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Radiation use efficiency and physiological traits in Kalmegh (*Andrographis paniculata* Nees) under various row spacings and nitrogen levels

Sanjay Patidar, A.S. Gontia, Anubha Upadhyay, S. Rao and **Preeti Sagar Nayak**
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Abstract

The investigations were carried out at the Crop Farm of Dusty Acre Area, under Department of Plant Physiology, JNKVV, Jabalpur during kharif 2008-09 to study the influence of three row-spacings viz; 15, 30 & 45 cms and five Nitrogen levels viz; 0, 40, 60, 80 and 100 kg/ha on radiation use efficiency, physiological traits and productivity in kalmegh (*Andrographis paniculata* Nees). 30 cm row-spacing, 80 kgN/ha and their combinations exhibited maximum seed and herbage yields owing to higher dry matter production, leaf area index, leaf area duration, crop growth rate, relative growth rate, specific leaf area, net photosynthesis, stomatal conductance, CO_2 and H_2O utilization, transpiration rate, radiation use efficiency and chlorophyll index.

Keywords: Kalmegh, radiation use efficiency, row-spacings

Kalmegh (*Andrographis paniculata* Nees) is a genus of herbs and shrubs, distributed mostly in the tropical and moist regions. It comprises of about 19 plant species found in India and Sri Lanka, certain parts of Thailand and Bangladesh. In India it is grown in Assam, Bihar, Karnataka, Karla, Madhya Pradesh, Andhra Pradesh and West Bengal. Kalmegh, also known as “King of bitter” is one among the prioritized medicinal plants in India, and this herb is being used mainly for treating fever, liver disease, diabetes, snake bite etc. The leaf and the whole herb contain the medicinal properties and is useful in treatment of diabetes, influenza, bronchitis, hepatomegaly, skin disorder and many such diseases (Patra et al. 2004). In addition to the alkaloid, the plant is also rich in other metabolites such as, total protein, amino acid and carbohydrates which act as the primary constituents for the growth of any plant which are greatly affected by changes in light intensity. The total chlorophyll content is also reported to be affected by changes in light intensity (Treshow 1970; Kapur 1999).

The productivity of a crop depends on its capacity for photosynthesis, its photosynthetic area and the utilization of photosynthetically active radiation within crop canopy. The genetic variability of yield differences among the cultivars may be related to some of the growth parameters viz., crop growth rate, relative growth rate, leaf area index, leaf area duration and specific leaf weight. The relationship between radiation use efficiency, photosynthetic efficiency and crop yield is a complex phenomenon. The yield is an integrated effect of numerous physiological processes and morphological yield components. Therefore, the productivity of cultivars depends in achieving better adoption to many environmental factors including the hazards of diseases, lodging and rains. For our understanding of the differences in yield in various cultivars of medicinal plants a physiological approach is needed. An understanding of the physiological processes involved in the economic production in medicinal plants such as vegetative growth, formation of storage organs and seed filling, helps in determining the best combination of the above three requirements and also suggests as to what improvements can be made to achieve a further increase in economic productivity in medicinal plants under given set of conditions. Keeping in view of the above facts the present investigations are undertaken.

Materials and methods

The experiment was carried out at the Research Farm, Dusty Acre area, Department of Crop Physiology, JNKVV, Jabalpur (M.P.) during the kharif season of 2008-09. The experiment was laid out in a Split plot design with three replications. Three row spacings viz;

15 cm (S_1), 30 cm (S_2) and 45 cm (S_3) were taken as main treatments, while five nitrogen levels viz; 0 (N_0) , 40 kg/ha (N_1) , 60 kg/ha (N_2) , 80 kg/ha (N_3) and 100 kg/ha (N_4) as subtreatments. Seeds of kalmegh were sown in the field adopting recommended cultural practices. The date of sowing and harvesting were 17th July 2008 and 3rd January 2009, respectively.

The leaf area index (LAI) was determined as per specifications of Gardner et al. (1985), whereas, Leaf area duration (LAD), Crop growth rate (CGR), Relative growth rate (RGR), Specific leaf area (SLA) were determined as per Watsons (1952) method. Radiation use efficiency was determined as per specifications of Sinclair and Muchow (1999). Physiological traits viz; stomatal conductance, transpiration rate, net photosynthesis, CO_2 and H_2O utilization were quantified by using infra-red gas analyser (IGRA, model CI 340) whereas chlorophyll index was recorded by using chlorophyll meter (Model CCM 200).

