed by cytological smears exhibiting evidence of sperm.

The recipients were synchronized ± 12 hours with the donors. Overall total ovulation response in PMSG administered animals (n=3) was 38 per cent with a range of 20 to 64. 28 per

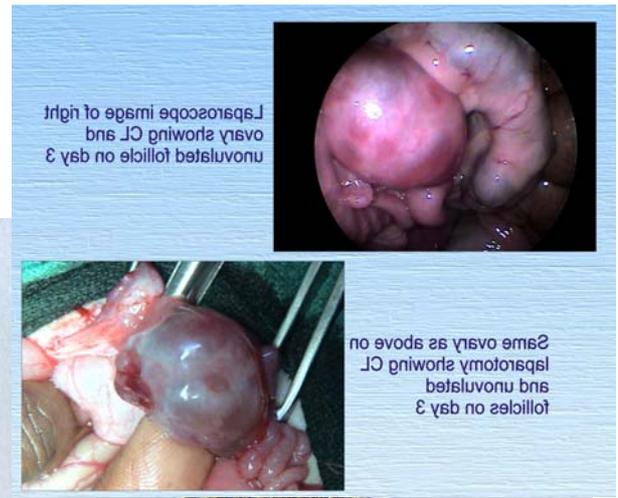


Laparoscopic and post-laparotomy images of superovulated goat ovaries

has been amplified using innovative modified hand made cloning (MHMC) and reconstructed embryos up to the stage of 16-32 cells has been produced.

Superovulation and empty collection in Jamunpari goats

Ten Jamunpari goats were superovulated either with PMSG or FSH and the protocol for superovulation and synchronization involved either one injection of PGF2 α or a double injection schedule of PGF2 α . The oestrus response and the tracking of the oestrus cycle were done by visual signs of oestrus and by exfoliative vaginal cytology. Superovulation was



cent whereas in the FSH administered group (n=5), the overall ovulation response was 69.76 per cent with a range of 64.28 to 75.00 per cent. It can thus be observed that in the animals administered PMSG, the incidence of animals with unovulated follicles was higher as compared to than those administered FSH. In the FSH treated group, in one animal, 75 per cent ovulatory response was observed, but premature luteal regression was observed when the animal was subjected to laparoscopy and laparotomy on day 6 for embryo flushing. No embryo could be obtained from this animal.

In the PMSG administered two animals, flushing on day 3 post oestrus, yielded one embryo each of 4-8 cell stage. One embryo was cultured for 24 hours which reached to 8-16 cell stage on culture indicating that it was a live embryo. Both the embryos were transferred in the oviduct of a recipient synchronized with the donors.

In the FSH treated animals, flushing on day 3 yielded 11 unfertilized ova in one animal and in another, 12 unfertilized ova were obtained. Failure of fertilization in these ova was ascertained by no cleavage on culturing these ova for 24 hrs.

Maturation and developmental potential of oocytes collected by transvaginal ultrasound guided aspiration from culled undernourished cows suffering with various forms of reproductive disorders:

The reproductive potential of culled cows with different forms of infertility can be salvaged using the OPU technique. Moderate oocyte recovery can be obtained from such animals with varying success without any treatment. However, the oocyte quality is usually poor with a low maturation and development potential. Increase in the total number of follicles available

for aspiration can be brought about by eCG treatment. Interrupting the oestrous cycle by PG treatment does not give any appreciable response with respect to the number and size of emerging follicles compared with the untreated group since most of the animals used were malnourished.

Development of primary and secondary fibroblast cell lines and cumulus cell lines of Jamunapari goats and their genetic characterization by RAPD-PCR:

Fibroblast cell lines were prepared from skin of ear tissue pieces from two female and one male Jamunapari goats. The skin fibroblast cells in early passage cultures showed different degrees of contamination with epithelial and other dermal cells. But by trypsin-EDTA treatment and careful detachment process, pure skin fibroblast cells were obtained. By fifth passage, no traces of epithelial cell contamination were found.

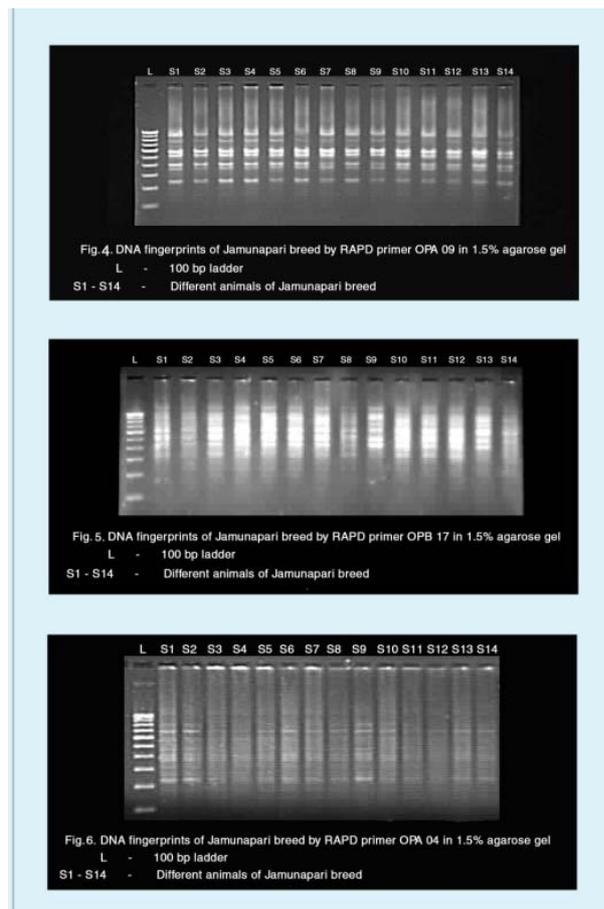
The expanded cumulus cells of the IVM goat oocytes (obtained by surgical method) were removed by repeated pipetting and placed in 60 mm size plasma coated Petri dish containing DMEM and 10% FBS, for developing primary cell line. Primary cell line with 70-80% confluency was reseeded to get secondary cell lines.

Cryopreservation of cell line: The pure skin fibroblast cells were obtained from fifth passage onward. After reseeded some of these cells in culture flasks for next passage, the remaining cells were cryopreserved successfully for future application as per the standard protocol.

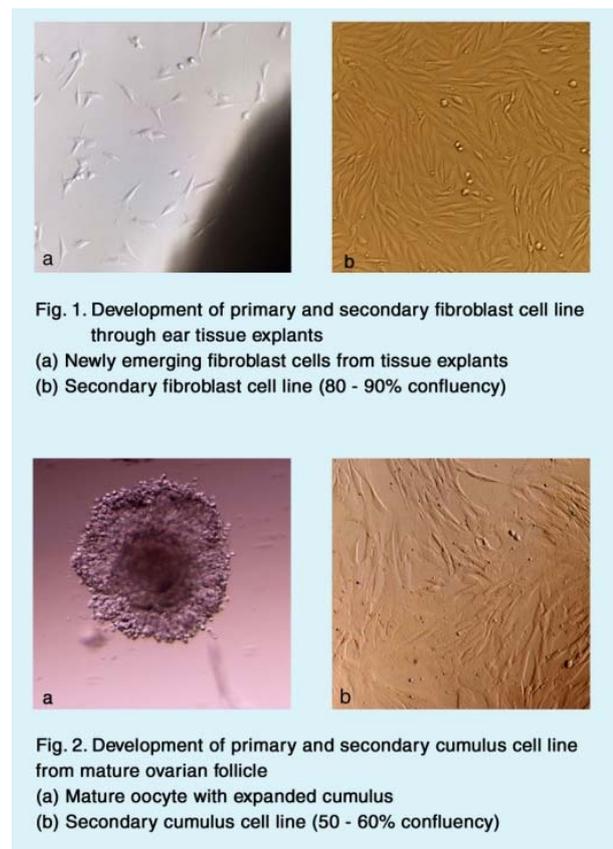
Molecular characterization by RAPD-PCR: A total of 14 animals belonging to Jamunapari breed of goat were evaluated by RAPD-PCR technique to explore the polymorphism at DNA

level. A total of 8 primers were employed using representative samples of breed. Among these 8 primers, 7 primers detected polymorphic banding profile and 1 primer showed monomorphic pattern. RAPD-PCR products were checked by 1.5% submarine agarose electrophoresis at power supply of 100 volt for

5 min followed by 50 volt for 3-4 hrs. Fragment data were entered in a computer file as a binary matrix, and analyzed using NTSYS-PC software. Based on analysis of data it was observed that all the animals within Jamunapari breed showed band sharing value ranging from 0.74 to 0.93.



Amplification products generated by different RAPD primers



Development of primary and secondary fibroblast and cumulus cell line

4.0 VETERINARY SCIENCE AND ANIMAL HUSBANDRY

4.1 Improvement of Poultry

AICRP on Poultry Breeding is working for development of suitable coloured bird for rural poultry production. By crossing of two pure lines of Kadaknath males with Jabalpur colour female, F1 population was produced, then by back crossing of F1 male with Jabalpur coloured female commercial coloured birds having 75% Jabalpur colour and 25% Kadaknath was generated and evaluated under farm and field condition with respect to its growth and production performance.

The growth performance of birds recorded were 564, 1690 and 1930 grams respectively at 6, 20 and 40 weeks of age. Birds matured at 160 days of age and produced 65.3 eggs with an average egg weight of 50.2 g up to 40 weeks of age. The cumulative feed consumption under intensive system was measured as 1817 g bird⁻¹, with average feed consumption of 87 g bird⁻¹ day⁻¹ at 16 week age and at adult stage, 119 g

bird⁻¹ day⁻¹. This dual type bird produces 1 kg egg mass by consuming 3.7 kg feed and 1 dozen eggs by consuming 2.3 kg feed under farm condition.

Under field condition commercial dual type coloured bird attained an average 520 g body weight in free range condition, 760 g in semi intensive system and 940 g in intensive system at farmers door at 8 weeks age.