Results and Discussion

The investigations revealed significant differences among main treatments, sub treatments and interactions for the most of the traits under study (Table 1-4). The results revealed that at 60- 80 DAT (days after transplanting) main treatment S_2 (1.20 and 23.67) possessed the significant maximum leaf area index and leaf area duration and the minimum was observed in S_1 (1.12 and 21.95), respectively. Among sub treatments N_3 (1.23 and 24.17) showed the significant highest values and N_0 (1.07 and 20.88) the minimum. In interactions S_2N_3 (1.27 and 25.10) showed the significant highest values and treatment combination S_1N_0 (1.01 and 20.03) recorded the lowest magnitude for these traits. In most of the crops a higher LAI was desired for higher productivity, further increase in LAI beyond optimum caused lodging and reduction in yield Nichipororich (1970). However optimum LAI reached well before anthesis and fell progressively as water stress increased Fisher and Kohn (1998). Leaf area index and interception of photosynthetically active radiation changed with row spacings but depended on the phenological stages, plant density, canopy architecture and management system Strieder et al. (2008). The study also revealed significant variation among interactions for LAI. It has been recorded that treatment combinations of 30 cm row-spacing with 80 kgN/ha were found to be superior for optimization of LAI and LAD. Further increase in either row spacings or N levels appears to be not desired for increasing these traits. The higher LAI and LAD in treatment combinations S_2N_3 and S_2N_4 was attributed to fulfilment of the optimum requirements for attainting higher LAI and LAD in combination which might have resulted in availability of all growth factors in abundance resulted in higher magnitudes of these parameters. The LAI had positive association with grain yield Sahoo and Guru (1998) and was found to be increased with increase in daily radiation, plant canopy closed sooner, leaf area duration (LAD) increased and plant dry matter weight, leaf area index (LAI) and crop growth rate (CGR) were higher up to the middle of seed development as row distance decreased Pourhadian and Khajehpour (2008).

Results showed in respect of RGR, CGR and SLA that among main treatments S_2 (0.0168 and 0.564) had the maximum RGR and CGR at 60-80 DAT and minimum was recorded in S_1 (0.0146 and 0.505) (Table 1). Among sub treatments N_3 (0.0168 and 0.562) recorded the significant more over the rest of the sub treatments and N_0 (0.0132 and 0.515) registered significant minimum value. In interactions S_2N_3 (0.0207 and 0.653) had the significant highest magnitudes over the remaining interactions and treatment combinations S_1N_0 (0.0120 and 0.390) were associated with the lowest. Results also revealed that among main treatments S_2 (1.036) possessed the significant highest SLA and S_1 (0.992) minimum at 60-80 DAT. Among sub treatments N_3 (1.023) noted the significant highest and N_0 (1.002) was associated with minimum value. In interactions S_2N_3 (1.054) had the significant more and S_1N_0 (0.978) was associated with the lowest magnitude. SLA possessed positive association with grain yield Sahoo and Guru (1998).

Row spacing of 30 cm (S_2) (0.0323 and 11.79) was associated with the significant maximum radiation use efficiency (RUE) and chlorophyll index over rest of the treatments and S_1 (15cm) minimum (0.0311 and 5.28). In sub treatments N_4 (0.0320) and N_3 (13.27) showed the significant more values and N_1 (0.0300) and N_0 (2.96) significant minimum (Table 1). In interactions S_2N_3 (0.0344 and 19.80) had the significant maximum values and treatment combinations S_2N_1 (0.0291) and S_2N_0 (1.78) minimum. Tei *et al*. (2004) workedout the critical % N dilution curve to analyse the effect of N availability on light interception and radiation use efficiency, confounded that in all years, the critical "uptake" curve was very close to the uptake curves obtained with the fertilizer N rate of 100 kg N/ha. in 1996, 200 kg/ha. in 1997 and 150kg/ha. in 1999 due to the increases of water content related to the osmotic effect of nitrates. Increasing N supply increased light interception throughout the growth cycle and slightly increased radiation use efficiency. Water use efficiency (WUEDM) is directly related to radiation use efficiency

Table 1. Morpho-physiological parameters as influenced by various treatments

Treatments	LAI	LAD (m^2.days)	RGR (g/g/day)	CGR (g/m^2/day)	SLA (m^2/g)	RUE (g/µmol/m^2/s)	Chlorophyll index (g/ m^2)
Main Treatments (Row –spacings)							
S_1 (15 cm)	1.12	21.95	0.0146	0.505	0.9920	0.0301	5.38
S_2 (30 cm)	1.20	23.67	0.0168	0.564	1.0360	0.0323	11.79
S_3 (45 cm)	1.19	23.29	0.0162	0.551	1.0080	0.0311	9.80
SEm ±	0.01	0.02	0.00006	0.0020	0.01100	0.00017	0.61
C.D. 5%	0.02	0.06	0.00023	0.0090	0.04100	0.00065	2.41
Sub Treatments (N levels)							
N_0 (Control)	1.07	20.88	0.0132	0.515	1.0020	0.0309	2.96
N_1 (40 kg/ha)	1.17	22.78	0.0145	0.520	1.0040	0.0300	7.07
N_2 (60 kg/ha)	1.17	23.08	0.0164	0.550	1.0140	0.0316	9.01
N_3 (80 kg/ha)	1.23	24.17	0.0178	0.562	1.0230	0.0314	13.27
N_4 (100 kg/ha)	1.21	23.96	0.0174	0.551	1.0180	0.0320	12.66
SEm ±	0.01	0.03	0.00009	0.0020	0.01700	0.00049	0.54
C.D. 5%	0.02	0.10	0.00026	0.0700	0.05000	0.00143	1.56
Interactions (Row – spacings × N levels)							
S_1N_0	1.01	20.03	0.0120	0.390	0.9780	0.0299	2.80
S_1N_1	1.14	22.23	0.0149	0.477	0.9960	0.0306	5.13
S_1N_2	1.12	21.80	0.0150	0.484	1.0000	0.0306	4.52
S_1N_3	1.17	23.03	0.0162	0.545	1.0080	0.0292	6.76
S_1N_4	1.15	22.67	0.0160	0.531	1.0070	0.0302	7.71
S_2N_0	1.10	21.50	0.0139	0.477	0.0940	0.0333	1.78
S_2N_1	1.20	23.50	0.0162	0.561	1.0100	0.0291	10.53
S_2N_2	1.18	23.47	0.0164	0.564	1.0290	0.0314	8.40
S_2N_3	1.27	25.10	0.0207	0.653	1.0540	0.0344	19.80
S_2N_4	1.26	24.80	0.0198	0.620	1.0450	0.0333	18.45
S_3N_0	1.09	21.10	0.0121	0.468	0.9620	0.0294	4.30
S_3N_1	1.17	22.63	0.0152	0.516	1.0040	0.0304	5.56
S_3N_2	1.21	23.97	0.0171	0.589	1.0290	0.0329	14.10
S_3N_3	1.24	24.37	0.0171	0.608	1.0360	0.0306	13.24
S_3N_4	1.23	24.40	0.0171	0.612	1.0420	0.0325	11.81
SEm ±	0.01	0.06	0.00034	0.0040	0.02900	0.00085	0.93
C.D. 5%	0.03	0.17	0.00100	0.0130	0.08400	0.00247	2.75

and inversely related to crop conductance. They proposed that reduced WUEDM, shortage of nitrogen results from a reduction in radiation use efficiency proportionally greater than the fall in conductance Caviglia and Sadras (2001). If all leaves have the same daily photosynthetic radiation use efficiency, than the whole canopy possessed the same Haxeltine and Prentice (1996). The results showed the influence of nitrogen nutrient in increasing chlorophyll content in leaves as the nitrogen is involved in chloroplast development and is essential component of chlorophyll molecule Pirjal et al. (1971), Khalil et al. (1992), Panwar and Singh (2000).

Row-spacing of 30cm possessed the higher photosyntically active radiation (PAR) interception which had reflected in its highest CO_2 and H_2O utilization which are the key factors in influencing the photosynthetic productivity of the whole crop stand. Higher stomatal conductance and transpiration rates were also noted in the same row- spacing, traits beneficial in terms of CO_2 and PAR uptake as long as the water availability is in abundance. The genotypes produced higher seed yield also showed higher value of net photosynthesis and stomatal conductance Kalpana et al. (2003). The rate of photosynthesis was positively correlated with stomatal conductance, transpiration rate, leaf temperature and grain yield Singh et al. (1997). Increased CO_2 concentration of air to 400 ppm reduced the transpiration rate of corn by causing the stomata to close completely Pollas et al. (1975).

Table 2. Physiological parameters as influenced by various treatments

Treatment	PAR (µmol/m²/s)	Stomatal Conductance (mmol/m²/s)	Transpiration rate (mmol/m²/s)	Net Photosynthesis (µmol/m²/s)	CO_2 utilization (ppm)	H_2O utilization (KPa)
Main Treatments (Row –spacings)						
S_1 (15 cm)	1011.53	108.93	2.67	18.12	65.73	0.356
S_2 (30 cm)	1167.53	116.93	3.39	21.55	74.00	0.420
S_3 (45 cm)	1156.27	116.40	3.16	20.68	72.27	0.397
SEm ±	17.00	0.29	0.01	0.33	0.42	0.005
C.D. 5%	66.75	1.14	0.04	1.31	1.66	0.018
Sub Treatments (N levels)						
N_0 (Control)	885.22	106.33	1.93	16.78	61.33	0.295
N_1 (40 kg/ha)	1074.33	110.89	2.79	19.30	68.33	0.379
N_2 (60 kg/ha)	1128.89	115.22	3.39	20.19	72.11	0.408
N_3 (80 kg/ha)	1250.56	118.22	3.55	22.58	75.22	0.438
N_4 (100 kg/ha)	1219.89	119.78	3.70	21.76	76.33	0.434
SEm ±	22.26	0.50	0.02	0.29	0.61	0.004
C.D. 5%	64.97	1.45	0.05	0.86	1.77	0.013
Interactions (Row – spacings × N levels)						
S_1N_0	888.33	106.33	1.98	15.70	58.00	0.291
S_1N_1	970.00	102.33	2.35	18.00	63.67	0.352
S_1N_2	996.33	109.67	2.87	18.17	66.33	0.364
S_1N_3	1118.00	111.67	2.97	19.60	69.67	0.394
S_1N_4	1085.00	114.67	3.17	19.16	71.00	0.378
S_2N_0	824.00	104.00	2.15	17.00	64.67	0.310
S_2N_1	1197.33	117.33	3.36	21.23	73.33	0.415
S_2N_2	1159.00	116.00	3.59	20.53	72.33	0.421
S_2N_3	1338.67	124.67	3.89	25.00	80.33	0.487
S_2N_4	1318.67	122.67	3.94	24.00	79.33	0.466
S_3N_0	943.33	108.67	1.66	17.63	61.33	0.283
S_3N_1	1055.67	113.00	2.65	18.66	68.00	0.370
S_3N_2	1231.33	120.00	3.70	21.87	77.67	0.440
S_3N_3	1295	118.33	3.79	23.14	75.67	0.433
S_3N_4	1256.00	122.00	3.98	22.13	78.67	0.458
SEm ±	38.55	0.86	0.03	0.51	1.05	0.01
C.D. 5%	112.53	2.50	0.08	1.49	3.06	0.02