The bird produces on an average 132 eggs and 146 eggs annually under free range and semi intensive management system, respectively. These birds are popular among farmers and tribals and as per feed-back, birds are less prone to predation due to their medium size weight, strong leg with long shanks, with more running and flight characteristics. The bird is good both for table and egg purpose and will adapt to village climatic conditions and is suitable for back yard poultry in rural areas.

Table: Comparative performance of Jabalpur colour, Kadaknath and commercial coloured birds

Particulars	Jabalpur	Kadaknath	Commercial Colour
Intensive system			
Fertility %	96.15	96.5	94.58
Hatchability%	84.09	75.55	72.70
6 weeks body wt. (g) - Male	956.3	258.39	687.10
- Female	824.2	214.06	564.60
20 weeks body wt. (g)	1872	977	1691.1
40 weeks body wt. (g)	2130	1421	1930.7
Age at sexual maturity (days)	154	174	162
Egg production (No.)	84.8	40.9	65.3
40 weeks egg wt. (g)	60.1	47.6	50.2

Particulars	Commercial colour
Semi-intensive system	
8 weeks body wt. (g)	760
Annual egg production (No.)	146
Intensive system	
8 weeks body wt. (g)	520
Annual egg production (No.)	132

4.2 Improvement of Pigs

Under the All India Coordinated Project on pigs, during the period under report, 20 females and 6 males each of Large White Yorkshire and Desi pigs were selected to produce 50% and 75% crossbred (inter se) pigs of 16th and 17th generation. All the selected females conceived. The average litter size at birth and weaning for 50% crossbred were 7.125 and 4.916, respectively. The average litter weight at birth and weaning for 50% and 75% crossbreds were 8.464, 6.785, 65.709 and 50.217, respectively. The average gestation period of 50% crossbreds inter se and 75% crossbred inter se were observed as 113.357 and 113.375 days, respectively. The overall mortality percentage as recorded as 21.10% and 16.83% for 50% and 75% crossbred inter se, respectively.

4.3 Animal Nutrition

Under the AICRP on Improvement of Feed Resources and Nutrient utilization for raising Animal Production, experiments were conducted to study the effect of strategic supplementation on productive performance of buffaloes. Dairy farms near Jabalpur were surveyed for their feeding practices and it was observed that buffaloes were fed in excess to their nutrient requirement (maintenance & production) when compared with ICAR standards. These buffaloes were also not supplemented with mineral mixture. Thus,

strategies were devised to reduce the excess and supply the deficit nutrients in the diet of the animals.

Mineral mixture was formulated as per the requirement of the animal and supplemented to the animals. These strategies improved the production of the animals as well as reduced the feed cost per kg milk production.

Experiments thus concluded that in commercial dairy farms, dairy, adjoining Jabalpur city, owners were following a traditional method of feeding. They were very liberal in feeding the concentrate mixture with the expectation that more feeding will lead to more milk production. This type of feeding increased the cost of feed per kg milk produced and thus was uneconomical.

Strategic dietary supplementation (supply of nutrients as per requirement of animals) was helpful in maintaining the productive efficiency of the buffaloes and was economical.

4.4 Animal Breeding and Genetics

Microsatellite polymorphism in Nimari, Malvi, Gaolao and Kenkatha Breeds of cattle: Four indigenous cattle breeds viz. Malvi, Nimari, Gaolao and Kenkatha were characterized using 25 microsatellite markers. The observed number of alleles ranged from 5 to 24 with a total of 304 alleles among all the breeds. The overall observed value of heterozygosity and PIC were 0.517 and 0.659 among all the breeds. Malvi-Nimari and Gaolao-Kenkatha were closer to each other where as Malvi-Kenkatha were distant to each other. Growth hormone gene loci revealed maximum genetic similarity between Malvi-Nimari and maximum genetic distance between Gaolao-Nimari breeds of cattle. Sequencing of growth hormone gene fragments at GH1, GH2 and GH3 loci in Malvi

cattle showed maximum mutation in GH1 as compared to GH2 and GH3 loci. Defensin, Leptin, N-ramp-I and BOLA gene polymorphism revealed total of 9, 3, 9 and 31 genotypes/patterns, respectively in all four breeds of cattle. The sequencing of N-ramp-I gene in Gaolao-Malvi cattle revealed total 9 mutations at various nucleotide sites.

4.5 Parasitology

Under the All India Network Programme on Gastrointestinal Parasitism, 8231 faecal samples were screened for the presence of GI parasites that comprised of 2726 of cattle (1823 adult, 903 calf), 1983 of buffaloes (1287 adult, 696 calves), 2730 of goats (1743 adult, 987 kids) and 792 of adult sheep from the villages/ farms of three Agro-climatic Zones IV- Vindhya Plateau and Satpura Hills, IX- Satpura plateau and X- Malva Plateau etc. The surveillance showed that the strongyles were the most predominant species of GI nematodes in all categories of domestic animals in Agroclimatic Zones IV, IX and X etc. Its rate of prevalence was highest in sheep (90%), followed by goat (83%), Cattle (74%) and buffalo (68%). Like strongyles, the prevalence of coccidian was also recorded throughout the year in all categories of animals. It was higher in sheep (96%) followed by goat (88%), Cattle (83%), and buffalo (74%). Among GI nematodes, parasitic infection in domestic animals viz. strongyles, *Strongyloides* spp., *Toxocara vitulorum* & *Trichuris* spp.; among flukes, Amphistome, Schistosome spp. and *Fasciola gigantica*; among cestodes, *Moniezia* spp. and among protozoa, *Eimeria* spp. was prevalent. The EPG/OPG of strongyles and coccidian in cattle, buffalo, goat and sheep was identically exhibited to be highest in the rainy season from July to October and when the humidity is at high level. Infective larval stage (L3) *Haemonchus* was the most predominant in all the domestic animals

under study. It was most prevalent in sheep (63%) followed by goat (61%), cattle (51%) and buffalo (43%). The rate of prevalence for *Oesophagostomum* was high in Buffalo (20%) followed by Cattle (15%), Goat and Sheep (12%). *Bunostomum* was the highest in Buffalo (16%) followed by Cattle (12%), Sheep (9%) and Goat (6%) etc. *Nematodirus* was reported in similar trend i.e. 7-8 % in all screened animals whilst *Cooperia* was reported with minor differences. In Agro-climatic zone X- Malva plateau, for the first time *Mescistocirrus* was reported in lower prevalence rate i.e. almost 4-5% in all category of domestic animals.

4.6 Pharmacology

Identification and validation of indigenous medicinal plants for anthelmintic efficacy in livestock in tribal areas of Madhya Pradesh was done. The study revealed that *B. frondosa* produced maximum effect against *Trichuris* whereas *S. chirata* was most effective against Amphistomes and *A. indica* was maximally effective against *Coccidia* spp. of parasites. The study further indicated that *B. frondosa* (Palash) and *A. indica* (Neem), when used in Half Dose Combination, exhibited most potent anthelmintic activity against all spp. of internal parasites. The combination of *B. frondosa* (Palash) and *A. indica* (Neem) showed 100 percent anthelmintic effect against *Trichuris*, however, the efficacy ranged between 86 to 91 per cent against *Trichostrongyles*, *Coccidia*, *Strongyles*, *Amphistomes*, and *Fasciola* spp. of parasites.

Surveillance studies and documentation of ITK practices in tribal areas of Hoshangabad District of M.P. were done. Indigenous medicinal plants were documented on the basis of their availability and traditional practices used by villagers/tribals in target areas of Hoshangabad. The study revealed local plants; viz. Shehdevi (Leaves) and Gulkandh (Flowers) are used for

treating kidney stones. Leaves of Parijaat are effective in arthritis and sciatica. Leaves of bamboo tree are extensively used for retention of placenta. Leaves of Gudmar are commonly used in jaundice.

4.7 Pathology

Endosulfan toxicity and antioxidant activity of α -tocopherol (at the dose rate of 50 and 100 ppm) was investigated in Kadaknath chickens. All the birds of endosulfan alone fed groups showed listlessness, huddling, ruffled feathers and laboured breathing on a long term exposure of 60 days with reduction in body weight of birds but those receiving endosulfan along with α -tocopherol (300 mg kg⁻¹ feed) showed clinical signs of reduced severity. Hematological alterations included significant decrease in TEC, hemoglobin concentration and PCV and biochemical alterations included significant increase in ALT, AST, GGT and glucose but a significant decrease in total protein. There was marked ameliorative effect on biochemical parameters in birds supplemented with α -tocopherol. Pathomorphological changes in kidney, included congestion and hemorrhages. Histopathology, focal areas of necrosis, diffused hemorrhages and sinusoidal dilatation were observed in liver. In kidney, extensive hemorrhages, coagulative necrosis and tubular degeneration were observed, whereas, in spleen, follicular hyperplasia and abnormal thickening of vessels were seen. Heart showed myofibril degeneration and myocardial congestion. α -tocopherol in the diet could reduce these changes to an appreciable extent when fed along with endosulfan. Elevation in total protein and notable reduction in ALT, AST, GGT and glucose as compared to control group birds.

Lead induced toxicity and ameliorative effect of selenium was studied in Kadaknath chicken. The birds fed with lead acetate at the

dose rate of 1000 ppm exhibited clinical signs of dullness, depression, ruffled feathers, paleness, listlessness, reduced feed intake and reduction in body weight increasing significantly with supplementation of selenium. Haematological alterations in lead acetate toxicity included decrease ($P < 0.05$) in total erythrocyte count, hemoglobin concentration and packed cell volume. Biochemical alterations in lead acetate fed birds significantly increased ALT, AST, ALP, GGT, total bilirubin, glucose, urea, blood urea nitrogen and creatinine and reduction in total plasma protein, serum protein and albumin levels. There was marked ameliorative effect by selenium feeding on biochemical parameters. Oxidative stress induced lead toxicity showed a significant ($P < 0.05$) rise in lipid peroxidation level. Significant increase ($P < 0.05$) in the value of GSH was seen in the selenium treated groups as compared with the value recorded in the toxic groups. Pathomorphological changes were observed in liver, kidneys, lungs and heart. Histopathology revealed areas of congestion, vacuolation and degenerative changes in the hepatocytes, marked dilatation of sinusoids and Kupffer cell prominence in liver, swollen endothelial cells of glomerular tuft and varying degree of degeneration in the tubular epithelium were observed in the toxic group. Shrunken tuft of glomeruli, increased Bowman's space and desquamated epithelial cells were noticed in the toxic groups.