The stomatal conductance maximum is a numerical measure of the maximum rate of passage of either water vapour or CO_2 through the stomata. It plays an important role in the plant atmosphere water exchange and hence is a key parameter in many ecological models. Diffusion of CO_2 into leaves and water vapour from the leaves to the atmosphere is mainly drives by the stomatal aperature, which is controlled by a complex system of plant physiological processes. If speed of conductance is too great plant transpires a lot of water and soil dries out placing the plant in water stress. To avoid the condition plants try to some extent to control the speed of transpiration by closing the stomata when the sun is bright Chen et al. (1999). However, the speed of photosynthesis depends on being able to release the CO_2 produced into the atmosphere, so closing the stomata too much as far too long reduces photosynthesis, so plants keep opening and closing of stomata to keep a middle line between the two constraints.

Among subtreatments N level 80 kg/ha (N_3) was found to be associated with the higher magnitudes of these physiological traits which may be attributed to the development of efficient canopy architecture for exploitation of growth factors resulting in higher uptake

Table 3. Yield Components and Yields as influenced by various treatments

Treatments	Plant height (cm)	No. of Branches/plant	No. of pods/plant	No. of seeds/pod	1000 seed weight (g)
Main Treatments (Row –spacings)					
S_1 (15 cm)	39.25	18.33	248.47	10.83	1.53
S_2 (30 cm)	47.91	22.57	272.20	12.67	1.66
S_3 (45 cm)	45.59	20.91	263.53	12.07	1.63
SEm ±	0.57	0.07	0.76	NS	0.01
C.D. 5%	2.25	0.26	2.98	NS	0.04
Sub Treatments (N levels)					
N_0 (Control)	34.66	16.76	228.78	9.39	1.44
N_1 (40 kg/ha)	42.67	19.53	256.78	11.67	1.57
N_2 (60 kg/ha)	45.08	20.26	264.11	12.22	1.63
N_3 (80 kg/ha)	49.89	23.31	279.44	13.06	1.69
N_4 (100 kg/ha)	48.96	23.16	277.89	12.94	1.71
SEm ±	0.56	0.27	1.19	0.43	0.01
C.D. 5%	1.65	0.80	3.47	1.24	0.04
Interactions (Row – spacings × N levels)					
S_1N_0	32.37	16.07	223.33	8.00	1.41
S_1N_1	39.80	18.60	248.67	11.33	1.51
S_1N_2	38.32	17.73	244.33	11.00	1.54
S_1N_3	44.07	20.10	265.67	12.00	1.61
S_1N_4	41.70	19.13	260.33	11.83	1.60
S_2N_0	36.81	17.40	234.33	10.83	1.49
S_2N_1	46.18	20.40	269.00	12.17	1.62
S_2N_2	47.94	21.03	275.33	12.67	1.64
S_2N_3	55.10	27.67	293.33	14.00	1.75
S_2N_4	53.53	26.33	289.00	13.67	1.78
S_3N_0	34.81	16.80	228.67	9.33	1.43
S_3N_1	42.05	19.60	252.67	11.50	1.58
S_3N_2	48.98	22.00	272.67	13.00	1.70
S_3N_3	50.49	22.17	279.33	13.17	1.71
S_3N_4	51.64	24.00	284.33	13.33	1.74
SEm ±	0.98	0.47	2.06	NS	0.02
C.D. 5%	2.85	1.38	6.00	NS	NS

of PAR which in turn might have reflected in the higher net photosynthesis. Treatment combinations of 30 cm row-spacing with 80 kg N/ha (S_2N_3) was found to be associated with the higher performance of PAR uptake, stomatal conductance, transpiration rate, net photosynthesis, CO_2 and H_2O utilization. 25 % light intensity was found to reduce the transpiration rate by 50% Bhatt et al. (2006).

Row-spacing of 30cm possessed the highest magnitudes of plant height, no. of branches/plant, no. of pods/plant, no. of seeds/pod, 1000 seed weight and HI (Table 3-4) which in turn had reflected in highest herbage and seed productivity. The higher productivity in this treatment may be attributed to the optimum crop stand geometry and canopy architature for exploitation of growth factors.

80 kg/ha N level was found to be associated with maximum herbage as well as seed yields due to higher magnitudes of yield components. Higher N levels were found to increase plant height, pod number (Butter and Aulakh 1999), branch number, herbage and dry leaf yields (Subramanian, 2008), (Balyan et al. 1987). Treatment combinations S_2N_3 (30cm row-spacing + 80 kg N/ha) recorded the maximum seed and herbage productivity, whereas S_1N_0 (15 cm row-spacing + 0 kg N/ha) the minimum.

Table 4. Herbage Yield and seed yield as influenced by various treatments

Treatments	Herbage yield (g/plant)	Herbage yield (kg/ha)	Seed Yield (g/plant)	Seed Yield (kg/ha)	Harvest Index
Main Treatments (Row –spacings)					
S_1 (15 cm)	17.51	4289.68	2.53	959.40	11.06
S_2 (30 cm)	25.43	5876.20	3.15	1088.20	14.34
S_3 (45 cm)	23.63	5552.32	2.76	1045.67	13.23
SEm ±	0.65	60.95	0.02	4.63	0.32
C.D. 5%	2.57	239.29	0.07	1.18	1.27
Sub Treatments (N levels)					
N_0 (Control)	14.11	3322.17	2.14	826.00	9.72
N_1 (40 kg/ha)	19.98	5020.33	2.71	1013.78	12.10
N_2 (60 kg/ha)	22.68	5405.34	2.75	1055.11	12.80
N_3 (80 kg/ha)	28.02	6475.66	3.27	1135.56	15.40
N_4 (100 kg/ha)	26.17	5973.50	3.19	1125.00	14.34
SEm ±	0.64	70.33	0.03	1.62	0.28
C.D. 5%	1.86	205.28	0.08	4.74	0.82
Interactions (Row – spacings × N levels)					
S_1N_0	12.77	3098.77	1.99	778.67	9.13
S_1N_1	17.94	4273.83	2.62	955.67	11.27
S_1N_2	16.83	3922.55	2.49	923.00	10.90
S_1N_3	21.02	5561.10	2.78	1088.67	12.45
S_1N_4	19.00	4592.17	2.75	1051.00	11.55
S_2N_0	15.26	3608.25	2.15	871.33	10.27
S_2N_1	22.62	5717.83	2.81	1099.00	12.74
S_2N_2	24.89	6008.53	2.84	1118.33	13.38
S_2N_3	33.23	7198.23	4.06	1181.33	18.95
S_2N_4	31.17	6848.13	3.88	1171.00	16.34
S_3N_0	14.30	3259.49	2.28	828.00	9.77
S_3N_1	19.37	5069.34	2.68	986.67	12.30
S_3N_2	26.33	6284.93	2.92	1124.00	14.13
S_3N_3	29.81	6667.63	2.96	1136.67	14.81
S_3N_4	28.35	6480.20	2.93	1153.00	15.14
SEm ±	1.11	121.81	0.04	2.81	0.49
C.D. 5%	3.23	355.56	0.13	8.21	1.42

Conclusions

Thus the investigations revealed that 30 cm row-spacing, 80 kg nitrogen/ha and their interactions were associated with maximum seed and herbage yields owing to the higher magnitudes of leaf dry matter, total DM production, LAI, LAD, CGR, RGR, SLA, PAR absorption, net photosynthesis, stomatal conductance, transpiration rate, chlorophyll index, radiation use efficiency, CO_2 and H_2O utilization reflected in maximum no. of branches, no. of pods/plant, no. of seeds/pod, 1000 seed weight, HI and subsequently economic productivity.

प्रस्तुत अन्वेषण जवाहरलाल नेहरू कृषि विश्वविद्यालय के फसल कार्यकी अनुसंधान क्षेत्र में तीन कतार अंतरो क्रमाशः 15, 30 एवं 45 से.मी. एवं पॉच नत्रजन स्तरों क्रमशः 0, 40, 60, 80 एवं 100 कि.ग्रा.हे. का ऊर्जा उपयोग क्षमता, कार्यकीय पैमाने एवं उत्पादकता पर प्रभाव जानने हेतु खरीफ 2008-09 में किये गये। 30 से.मी. कतार अंतर, 80 कि.ग्रा./हे. नत्रजन स्तर एवं उनका मिश्रण उत्पादकता में सर्वोत्तम था, जिसका कारण अधिक पौध शुष्क भार पत्ती क्षेत्रफल सूचक, पत्ती क्षेत्रफल अवधि, फसल वृद्धि दर, आपेक्षिक वृद्धि दर, विशिष्ठ पत्ती क्षेत्रफल, शुध्द लाभ प्रकाश-संस्लेषण, वातरंध्र संचालन, कार्बन डाईआक्साइड, एवं पानी उपयोग, उस्वदेन दर, ऊर्जा उपयोग क्षमता एवं क्लोरोफिल

सूचक पाया गया ।

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Population dynamics of surface herb flora in plantation forests of Jabalpur, Madhya Pradesh