Mercuric chloride toxicity and antioxidant activity of α -tocopherol was studied in Kadaknath chicken. All the birds of mercuric chloride alone fed groups showed listlessness, huddling and ruffled feathers and reduction in body weight on a long term exposure of 42 days. However, birds received mercuric chloride diet along with α -tocopherol showed improvement in body weight. Haematological alterations included significant decrease in TEC,

hemoglobin concentration and PCV. Biochemical alterations included significant increase in ALT, AST, ALP, GGT glucose, bilirubin, urea, blood urea nitrogen, creatinine, lipid peroxidation with low protein and glutathione. There was a marked ameliorative effect of α tocopherol on haematological and biochemical parameters. Pathomorphological results were more pronounced in long term exposure in liver, kidney, lungs and heart. Histopathology revealed focal areas of degenerative changes, Kupffer cells prominence and sinusoidal dilatation in liver, tubular degeneration in kidney, areas of hemorrhages in lungs, myofibril degeneration and myocardial congestion in heart were observed. α tocopherol in the diet could reduce these changes to an appreciable extent when fed along with mercuric chloride.

Arsenic induced immuno-toxicity and ameliorative effect of gallic acid was studied in albino rats. There was a dose dependant reduction in the body weight in arsenic 100 and 200 ppm and increase in the body weight in gallic acid control and arsenic plus gallic acid groups. Haematologically, a reduction in TEC, Hb, PCV, MCV and TLC in arsenic 100 and 200ppm groups and partial improvement towards normal in arsenic plus gallic acid treated rats. Dose dependant increase in AST, ALT, ALP, blood urea, creatinine and decrease in total serum protein and serum albumin was also observed. Oxidative stress in sodium arsenite induced toxicity reduced glutathione (GSH) in erythrocytes and a significant ($P < 0.05$) dose dependant increase in lipid peroxidation (LPO) and decrease in GSH. Dose dependant gross pathological changes like hepatomegaly, pallor of liver and kidneys, haemorrhagic patches in kidneys and lungs, splenomegaly and slight enlargement of testes were observed. There was a reduction in the haemagglutination titre, A:G ratio and gamma globulin in arsenic toxicity.

Nitrosamine induced hepatic carcinoma and chemopreventive actions of ferulic acid was studied in albino rats over a period of 24 weeks. Free ferulic acid at the dose rates of 20 mg kg⁻¹ BW and 40 mg/kg BW had insignificant chemo preventive efficacy in diethyl nitrosamine induced hepatic carcinoma. The elevations of serum enzymes levels can be used as a valuable diagnostic indicator whereas; the high mitotic and AGNOR indices can be used as the prognostic marker for the hepatic carcinoma. Since the serum alpha fetoprotein values were observed only in the cancer induced groups it can be used as a screening tool for diagnosis of hepatic carcinoma.

Diclofenac is a common non-steroidal anti-inflammatory drug used in the medical practice. Clinico-pathological effect of Diclofenac sodium toxicity was studied in domestic fowl. The study showed that Diclofenac is nephrotoxic as well as hepatotoxic in young as well as adult fowl at the dose rate of 0.25 mg/kg and 0.5 mg/kg. Degenerative changes were observed in the hepatocytes with dilatation of sinusoids, hyperemia, hemorrhages and degenerative changes in the endothelium.

Systemic inflammatory response and hepato-renal dysfunction was observed in canine pyometra. Haematological examination revealed a decrease in the total erythrocyte count, hemoglobin, and packed cell volume. Leukocytes with neutrophilia was a consistent feature. The number of Band cell per microscopic field was also more in animals with pyometra. Biochemically, there was significant elevation of serum ALT, AST, ALP, BIT, BUN and CRE, and a decrease in protein and albumen concentration in serum of all dogs with pyometra. Urinalysis showed a decrease in specific gravity, proteinuria, and elevated GGT.

Criteria used to evaluate SIRS in pyometra were concentration of inflammatory marker

TNF α , CRP; haematological parameters TLC and band cells number, and clinical parameters heart rate, respiratory rate and temperature. Of these combinations of TNF α , CRP, band cells and TLC was strongly related to SIRs as compared to all other parameters alone or grouped. The present study identified markers of SIRS and determined multiple organ dysfunctions with hepato-renal involvement in canine pyometra. Uteri of clinically affected animals showed typical lesions of pyometra viz. severe inflammatory reaction in the endometrium and myometrium as observed by earlier workers. Uterine lesions with increased endo-myometrium ratio and moderate fibroblast proliferation were classified as hyperplastic pyometra whereas those with decreased endo-myometrium ratio and no fibroblast proliferation were classified as atrophic pyometra. Cystic endometrial hyperplasia (CEH) and pyometra could be clearly differentiated histologically by presence of inflammatory reaction in pyometra and its absence in CEH. Severity of clinical symptoms was not related to the severity of uterine pathologies and it was observed that CEH may produce clinical signs indicative of pyometra. The microscopic section of liver and kidney tissue from affected animals showed degenerative changes further confirming multiple organ dysfunctions in pyometra.

4.8 Wildlife Health and Management

Occurrence of *Gnathostoma spinigerum* infection in a tigress (*Panthera tigris*) of Pench Tiger Reserve

Post mortem examination of 15-16 years old female tiger at the Pench Tiger Reserve, Seoni, Madhya Pradesh, revealed nodules/out growth in the sub mucosal layer of the stomach with embedded worms identified as *Gnathostoma spinigerum*, a spiruroid stomach nodular worm. The parasite has zoonotic

importance and is prevalent in South East Asian countries including India.

4.9 Surgery and Radiology

Comparison of conventional versus laparoscopic ovario-hysterectomy in bitches: The study was undertaken on 12 bitches, 6-12 years of age and weighing 15-20 kg. These bitches were randomly divided in two groups, each group consisting of six bitches. In the bitches of group I conventional ovario-hysterectomy was done by midline laparotomy, whereas in bitches of group II laparoscopic ovario-hysterectomy was done. The animals of both the groups were anesthetized by using atropine sulphate + xyline and ketamine. The duration of surgical anesthesia was significantly more (115.00 ± 15.32 min) in group II as compared to group I (65.00 ± 13.78 min), whereas complete recovery from anesthesia was in 117.5 ± 14.00 & 132.50 ± 15.69 min in group I & II respectively. The time required to complete hysterectomy was significantly more (84.16 ± 14.28 min) in group II as compared to group I bitches (45.00 ± 6.19 min). In group I bitches, healing completed in 8-10 days, whereas in group II, in 3-4 days. Group I bitches also exhibited more pain, more tissue trauma and restriction of diet and movement post conventional ovario-hysterectomy as compared to laparoscopic ovario-hysterectomy. Rectal temperature, respiration and heart rate showed significant decrease up to 6 hrs in both the groups, thereafter, the values increased gradually and from 24 to 96 hours the values fluctuated within the normal range in both the groups.

Ultrasonographic evaluation of various urogenital abdominal disorders in canine- Pre- and post therapeutic studies: Twenty-five clinical cases suffering from different abdominal disorders and referred for ultrasonography were

evaluated. In all the animals, haemato-biochemical examination and ultrasonography was performed on day 0, 5, 10 and 15 post-treatment. Maximum incidence (13.6%) of uterine diseases was recorded followed by peritoneal cavity diseases (11.6%), which included ascites and tumorous growths. The incidence of liver, gastrointestinal tract and urinary bladder diseases was 10.7, 9.71 and 7.77 per cent, respectively. The incidence of kidney, ovary, spleen and prostate gland diseases was very low. However, during the course of the study, pancreatic diseases, lymph node enlargement and diseases of adrenal glands were not observed. It was concluded that most of the abdominal disorders could be diagnosed ultrasonographically. Further, post-treatment, haemato-biochemical examination and ultrasonography is useful to evaluate the improvement or deterioration in the condition in response to treatment undertaken.

Diagnostic and therapeutic studies on ear affection in dogs: Video-otoscopic studies: The study was undertaken on 18 dogs irrespective of their age, breed and sex, presented to the hospital for the treatment of otitis. These dogs were randomly divided in two three groups, each group consisting of six dogs. The dogs of group I were treated with cleaning of ear canal with clean cotton swab + normal saline + paining of ear canal with Providone iodine + Waxolve + Candibiotic ear drops + inj. Cefotaxim + inj. Nimusulide. Group II : treatment as in group I except Candibiotic ear drops + low level laser therapy and group III treatment as in group I + low level laser. On video otoscopic examination, mild to extensive deposition of cerumen was noticed in all the dogs of three groups on day 0. Reduction in quality of cerumen was recorded from day 5 onwards, which became practically nil on day 15 in all the dogs of groups III. In all the dogs of three groups, inflammation of the external ear canal ranged from mild to extensive

on day 0. From day 5 onwards, no inflammation of the ear canal was noticed in all the dogs of group III, whereas mild to severe inflammation was seen in groups I & II. No ulceration of external ear canal was noticed in any of the dog of group I, whereas ulceration was recorded in one dog of group II and three dogs of group III on day 0. On day 5, no ulceration was recorded in all the three dogs of group III, whereas, in group II, it persisted up to this interval, but it got cured up to day 10.

Therapeutic management of epiphora in dogs: The incidence of various eye affections of all the cases presented to the college hospital was observed to be 3.16 per cent of which, incidence of epiphora was 28.1 per cent. The highest incidence of epiphora was observed in age group of 7-9 years (37.03 %). Pomeranian breed was found to be most susceptible breed followed by Samoyed and non-descript. For the treatment, dogs were divided in two groups. Dogs of Group I were treated with various ophthalmic preparations i.e. eye wash with boric acid 1.5 % solution, Tobramycin-D eye drop, while the dogs in group II were subjected to probing on nasolacrimal duct system followed by flushing. The discharge was noticed to be severe in the initial period of observation, which declined gradually in the later phase of the study. Medicinal therapy used in cases with secondary affection of eye leading epiphora, resulted in favorable outcomes in all the dogs. In cases of true epiphora, nasolacrimal probing was found easy, swift and safe procedure, practically without any complication. However, probing along with flushing was found to be superior than the probing alone as it adds complication blend by confirming the patency immediately and further dilating the duct to reduce the chance of occurrence. Conjectivoralostomy could be considered in cases of reoccurrence with successful results.

Use of physiotherapy for the treatment of paraplegia in dogs: The study was conducted on 18 dogs of either sex, age, and irrespective of breed which were showing signs of spastic gait, paresis, paraplegia, and quadriplegia. The incidence of spinal disease was 0.6 per cent. All the animals were randomly divided into three groups comprising of 6 animals each. Complete physical, clinical and haematological examination of all animals was carried out. Neurological grading of each animal was done after examination of posture, gait, pain perception and urinary bladder control before the starting of treatment. Evaluation of spinal reflexes, and deep pain perception was performed on day 0 and subsequently on day 7th, 14th, 21st, and 30th to know the recovery status of the animal during treatment period. Plain radiograph of thoracolumbar region of each animal was taken in ventro-dorsal and lateral position. Myelographic examination was performed only in those cases where lesion was not visualized in plain radiograph. On the basis of results it was concluded that short wave diathermy was useful in cases of peripheral neuromuscular injuries, having duration of paraplegia of 1-2 days, sluggish hind limb reflexes and if the animal was in grade 3. Therapeutic ultrasound was found to be effective for the treatment of the cases of intervertebral disc protrusion, and spondylitis with very weak and abolished spinal reflexes and in grade 4. Nerve muscle stimulation was found effective in those animals where the spinal reflexes are completely abolished, hind limbs are completely paralyzed and if the animal was in grade 4 or 5, such as spinal stenosis, subluxation and atrophy of muscles due to denervation.

4.10 Animal Reproduction, Gynaecology and Obstetrics

Studies on ovarian functions and fertility

response using insulin in anestrus buffaloes was conducted on 24 anestrus cow buffaloes, randomly divided into four equal (n=6) groups. Animals of group I (insulin) were treated with long acting bovine insulin (Vinsulin TM) subcutaneously @ 0.25 IU per kg body weight, once daily for five consecutive days. Animals of group II (GnRH) were treated with Buserelin acetate (Receptal TM) @ 5 ml as a single intramuscular injection. Animals of group III (Insulin + GnRH) were treated with insulin similar to group I for 3 consecutive days, followed by a single injection of Receptal at @ 5 ml intramuscularly after 24 hrs. Group-IV animals serving as control were not administered any drug and only normal saline was injected as a placebo.

Exogenous administration of insulin alone and pre treatment with GnRH enhanced ovarian functions and fertility response in anestrus buffaloes. Thus, insulin therapy may be taken as an alternative approach to modulate reproductive efficiency in anestrus buffaloes. Effect of gonadotropic releasing hormone and insulin on fertility response in repeat breeding cows was evaluated on twenty four repeat breeder cross bred cows randomly divided into four groups, each comprising 6 animals. Animals of group I (insulin) were treated with long acting bovine Insulin (Vinsulin) @ 0.25 IU kg⁻¹ b.wt., S/C, OD for 3 consecutive days starting from 2nd dose of AI. Animals of group II (GnRH) were treated with GnRH (ReceptalTM) @10µg (2.5ml) as a single intramuscular injection, just after second dose of AI. Animals of group III (Insulin + GnRH) were treated with Vinsulin @ 0.25 IU/kg b.wt., S/C, OD for 3 consecutive days similar to Group I plus Receptal @10 µg (2.5ml) as a single intramuscular injection, just after second dose of AI. Group-IV animals were untreated controls.

Higher overall conception was found in animals treated with insulin (50 % each in Group-I and Group-III) as compared to GnRH alone and control groups (16.67% each in G-II and IV). Study revealed that post-insemination, administration of insulin improves fertility in repeat breeder crossbred cows. Thus, insulin therapy may be taken as an alternative approach to modulate reproductive efficiency in repeat breeder cows. The present study also suggests that progesterone estimation at estrus may be used as a marker for prediction of future fertility in repeat breeder cows.

Studies on synchronization of estrus using controlled internal drug release alone and in combination with pregnant mare serum gonadotropin in anoestrus buffalo was conducted on 42 post partum true anoestrus buffaloes to study the efficacy of CIDR alone and in combination with Oestradiol valerate and PMSG for synchronization of estrus and fertility response. Animals were randomly divided in six groups (n=7 in each group). After confirmation of true anoestrus, 20 ml of liquid terramycin was administered intrauterine in all the animals (to rule out subclinical infection of the genital tract if any) except in animals of G1 & G3. The CIDR was implanted intra vaginally for 9 days to the animals of G3 to G6. The animals of G1 served as control for the animals of G2; whereas, animals of G2 served as control for the animals of G3 to G6. The treatment protocol for different groups was (a) CIDR alone (G3), (b) CIDR + 20 ml liquid terramycin (G4), (c) CIDR + 20 ml liquid terramycin + an intramuscular injection of 1 mg estradiol valerate on the day of CIDR implantation and on the day of its withdrawal (G5) and (d) CIDR+ 20 ml liquid terramycin followed by an intramuscular injection of 500 I.U PMSG on the day of CIDR withdrawal (G6). Study revealed that CIDR alone can be used for successful induction of estrus in anoestrus

buffaloes. Also, better fertility response in anoestrus buffaloes can be achieved by CIDR, liq. terramycin and PMSG in combination as compared to CIDR and liq. terramycin with or without estrogen.

Studies on pregnancy diagnosis and fetal development was conducted on 12 pregnant German shepherd bitches in various stages of gestation by ultra sonography. It was observed that pregnancy can be diagnosed as early as 20 days and embryo with cardiac activity can be visualized from day 23 post mating. The gestational sac diameter (GsD) is more accurate predication of gestational age and time of whelping between day 25-35 post-mating than crown-rump length (CRL). The little size prediction by sonography was better between 30-35 days of pregnancy. Sonography is not accurate as far as predication of litter size is concerned.

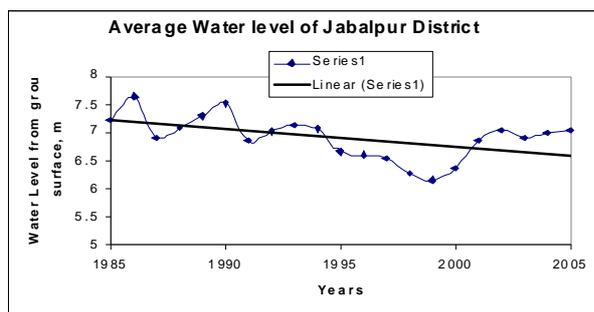
Effect of certain dilutors on semen characteristic and artificial insemination was studied in German Shepherd dog. Semen was collected by massage method. Preservation in EYC, TFC and CME revealed better preservability of semen in EYC diluter (higher individual motility, higher live percentages and lower morphological defect) after 72 hours on preservation at 5°C with highest conception rate as 50 per cent.

Management of anoestrus in buffaloes during summer was attempted with conventional and homeopathic drugs on 105 post partum anoestrus buffaloes (30 suboestrus and 75 true anoestrus). It was observed that low serum inorganic phosphorus was one of the causes of true anoestrus and its supplementation can ameliorate the condition. Homeopathic drug is as effective as GnRH in management of anoestrus.

5.0 AGRICULTURAL ENGINEERING

5.1 Soil and Water Engineering

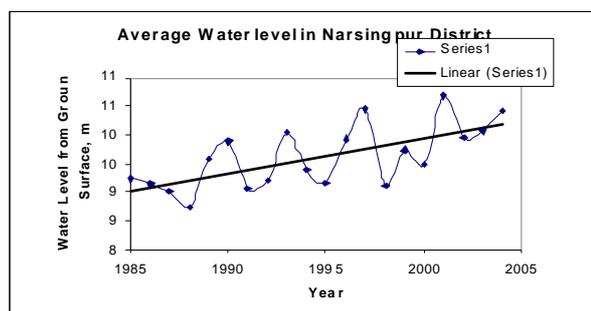
Ground water assessment in Narmada river basin: Analysis of static ground water level data for the last 20 years (1985-2005) in Narmada basin showed a rising trend in Mandla, Dindori, and Jabalpur districts, whereas, Narsinghpur and Hoshangabad districts were associated with depleting ground water levels. Data on ground water draft and ground water balance for past years indicate that there is a wide scope of ground water development in the districts Dindori, Mandla and Jabalpur.



Conjunctive use approach in canal command area: Impact assessment of conjunctive use in Khulri minor of Rani Awanti Bai Sagar irrigation project indicated positive effect of introducing wells in canal command for controlling ground water table in the command area. The water table which was lying between 1.5 to 2.0 m below ground surface about 10 years before is still in dynamic equilibrium of 1.8 m below surface, as number of dug-cum bore well increased from 7 to 25. Based on the optimum depth to water table from ground surface, the best alternative found was to have canal supplies of 60% of the total water

required and remaining 40% through wells.

Performance of irrigation system: Performance of irrigation system of command area of Jhansi minor evaluated on RS and GIS platform indicates uniform availability of canal water in head, middle and tail reach as wheat area intensity was found to be more than 0.92 in all segments. Performance of surface irrigation system was assessed for early grown wheat, gram and middle reach and by tube well in tail reach. Low values of CV NDVI from 0.15 to 0.14 for early grown wheat, 0.061 to 0.1 for gram and 0.19 to 0.21 for late grown wheat



obviously attributed to uniformity of irrigation distribution in all reaches through conjunctive use of water resources.