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Abstract

Population dynamics of surface herb flora in 25 year old plantation forests of Jabalpur, Madhya Pradesh, viz. *Acacia auriculiformis*, *Tectona grandis*, *Hardwickia binata*, *Eucalyptus camadulensis*, *Albizia porcera* and *Terminalia arjuna,* have been measured in the present study. The plantations recorded the occurrence of total 281 species belonging to 171 genera and 58 families of surface herb flora. Among different plantations, *T. arjuna* recorded the maximum species richness (178 species, 119 genera and 44 families), and *H. binata* recorded the minimum species richness (155 species, 108 genera and 34 families). The herbaceous ground flora of all the plantations witnessed a high turnover rate of species according to the seasons, with the maximum during rainy and the minimum during summer seasons. Shannon-Weiner index of diversity showed much variation with respect to different plantations varying from 2.72 to 3.64. The maximum index of diversity (3.64) was noted in *A. procera* plantation, followed by that in *A. auriculiformis* (3.59), *E. camadulensis* (3.55), *T. grandis* (3.48), *H. binata* (3.44), and *T. arjuna* (3.33) plantations. The index of equitability varied narrowly from 0.9 to 0.99. The coefficient of dominance showed inverse relationship with the diversity index and ranged between 0.02 and 0.09. The maximum value (0.09) was recorded in *A. auriculiformis* plantation, followed by *T. grandis* (0.08), *H. binata* and *T. arjuna* (0.07), *E. camadulensis* (0.06), *A. procera* (0.02). The species richness recorded wide variation from an average of 18 to 42, with the maximum in *A. procera*, followed by *A. auriculiformis*, *E. camadulensis*, *T. grandis*, *H. binata*, and *T. arjuna* plantation. The density also recorded large variation among different plantations varying from an average of 274 to 758.8 plants m^{-2}, with the maximum in *T. grandis* and the minimum in *T. arjuna* plantation. The standing crop biomass varied from 60.2 to 288 g dw m^{-2} among different plantations without any notable seasonal differences. High values of indices of diversity and equitability may denote good ecological health of these plantations. A high turnover of species together with low similarity between plantations in a small geographical area indicates high sustainability status of the plantations.

Key words: Surface herb flora, biodiversity, indices of diversity, density, tropical deciduous forest plantations

Biological diversity means the variability among living organisms from all sources including inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part. This includes diversity within species, between species and of ecosystems (CBD 1992). Biodiversity refers to the variability within the ecological complex where it exists and that is essential for proper functioning of the ecosystem (CBD 1992). It is a vital provider of goods and services to the sustenance of the present and future human civilizations. However, today human themselves are posing the greatest threat to the quality and quantity of biodiversity, resulting in its wide spread losses and aberration in ecosystem functions and stability (CBD 1992).

Diversity can be studied at three different scales

Alpha diversity

The species diversity within a community or habitat that responds to a balance between the actions of local biotic and abiotic elements and immigrations from other locations. This comprises of two components, i.e. species richness and evenness that can be measured by variety of indices even including taxonomic diversity in Avalanch index (Ganeshaia 1998).

Beta diversity

It is the inter community diversity that expresses the rate of species turnover per unit change in habitat and can be assessed by a variety of indices (Schluter and Ricklefs

1993).

Gama diversity

The overall diversity at the landscape level that includes a and b diversities (Schluter and Ricklefs 1993).

Threats to Biodiversity

Human activities are directly and indirectly responsible for current high rates of biodiversity loss. Some of the major issues are:

Habitat loss, fragmentation and degradation result due to agricultural activities, extraction (i.e mining, fishing, logging and harvesting) and development (i.e. human settlements, industry and associated infrastructure). Habitat loss and fragmentation lead to the formation of isolated, small, scattered populations. These small populations are increasingly vulnerable to inbreeding depression, high infant mortality and are susceptible to stochastic environmental events, and consequently, possible extinction. Changes in forest composition and quality, and the resultant habitat type lead to decline in primary food species for wildlife due to following reasons (SoE 2009):

- Poaching and hunting
- Invasive species
- Over-exploitation of wild bio resources
- Pollution of atmosphere, water and soil
- Global climate change

Habitat destruction

The primary causes of loss of biodiversity is not direct human exploitation but habitat destruction that inevitably results from the expansion of human population and activities in many countries particularly on island and where human population density is high. Most of the original habitat has been destroyed. More than 50% for wildlife habitat has been destroyed in 49 out of 61 old world tropical countries (IUCN, UNEP, GEF 2001)

Habitat fragmentation

Habitat that formerly occupied wide areas are now often divided into pieces by roads, agriculture fields, towns, canals, power lines, etc. The continuous area of habitat is both reduced in area and divided into two or more fragments. Habitat fragmentation may limit the potential of species for dispersal and colonization. It also reduces the foraging ability of animals. It causes such edge effects as microclimatic changes in light, temperature, wind, etc.

A significant loss is also taking place due to introduction of exotic species, high levels of disease incidence and excessive exploitation of particular species by people, and shift or Jhum cultivation, etc.

Ground flora is an important component of forest floor because it provides a wide array of goods and services to the ecosystem in addition to its valuable gene diversity. It conserves soil, maintains nutrients, provides crucial support to wild animals and supplies fodder, food and medicines to humans. Diversity and production of ground flora under plantation forests vary with the age and type of tree species, soil structure and climate (Mathur and Soni 1983; Singh et al. 1986; Rajvanshi et al.1983; Singh et al. 2001; Sharma et al. 2002; Khanna et al. 1989).