Efficient pumping devices for saving energy: Field evaluation of submersible pumps indicates inappropriate utilization of pump size and stage by the farmers. Reduced voltage supply is a common feature. Removing 2/3/4 nozzle heads from a sprinkler system compensated head and discharge. Study on load factor of transformers connected to the irrigation pumps, suggests reduction of load factor by making the pump site efficient. The load factor varied from 0.1 to 0.4.

Studies on ground water pollution: Sources of waste water irrigation were demarcated in Jabalpur and surrounding area. Ground water quality is by and large good in M.P. EC ranges below 500 ms/cm. Pollution has been noticed through factory, agrochemicals, and dairy waste. Pollution of Fluoride and Nitrate was

found in scattered pockets of ground water in the State. Nitrate pollution is seriously coming up in 205 samples in Indore and 12.5 % in Bhopal. Iron in 28%, manganese in 24% and cadmium in 12 % ground water samples was reported critical for industrial areas of Jabalpur town.

Effectiveness of SRI method on the economics of rice production

Treatment	Average production (q ha ⁻¹)	Cost of production (Rs. ha ⁻¹)	Gross benefits (Rs. ha ⁻¹)	B/C ratio
Control	21-26 (23.5)	12870.00	21600.00	1.68
SRI	42-47 (44.5)	16810.00	39600.00	2.35

Effectiveness of border irrigation method on yield and economics of gram

Treatment	Average production (q ha ⁻¹)	Cost of production (Rs. ha ⁻¹)	Gross benefits (Rs. ha ⁻¹)	B/C ratio
Farmer's Practice	12.48	4852.00	18720.00	3.72
Border irrigation	20.75	6070.00	24675.00	4.06

Effectiveness of border irrigation method on yield and economics of Wheat

Treatment	Average production (q ha ⁻¹)	Cost of production (Rs. ha ⁻¹)	Gross benefits (Rs. ha ⁻¹)	B/C ratio
Farmer's Practice	2246	6230	19469	3.12
Border irrigation	2618	6455	23594	3.65



SRI Rice



Conventional Rice

The trials were conducted in the farmers' field in selected canal command areas for field and vegetable crops. The trials mainly covered productivity improvement of irrigated crops through integrated water, nutrient and land management practices, improved irrigation methods, improved varieties along with packages of practices. The trials showed enhancement in productivity of crops to the extent of 20 to 100 per cent.

Agricultural thematic mapping: Agricultural land and water bodies were mapped using satellite images of Tons Basin under Agricultural Thematic Mapping. Information was extracted from different sources (including IRS & LUP, NSD) and digitized for 24.5 lac ha area of Tons basin and 12.3 lac ha of Tons basin in M.P. The thematic maps can be used by planners for improving land use decision support systems.

2.2 Farm Machinery and Power

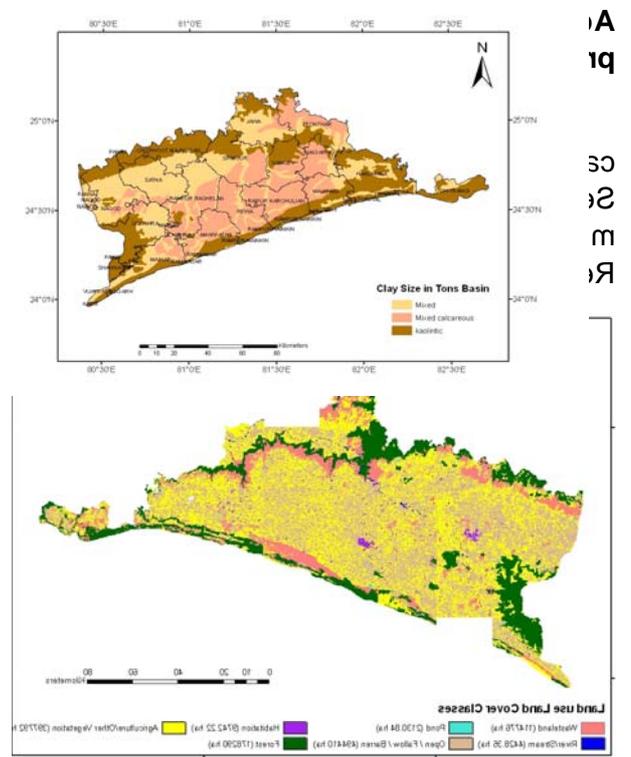
2.2.1 Improvement in vibration characteristics of tractor seats

Field and laboratory studies on tractor seats of different makes revealed that seating dimensions of tractor seats are lacking in their

On-farm water management for rainfed agriculture: As a part of Indo-US AKI project, studies were undertaken to assess on-farm impact of adoption of land and water management practices in paired watersheds in Banda village, Jabalpur District. One of the paired watersheds was treated with soil and water conservation and improved cultivation practices and was compared with the untreated watershed areas. The improved practices included provision of water harvesting in dugout pond and recycling of harvested water for paddy and wheat.

Irrigation in sugarcane

Studies carried out at Zonal Agricultural Research Station, Purnia revealed that maximum sugarcane yield (127.8 t ha^{-1}) was recorded with drip irrigation at 0.75 PE under normal planting ($90 \times 90 \text{ cm}$) as compared to farmers practices of surface method.



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device includes a microcontroller system, seed collecting and picking unit, space counting wheel and seed counter. The desired seed in seed spacing can be fed and displayed in microcontroller system. The MCBPMD was tested in laboratory for round seed (Soybean). Seed calibration, seed damage and seeding uniformity were calculated based on recorded observations. The seed rate and spacing could be controlled from 1.2 kg ha⁻¹ to 50 kg ha⁻¹ and 4.8 cm to 33.6 cm, respectively, when the digit 1 to 7 was selected. There was no mechanical damage of seed when it was tested for calibration cum seeding uniformity. Seed distribution in row was fairly uniform when the digits above 3 were selected. Seed counter gave satisfactory results when it was tested with soybean seeds, 21.23% seed could not be counted. Seeding uniformity was better for the metering device worked satisfactorily for spherical seeds (Soybean).

Performance and emission analysis of tractor engine with diesel, jatropha methyl esters and their blends: Methyl ester of Jatropha oil (JME) has been found to be a functional substitute for diesel fuel. This research outcome showed that JME biodiesel could be easily substitute in an unmodified tractor engine. Brake specific fuel consumption (BSFC) decreased with increase in the brake

design for comfort of Indian tractor operators and seating dimensions in tractor seats were noticed for longitudinal, lateral, vertical directions under various field operating conditions; except for transport on farm road for lateral vibrations. Vibration isolators set including seat mounting base plate, costing only Rs. 500, can attenuate about 27% (maximum) whole body vibration at seat-operator interface of the tractor in different engine speeds in field and on road for transport. Thereby, minimizing physical and neuro disorders among tractor operators for better comfort. Further, the findings of this investigation opens new avenues for R & D experts to concentrate and focus their attention collectively to find some amicable technical solutions for vibration attenuation to safe limits.

Design and fabrication of microcontroller based pneumatic seed metering device (MCBPM): Considering the fact that devices



Toto-Till-Drill

Pneumatic Planter

power. Brake thermal efficiency was found to increase with increase in brake power. It gave better results of emission characteristics for JME biodiesel compared to diesel.

5.3 Post Harvest Process and Food Engineering

Extruded snacks

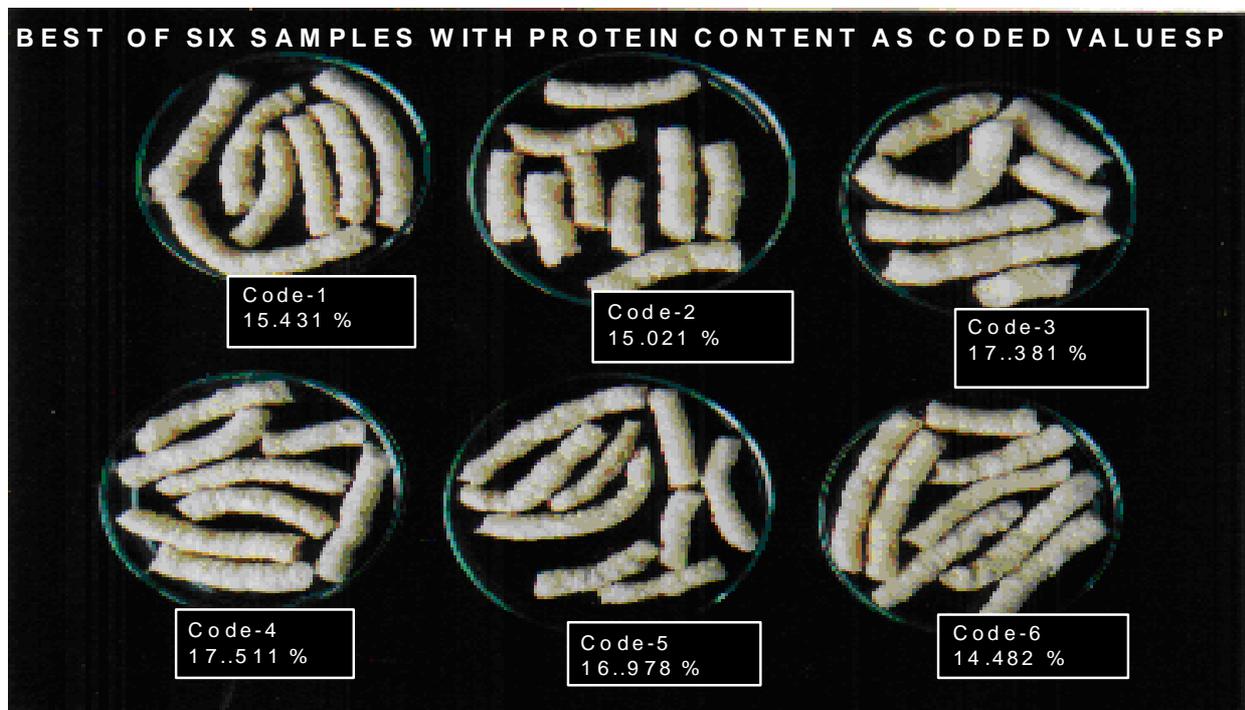
Studies on extrusion cooking technology for preparation of ready to eat extruded snack from different blends of rice, maize, defatted soy-flour and safed musali (*Chlorophytum borivillianum*) and production of coarse cereal based fortified snacks revealed:

- The optimum machine parameters characterized for most acceptable extrudes were 130°C Barrel Temperature (Zone III), 170°C Die head temperature, and a screw speed of 110 rpm. The optimum blend ratio identified for best quality extrudes was for rice 35%, maize

35%, defatted soy flour 20% and safed musli powder 10%.

- For monthly production of 15,00,000 units of 20 gram packets of ready to eat extruded snacks of above blended flour with selected infrastructure, the break even quantity is 15,895,109 units, break even sales is Rs. 95,34,654/- for break even period of 259 days. Benefit : cost ratio was found to be Rs. 19.60.
- Rice flour, defatted soy flour and Ashwagandha powder mix at a blend ratio of 70:15:15, feed moisture of 9%, barrel temperature of 180°C, and screw speed of 100 rpm gave the best quality extruded product with mean sensory score of overall acceptability of 7.9.

Effect of process and operational parameters for extrusion cooking of sorghum, horse gram and defatted soy flour blend: Study of the effect of process and



operational parameters of extrusion cooking of sorghum, horse gram and defatted soy flour blend on properties of extruded revealed:

- The blend 80:10:10 (Sorghum : horse gram: defatted soy flour) was mixed with 2% salt, 2% oil, 2% chilli powder and 1% other spices.
- This mixture was extruded at 15% moisture content, 130°C barrel temperature and 130 rpm of screw speed.
- The extrudate had a mean sensory score of overall acceptability of 6.9.

Ready- to- eat snacks from rice-defatted soy flour and winter cherry powder blends by using extrusion cooking technology: It was observed that the final extrudate obtained at 9 per cent feed moisture content, 70:15:15 blend ratio of feed (rice flour:defatted soy flour: ashwagandha powder), 180°C die head temperature and 100 rpm screw speed was at par with a market product. The mean sensory score of overall acceptability for that product was 7.9.

Blending and coagulation of Soy paneer: Studies on effect of different blends and coagulants of biochemical, organoleptic & textural properties of soy paneer revealed:

- Increase in proportion of buffalo milk increases the recovery of soy paneer.
- Increase in proportion of buffalo milk reduces the resistance to penetration.
- Hardness of Soy paneer reduces with increase in proportion of buffalo milk.
- Sensory quality of soy paneer improves with increase in proportion of buffalo milk.
- The maximum protein was retained by using citric acid as coagulant.

Development of aonla stone removing cum slicing equipment

The aonla stone removing cum slicing equipment was developed. This equipment decreased the time of operation and effort of slicing. The pulp obtained is more hygienic as compare to manual practice. The operational cost for de-stoning and slicing is about Rs.10 kg⁻¹ in case of manual operation and Re 1 kg⁻¹ with this equipment.

Field evaluation and testing of equipments development at other centers

PKV Akola Dal Mill

In the year 2006-08 Akola Dal Mill was tested for pigeon pea (*Cajanus cajan*). Pigeon pea was initially soaked in water for 7-8 hr and then dried in sun or cabinet dryer to 11-12% moisture content. It was then tested for different feed rates i.e. 40 kg hr⁻¹, 60 kg hr⁻¹, 75 kg hr⁻¹, 90 kg hr⁻¹ and 110 kg hr⁻¹ and for different retention times of 1, 1.5, 2 and 3 minutes. It was observed that at a feed rate of 60 kg hr⁻¹ with the retention time of 1.5 minute, the efficiency was 68.31% where as in case of control sample the efficiency was 43.95%. The efficiency dropped to (60%) when the feed rate and retention time was increased to 110kg hr⁻¹ and 4 minutes respectively. The variation in efficiency of treated and untreated samples varied by 24.37%.

Post harvest management of medicinal crops: Studies were conducted on performance of peeling and drying methods in Safed Musli (*Chlorophytum borivillianum*). Highest capacity of peeling was obtained when peeled by knife, i.e. 101.6 g hr⁻¹. The other methods considered were peeling by passing through sharp edge of stainless steel holes, and peeling by knife of initially treated sample with steam for 5 min. Four drying methods were considered viz. shade,

sun, solar and cabinet drying. Minimum drying time of 1.3 hours was observed by drying in mechanical dryer at air velocity ranging between 1.62-1.88 m second⁻¹ and the temperature of the product being in the range 85-92°C. At this condition the colour and saponin content was observed to be 79.74% in terms of lightness and 0.743 respectively.

5.4 Agricultural Structures and Environmental Engineering

Renewable energy sources for agriculture and agro based industries

Field evaluation of improved durable cook stoves: Field installation and evaluation of improved durable cook stoves of two models i.e. single pot chetak model and double pot udairaj model, MPUAT, Udaipur design involving 200 beneficiaries revealed:

- Positive favorable reactions in respect of venting out of almost all smoke, non-requirement of air blowing, reduced maintenance requirement and apparently long life.
- About 40% users reported fuel wood saving up to 25%.

- The benefits of improved chulha as perceived by the users are prevention of accidents (91%), smoke removal (84%), clean kitchen (84%); fuel saving (65%), cleaner vessels (60%) and time saving (50%). However, about 10% of the users felt that there was no fuel saving and about 21% of the users felt that there was higher fuel consumption. In spite of various reasons, the households were using improved chulhas mainly because of the smoke removal feature.
- Thermal efficiencies ranged from 20.1 to 20.5% for improved chulhas and 9.8 to 10.7% for the traditional chulhas.
- The energy consumption varied from 31 to 116 MJ and 27 to 109 MJ for the traditional and improved chulhas, respectively.

Field evaluation of domestic solar dryer : The domestic solar dryer was used for drying of leafy vegetables (spinach leaves, methi leaves, and coriander leaves) amla pieces, potato slices, ginger, water chestnuts, chillies, ber and turmeric. The loading capacity varied in the range of 0.5 to 0.75 kg in case of leafy vegetables and 1.5 to 2.5 kg for remaining items. It took 2-3

Influence of date of sowing and chickpea varieties on *H. armigera* infestation

Cultivars	Date of sowing						Average	
	08 November		28 November		18 December		Larvae*	Pod Dg**
	Larvae*	Pod Dg**	Larvae*	Pod Dg**	Larvae*	Pod Dg**		
Kabuli	4.58	9.73	6.9	12.73	9.34	19.0	6.94	13.82
Gulabi	6.16	12.13	8.6	13.73	11.93	21.93	8.89	15.93
Desi	4.04	9.0	6.04	11.30	7.61	12.8	5.89	11.03
Average	4.92	10.28	7.18	12.58	9.62	17.91		

Larvae* - *H. armigera* larval population per 4 meter row length

Pod Dg** - Per cent pod damage by *H. armigera*

sunny days to dry the material. The drying was faster and quality of the dry product was superior to the product obtained by open sun drying as per user's feed back.

Evaluation of portable updraft biomass stove of PDKV design: Performance was satisfactory with thin dry wood sticks resulting into thermal efficiency of 21 to 26 per cent with almost negligible concentration of CO in the surrounding working atmosphere.

Fuel time consumption	Traditional stove	Chetak stove	Mean saving %
Fuel consumed, kg	3.50	1.60	54.28
Cooking time h	2.65	1.00	62.26

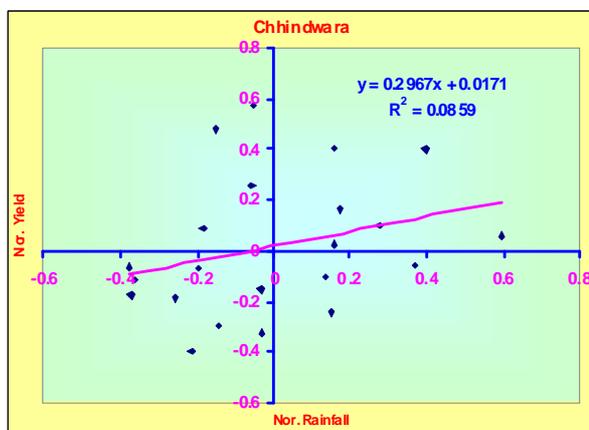
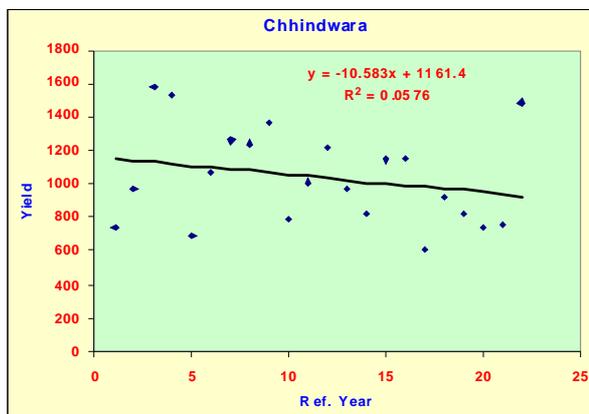
Study on Jatropha utilization through gasification route : Saving of 47.3 and 57.8 % appeared possible at the respective lowest and highest cold gas efficiencies of 60 % and 75 % by adoption of Jetropha Fruit (JF) gasification against bio-diesel production route to obtain fuel gas with equivalent energy value of 1 kg of bio-diesel (Jatropha Methyl Easter). With Jatropha, fruit there was no sign of bridging or ash fusion at the attained temperature range up to 84.5°C. The gas of highest quality, i.e. with GCV of 4.69 MJm⁻³ and tar content of 0.84 g m⁻³ at secondary air entry distance of 40 cm from grate. The trouble free operation of the gasifier with consistent gas generation proved that the JF were excellent feed stock for gasification.