Various workers, in different forest ecosystems throughout the world, have conducted studies on plant diversity. Monk (1967) and Risser and Rice (1971) have found diversity indices ranging from 1.49 to 3.40 for deciduous forests of North America and for temperate forests of New world. Knight (1975) reported diversity index value of 5.06 to 5.40 for tropical forests. Simpson (1964) has attributed the lower diversity and greater concentration of dominance in temperate vegetation to lower rates of evolution and diversification of communities. Whittaker (1975) proposed the niche preemption hypothesis for dominance diversity curves. According to him, the geometric forms of the dominance diversity curves of vascular plant communities show low diversity.

Species diversity and vegetation structure in tropical dry deciduous forest ecosystems of India have been studied in details by several workers (Shah et al. 1978; Shah and Bhatt 1980; Verma and Das 1981; Banerjee and Lal 1985; Sharma et al. 1986; George and Verghese 1993; Khare et al. 1989; Choudhary et al. 1986).

An ecological equilibrium, however, is never static and is a dynamics process (Huston 1994). Within each community, there is circulation of matter and flow of energy resulting in dynamics equilibrium. It is not an actual equilibrium but always has a tendency to re-establish if left undistributed. Unfortunately, human interference does not leave it as such. Studies dealing with distribution of individual species of various classes,

association between species, pattern of dispersion and various indices of diversity are considered very important in understanding three dimensional structure of the forest. Plant diversity is enhanced during the later stages of succession with maximum in mid succession (Huston 1994). Spatial variation in soil water, nutrients or texture is almost always reflected by pattern in the communities of plant and other organisms growing on the soil. Diversity in early succession can be high or low, depending on propagule input, soil nutrient availability and their affect on growth rates and competitive interactions. Diversity does not always increase with productivity or the environmental conditions that influence productivity. However, productivity can be either negatively or positively correlated with species diversity (Huston 1994).

No systematic information is available on the population dynamics of herbs in man- made ecosystems. Hence, studies were undertaken to determine spatial and temporal patterns of diversity with following objectives:

1. To asses the surface herb flora under plantation of different tree species.
2. To study the seasonal variation in surface herb flora under plantation forests.

Material and methods

Study site

Six plantations (95.1ha) located in the campus of the State Forest Research Institute situated on the southern fringe of Jabalpur city with coordinal points 79^0 56' E Longitude and 23^{0}10' N Latitude, 400 on AMSL were chosen for study. The topography of the area was undulating with lush green natural vegetation. The climate of Jabalpur is governed by the monsoon pattern (1403.72 mm) and the year may be divided into three season, viz. summer (March to mid June), winter (November to February) and rainy (mid June and end in October) (Fig.1). The present study was under taken in

Table 1. Description of plantations

Common name	Botanical name	Year	Compartment number	Area (ha)	Number of trees ha^{-1} Originally raised	Surviving	%
Acacia	*Acacia auriculiformis*	1978	24	0.4	720	593	82
Teak	*Tectona grandis*	1978	5	0.38	658	384	58
Anjan	*Hardwickia binata*	1980	8	0.21	2100	1533	73
Eucalyptus	*Eucalyptus camadulensis*	1981	9	0.47	834	453	54
Albizia	*Albizia procera*	1978	11	0.34	594	268	45
Arjun	*Terminalia arjuna*	1978	40	0.20	1250	515	41

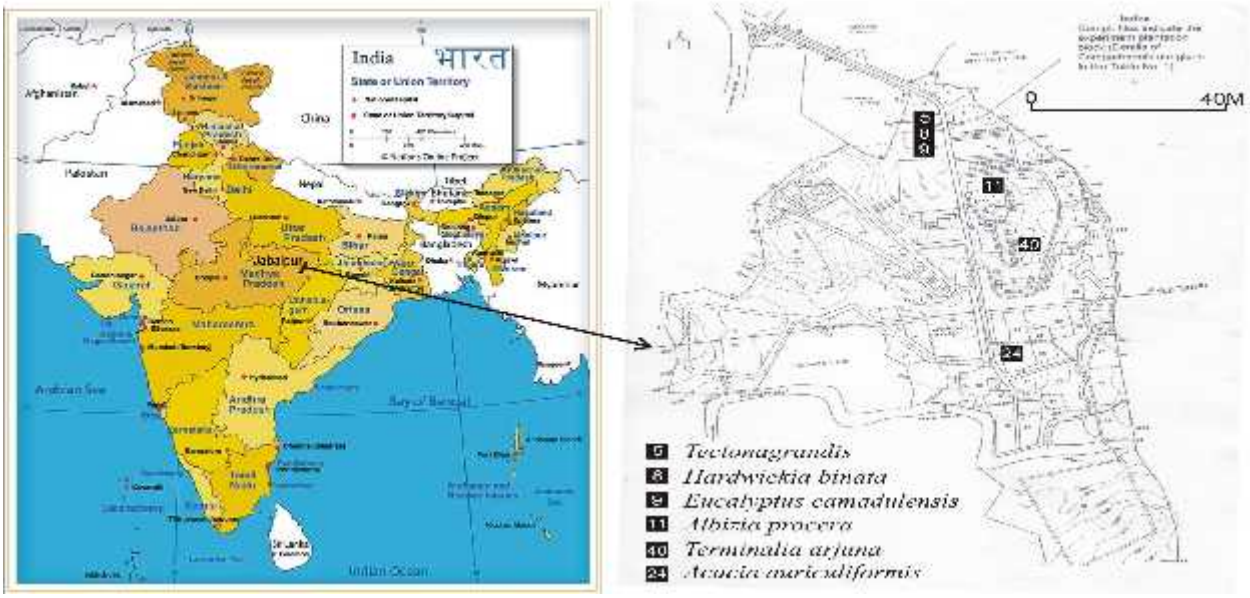

Fig.1. Location of study site

the six plantations (Table 1).

a Diversity was measured by Shannon- Weiner index of diversity (H) (Magurran 1988), McIntosh index of species richness (S) (McIntosh 1967), and Simpson's index of dominance (Simpson 1949).