5.5 Physics and Agrometeorology

Impact of weather parameters: During South-West (SW) Monsoon in 2008 out of 45 districts of M.P., 34 districts received below normal rainfall and remaining 11 districts received above normal rainfall. Bundelkhand, Chhatarpur and Tikamgarh regions of Madhya Pradesh received rainfall around below normal 50 percent of the time and below normal number of rainy days

(14 and 43 per cent time), respectively. Productivity of oilseed and pulses was average while; productivity of rice was below normal.

Result of experiments revealed that yield reduction in all chickpea types was noted when crop was planted earlier or later than November. This may be due to suboptimal photo-thermal regimes encountered for early and late planted crop. Relationship between seed yield and dry matter of chickpea and mean temperature (from 50% flowering to physiological maturity) indicated that post flowering temperature are more detrimental for yield reduction in chickpea. Seed yield of chickpea increased, as GDD (Growing Degree Days) increased. Correlation coefficient of pest population of chickpea with different weather parameters showed significant relationship with temperature and humidity.



Analysis of soybean productivity: To study the effect of rainfall on soybean productivity, yield trends in different districts was examined in relation to rainfall of 3 district (Jabalpur, Indore and Chhindwara). The long term productivity trends in these districts was different. At Jabalpur and Indore there was an increasing trend in productivity till 1990-95 and thereafter it started declining whereas, in Chhindwara productivity showed a downward trend. But normalized yields at Chhindwara show no change in yield levels. A plot of normalized yields with normalized rainfall of three districts showed that there is an increase in yield levels with increasing rainfall at Chhindwara and Indore, but there was a yield decline with increasing rainfall at Jabalpur showing a negative effect of high rainfall on soybean productivity at Jabalpur.

Forewarning studies of *Heliothis armigera* on chickpea and pigeonpea egg population

Weather Parameter and pest population in pigeonpea: Correlation coefficient of pest population with different weather parameters has shown significant relationship with temperature and humidity. Higher temperature and humidity favoured pest incidence which caused maximum pod damage. *Helicoverpa* population in form of eggs or larvae was found lowest with highest light period i.e. during 36th to 50th week. It was highest in 2nd to 3rd standard meteorological week (SMW).

Climate variability study

Variation in rainy days : Model predictions of future scenarios indicated that there will be an overall decrease in number of rainy days over major part of the country. Analysis of long-term data indicates that in Chhindwara district number of rainy days were decreasing during month of July and August, whereas showing increasing trend in June and September months

of monsoon season. In winter season, October and January months indicated decreasing trend while rainy days showed an increasing in October and December months. In Indore district number of rainy days were decreasing in June and August where as they were increasing in July and September month of rainy season. During winter season trend was decreasing almost during the entire month except November. Gwalior showed decreasing trends in the month of July and August but in June and September, there was an increasing trend during S-W monsoon season. The trend was decreasing in all the months except in November during winter. Trend of rainy days during monsoon months in Jabalpur district indicated decreasing trend during June and July where as it showed an increasing trend in August and September months. In winter season number of rainy days were decreasing in almost all the months except October. Trend analysis showed that in Morena district of Madhya Pradesh number of rainy days were increasing in all the monsoon months, whereas, the same was decreasing during almost all the post monsoon months except December.

Verification of weather forecast

Rainfall: The analysis of verification of forecast indicated that usability percent of forecast was around 80% in all the seasons. The RMSE was higher in rainy season as compared to other seasons.

Temperature: Usability percent of maximum temperature was highest in post rainy season as compared to other seasons. RMSE value was higher in all the seasons except winter season. In case of minimum temperature usability percent was highest in rainy season as compared to other seasons. RMSE value showed that accuracy of forecast was more in rainy season than other seasons.

5.6 Instrumentation

Multi channel Electronic choke Indicator has been developed. This monitors seed dropping through seed drills and gives audio video indications to the tractor driver, whenever seed tube gets choked and/or seed box becomes empty. (Patent No.: 232368).

Web Based Information System Software on Production Technologies

This web based software has been prepared for disseminating production technology of 15 vegetable crops namely- tomato, brinjal, chilli, cabbage, cauliflower, bottle gourd, bitter gourd, cucumber, sponge gourd, onion, garlic, bhindi, garden pea, cow pea and french bean by use of information technology. The software is bi-lingual (Hindi &



Multi-channel seed drill choke indicator

English) and it has been developed for farmers, scientists, teachers, students and KVKs. No special training is required for end users to know the contents of the software.

This software contains information about almost every aspect of vegetable crop production technology. It contains different modules like variety, soil & climate, weed control, Irrigation & intercultural management, insect and disease management, genetic resources etc. The web application is available at URL www.jnkvv.nic.in and www.jnkvv-vegsoft.com



Web based Information System on Production Technologies

6. STATUS OF SEED, PLANT AND FRUIT SAPLING PRODUCTION

Production of Breeder Seed (in qtls)

S.No.	Crop / Variety	2007-08	2008-09
Kharif			
1.	Soybean	6196.09	6301.10
2.	Paddy	857.78	1040.00
3.	Sorghum	33.60	13.80
4.	Maize	65.59	47.00
5.	Tuar	139.14	207.25
6.	Moong	54.15	55.51
7.	Urad	60.30	47.30
8.	Niger	4.33	7.10
9.	Kodo	7.77	5.10
10.	Kutki	0.46	2.25
11.	Til	19.17	7.50
12.	Groundnut	37.66	27.50
13.	Bajra	6.08	34.20
14.	Cotton	0.11	19.10
Rabi			
1.	Wheat	7813.06	7527.00
2.	Barley	10.00	15.00
3.	Chickpea	3601.75	3584.35
4.	Mustard	3.82	301.28
5.	Toria	2.18	0.34
6.	Niger	3.00	6.56
7.	Linseed	11.50	16.50
8.	Lentil	70.31	60.00
9.	Safflower	8.00	3.79
10.	Berseem	33.00	58.20
11.	Oats	35.00	57.00
12.	Groundnut	--	8.00
13.	Pea	638.15	378.34
14.	Maize	59.00	55.00
15.	Sugarcane	3505.00	1300.00
Summer			
1.	Moong	34.00	600.00
2.	Urad	34.00	60.00
3.	Soybean	2000.00	--

Seed of Medicinal and Aromatic Plants (in kg)

S.No.	Crop / Variety	2007-08	2008-09
1.	Isabgol	200.00	150.00
2.	Chandsur	1500.00	1100.00
3.	Ashwagandha	200.00	150.00
4.	Satawar	3.00	2.40
5.	Soya	11.00	0.60
6.	Sarpagandha	0.400	0.150
7.	Sikakai	4.00	2.50
8.	Shivnak	8.00	10.00
9.	Basalicam somia	30.00	14.00
10.	Putranjeeva	3.00	4.50
11.	Safed ghuchi	60.00	45.00
12.	Kali haldi	400.00	3.50
13.	Aama haldi	40.00	65.00
14.	Castas keokand	100.00	55.00
15.	All planting materials and seedlings of medicinal & aromatic plants (numbers)	1,60,000	2,35,000

Availability of Vegetable Seed (2007-08)

Crop/Variety	Breeder Seed (kg)	Jawahar Seed (kg)
Bhindi (Prabhani Kranti)	-	100
Cowpea (CP-04)	-	80
Pea (E-6)	115	-
Pea (Arkel)	1800	-
Methi (PEB)	290	-
Methi (RmT-1)	-	170
French bean (A Komal)	100	-
Onion (N-53)	-	15
Palak (Jobner green)	-	500
Palak (All green)	-	240

Availability of seed of Vegetable and Spices (2008-09)

Crop	Variety	Breeder seed	Jawahar seed
Methi	PEB	4.40	7.00
	RMT	-	15.82
	AM-1	-	1.20
	AM-2	-	2.75
Total		4.40	26.77
Coriander	Cimpo	-	6.00
Total		-	6.00
Spinach (Palak)	All green	-	23.50
	Jobner green	-	2.40
Total		-	25.90
Bhindi	Prabhani Kranti	-	55.37
Total		-	55.37
Radish	Japanese white	-	0.32
Cowpea	Pusa komal	-	3.50
Sem	JDL-53	-	3.00
Onion	AFLR	-	1.80
Total		-	8.62
French bean	A-Komal	-	1.00
Total		-	1.00

Availability of fruit plants/saplings 2008-09

Fruit	No. of plants	Rate/plant (Rs.)
Aonla(Budded	9,05,150	20.00
Aonla saplings	5,00,000	5.00
Mango	50,200	20.00
Guava	20,000	6.00
Lime	9,520	6.00
Ber	3,000	6.00
Pomegranate	5,000	6.00
Lemon	1,000	6.00
Jackfruit	50,000	6.00
Jamun	5,000	6.00
Other fruits	50,000	6.00

7. RESEARCH PROJECTS (2007-08 and 2008-09)

S.No.	Name of Project	Centre	Total Outlay (Rs. in lakhs)	
			2007-08	2008-09
Faculty of Agriculture				
1.	Maize Improvement	Chhindwara	11.73	17.00
2.	Rice Improvement	Rewa	19.59	30.00
3.	Niger	Chhindwara	11.00	10.72
4.	Linseed	Sagar	13.12	11.92
		Powarkheda	01.50	01.50
5.	Sesame	Tikamgarh	24.80	23.00
		Powarkheda	10.75	10.76
6.	Soybean	Jabalpur	11.60	16.40
7.	Chickpea	Jabalpur	14.68	32.30
8.	Millet Improvement	Dindori	20.58	28.19
		Rewa	17.75	24.50
9.	Wheat Improvement	Powarkheda	23.81	28.86
		Sagar	23.80	42.24
10.	Cropping System Research		89.27	96.74
11.	Sugarcane	Powarkheda	29.79	31.91
12.	Micro & Secondary nutrients and Pollutant Elements in Soils	Jabalpur	32.30	34.87
13.	Soil Test Crop Response	Jabalpur	16.95	25.23
14.	Long Term Fertilizer Experiment	Jabalpur	16.95	18.40
15.	AINP-Biofertilizer (BNF)	Jabalpur	14.00	14.60
16.	Nematode Pests and their Control	Jabalpur	18.85	18.42
17.	Vegetable Improvement	Jabalpur	20.34	28.56
18.	Potato Improvement	Chhindwara	15.70	16.50
19.	Sub Tropical Fruits	Rewa	38.73	16.32
20.	AINP on Betelvine	Jabalpur	12.60	15.50
21.	Barley Improvement	Rewa	06.31	18.56
22.	Agro-Forestry	Jabalpur	19.17	22.67
23.	Forage Crops	Jabalpur	44.28	38.60
24.	Dryland Agriculture	Rewa	41.20	43.50
25.	National Seed Project - BSP	Jabalpur	37.50	37.50
	- STR	Jabalpur	39.75	39.75
26.	Production of Breeder Seed of Annual Oilseed Crop - Soybean	Jabalpur	02.16	07.63
	- Groundnut	Jabalpur	02.16	09.47
27.	BSP - NSP on Vegetable Merged with AICRP on Vegetables	Jabalpur	8.92	
28.	Network Project on Organic Farming	Jabalpur	03.30	05.55

S.No.	Name of Project	Centre	Total Outlay (Rs. in lakhs)	
			2007-08	2008-09
Faculty of Agricultural Engineering				
1.	Farm Implements and Machinery	Jabalpur	17.13	16.67
2.	Ground Water Utilization	Jabalpur	25.80	27.53
3.	Harvest & Post Harvest Technology	Jabalpur	81.47	78.80
4.	Renewable Energy Sources	Jabalpur	05.98	14.92
5.	Agro-meteorology	Jabalpur	21.33	19.16
6.	Water Management	Powarkheda	38.60	38.61
Faculty of Veterinary Science & Animal Husbandry				
1.	Poultry Breeding	Jabalpur	66.73	56.19
2.	Pigs	Jabalpur	23.73	40.00
3.	Improvement of feed resources and nutrient utilization for raising animal production	Jabalpur	06.07	10.05
4.	NWP on Gastrointestinal Parasitism	Jabalpur	04.00	09.50
5.	NWP on Blue Tongue	Jabalpur	01.00	00.95
6.	NWP on Ethnoveterinary Medicine	Jabalpur	05.83	-

AD HOC RESEARCH PROJECTS (2007-08 and 2008-09)

S.No.	Title of Project	Amount (Rs. in lakh)
Agriculture		
1.	Comprehensive Plan scheme for study of cultivation production of principal crops in Madhya Pradesh & Chhattisgarh, Jabalpur	182.00
2.	CSS on Cultivation and Development of Medicinal and Aromatic Plants, Jabalpur	10.00
3.	Professor on IFFCO Chair, Indore	4.30
4.	TMC on Cotton, Chhindwara, Khandwa and Indore	24.19
5.	Network Project on upland shuttle breeding activities on rice, Rewa	48.00
6.	Est. of Regional analytical laboratory for testing of M & AP, Jabalpur	38.83
7.	CSS for implantation of PVP and legislative., Jabalpur	35.70
8.	CSS on equipping and strengthening of DUS Centre	11.90
9.	Technology development and extension of training for development of non forest wasteland through agro forestry system, Jabalpur	70.26
10.	JNKVV-Gramin Vikas Trust Collaborative Research Project, Indore	74.73
11.	Network Project on Organic Farming, Jabalpur	20.89
12.	Collection of elite material and model plantation of Jatropha - Trainee's and farmers, Jabalpur	73.69
13.	National Network Project on Integrated Development of Jatropha and Karanja	13.95
14.	Multiplications evaluation of bread wheat, Powarkheda	2.00
15.	Development, evolution and dissemination of management practices and infrastructure facilities for growing high value medicinal crops Vanilla sativa in Madhya Pradesh, Indore	48.38
16.	Emerging issues and strategies at Agri Export Zone of Malwa Plateau of Madhya Pradesh, Indore	8.19
17.	Conservation, cultivation, processing and evolution of aromatic and medicinal plants under plan scheme Niche Area of Excellence, Jabalpur	207.60
18.	Development of Improved varieties of medicinal and aromatic plants, Jabalpur	8.00
19.	Development of extra large seeded kabuli chickpea varieties for crops diversification, Jabalpur	2.42
20.	Evolution of gypsum utility in various crops and reclamation of black soils of Madhya Pradesh, Indore	15.00
21.	Development and popularization of model seed system for quality seed production of major legumes to ensure seed sufficiency at village level, Jabalpur	100.10

S.No.	Title of Project	Amount (Rs. in lakh)
22.	Molecular diagnosis of infectious bronchitis virus of poultry development of DNA D-base, Jabalpur	28.56
23.	Quality analysis of medicinal and aromatic plants, Jabalpur	25.00
24.	Community managed bio-industrial watersheds for sustainable use of natural resources and enhanced living (MSSRF-JNKVV Collaboration), Jabalpur	122.75
25.	Development of software tools for identifying bi-legend site of a given 3 D structure of a protein, Jabalpur	12.07
26.	Utilization of distillery effluent as a source of nutrient for crop production in different agro-climatic regions of India, Indore	17.25
27.	Seed Village Programme, Jabalpur (ग्राम बीज योजना)	113.00
28.	Web based information system on production technology with marketing strategies along with genetic resources D base with characterization of cultivars of vegetable crops of central India, Jabalpur	19.80
29.	Ailing agril. Productivity in economically fragile region of India : an analysis of synergy between public investment and farmers capacity, Jabalpur	2.28
30.	Breeding soybean utilizing radiation induced mutation and elite lines of resistance against YMV and root rot, Jabalpur	15.32
31.	Rehabilitation of 3 plant tissue culture labs (Indore, Mandasaur and Jabalpur)	64.00
32.	Detecting and fine mapping QTLs with minor effects on rice yield under drought stress for deploying via marker aided breeding, Rewa	5.00
33.	DNA finger printing of medicinal and aromatic plants, Jabalpur	14.66
34.	Demonstration of medicinal plants based system of cultivation and training on viable production of M& AP crops in western Madhya Pradesh, Jabalpur	29.46
35.	Evolution of bamboo species in agri-silvi culture/silvi pastoral system of agro forestry under wasteland condition of Madhya Pradesh, Jabalpur.	15.00
36.	Establishment of Facilitation Centre on M & A P, Jabalpur	30.00
37.	Strengthening of infrastructure facilities for enhancing the BSP at nine Production Farms, Jabalpur	200.63
38.	Development of new varieties of moong bean, urd bean and pigeonpea crops and popularization of released varieties, Jabalpur	1.51
39.	Low cost production technology of microbial pigments using byproducts of food processing, Jabalpur	4.84
40.	Enhancing BSP and creation of training structures (NSFM), Jabalpur	10.00
41.	Training programme on molecular diagnosis of viral diseases, Jabalpur	6.50

S.No.	Title of Project	Amount (Rs. in lakh)
42.	National Invasive Weed Surveillance Pogramme, Gwalior	21.60
43.	Integrated farming system modules to ensure sustainable livelihood security for the peasants of disadvantage districts of Madhya Pradesh, Jabalpur (NAIP)	622.00
44.	Development of goat having knocked down of Myostatin gene through RNA interference technology to enhance tribal areas of Madhya Pradesh, Jabalpur	196.18
45.	Ensuring livelihood security through management of genetic resources and seed system in tribal areas of Madhya Pradesh, Jabalpur	751.47
46.	Collection, maintenance, characterization and evaluation of land races of small millets for biotic stress in the tribal areas of Rewa division of Madhya Pradesh, Rewa	10.51
47.	Vegetation carbon pool assessment in India	2.44
48.	Studies on shelf life extension of wild edible medicinal and cultivated mushroom from tribal areas of Madhya Pradesh by Gamma radiation	19.98
49.	Enhancing chickpea production in rainfed fallow land (RPFL) of Madhya Pradesh and Chhattisgarh, Jabalpur	134.31
50.	NADP/RKVY 2008-09	100.00
51.	Network project on harvest, processing and value addition of natural resin and gums, Jabalpur	61.15
52.	Development potency of patheno genetic goat embryos, Jabalpur	39.50
53.	Biological control of crop pests and weeds, Jabalpur	5.00
54.	Voluntary Centre on AICRP on Spices, Jabalpur	3.80
55.	National Network project on Onion and Garlic, Jabalpur	52.16
	Sub total	3943.58

Agricultural Engineering

1.	Modeling environment modulation in role of development of soybean genotypes	2.22
2.	Rainwater management through economically feasible water harvesting tanks in black soils of Malwa Region	27.25
3.	On-farm water management for rainfed agriculture on watershed in diverse eco-regions of India, Indo-US AKI project	11.80
	Sub total	41.27

S.No.	Title of Project	Amount (Rs. in lakh)
Govt. of India		
Agricultural Engineering		
1.	Agro-Met Advisory Services (EAAS)	14.58
	Sub total	14.58
Veterinary Science & Animal Husbandry		
1.	Evaluation of draughtability and related physio-biochemical changes in Malvi and Nimari bullocks of M.P.	24.20
2.	(a) Investigation of infectious causes of death in goats, cattle and poultry reared in tribal areas of M.P.	11.73
	(b) Identification and validation of indigenous medicinal plants for anthelmintic efficacy in livestock and poultry in tribal areas of M.P. to develop an alternate approach.	11.73
	(c) Prevalence and epizootiology of the parasites of livestock in the tribal areas of Madhya Pradesh	11.73
3.	Studies on utilization of soybean straw in crossbred lactating cattle cows	27.41
4.	Immunophysiological assessment of the neonatal buffalo calves to explore the cause of high mortality	27.91
5.	Survey, evaluation and characterization of Kenkatha breed of cattle	10.30
6.	Ex situ conservation of germplasm and somatic cells in endangered Jamunapari goats	4.50
7.	Molecular probing of infectious causes of death in neonatal calves	5.00
8.	Centre for Wildlife Health and Forensic	413.25
	Sub total	547.76