(1) Shannon Weiner index of diversity (H)

$$H = -\sum_i P_i l_n P_i$$

Where, P_i = ni/N. ni is the number of individuals of a species and N is the total number of individuals of all the species.

(2) McIntosh index of species richness (S)

S= Total number of species

(3) Simpson's index of dominance (Cd)

$$Cd= \sum_i P_i^2$$

(4) Shannon- Weiner index of equitability (J)

$$J = \frac{H}{lns}$$

b Diversity was calculated by Sorenson's Similarity index

(1) Sorenson's similarity index (S.I.)

The Similarity index between pairs of communities was calculated following Sorenson's formula (Gupta and Shukla 1991)

$$\text{Similarity index} = \frac{2C}{A+B} \times 100$$

Where,

A = Total number of species in Community A

B = Total number of species in Community B

C= Total number of species common to both the Communities

Result and Discussion

Floristic composition of surface ground flora

The distribution of surface ground flora of 25 years old six different tree species, viz. *A. auriculiformis, T. grandis, E. camadulensis, H. binata, A. procera* and *T. arjuna*, exhibited significant variations in numbers of species (Table 2). The herbaceous flora of *A. auriculiformis* plantation comprised of a total of 162 species belonging to 107 genera and 43 families. *T. grandis* plantation comprised of a total 160 species belonging to 106 genera and 37 families. *H. binata* plantation comprised of a total 155 species belonging to 108 genera and 34 families. *E. camadulensis* plantation comprised of a total 161 species belonging to 114 genera and 37 families. *A. procera* plantation comprised of a total 161 species belonging to 106 genera and 39 families. *T. arjuna* plantation comprised of a total 178 species belonging to 119 genera and 44 families. Among different plantations, *T. arjuna* recorded the maximum species richness (178 species, 119 genera and 44 families), and *H. binata* recorded the minimum species richness (155 species, 108 genera and 34 families). The herbaceous flora of all the plantations consisted of a total 281 species belonging to 171 genera and 58 families (Table 2). Sonkar et al. (2005) have registered changes in ground flora diversity and productivity due to plantation of six tree species, viz. *Azadirachta indica* (Neem), *Bauhunia vahlii* (Kachnar), *Eucalyptus camadulensis* (Eualyptus), *Emblica officinalis* (Anola) and *Pongamia pinnata* (Karang), raised in degraded land in Karaboh area in East forest Division, Chhindwara (M.P.). After six years of planting, the ground flora consisted of 21 species in ~~*E. officinalis*, followed by 17 in *P. pinnata*, 16 in *B. vehlai*~~ and 14 each in *A. indica* and *E. camadulensis* plantations.

Table 2. Floristic composition of surface herb flora in different plantations at State Forest Research Institute Jabalpur

Name of the plantation	Families	Genera	Species
A. auriculiformis	43	107	162
T. grandis	37	106	160
H. binata	34	108	155
E. camadulensis	37	114	161
A. procera	39	106	161
T. arjuna	44	119	178
Total	58	171	281

Poaceace recorded the maximum number of genera (34) and species (51), was followed by Fabaceae with 20 species and 9 genera; Asteraceae, Euphorbiaceae, Malvaceae each with 17 species belonging to 12, 5 and 7 genera respectively; Cyperaceae (15 species and 4 genera); Lamiaceae and Papilionaceae with12 species each belonging to 9 and 6 genera, respectively, Tiliaceae (10 species and 2 genera); Acanthaceae (9 species and 7 genera); Amaranthaceae (8 species and 4 genera); Commelinaceae (6 species and 5 genera); Cesalpinaceae, Oxaliadaceae, Rubiaceae, Scorophularaceae with 5 species belonging to 1, 3, 3 and 2 genera, respectively; Convolvulaceae and Dioscoreaceae with 4 species each belonging to 2 and 1 genera, respectively; Apocynaceae, Asclepiadaceae, Cucurbiataceae, Gentianaceae, Polygonaceae and Solanaceae with 3 species each belonging to 3, 3, 3, 2,

3, 2 genera, respectively; and Basellaceae, Cappariadaceae, Caryophyllaceae, Liliaceae, Menispermaceae, Mimosaceae, Zingiberaceae with 2 species each belonging to 1, 2, 2, 2, 2, 2, 1 genera, respectively. Twenty seven families were represented by only 1 species and 1 genera, viz. Apiaceae, Araceae, Aristolochiaceae, Averrhoaceae, Begoniaceae, Boraginaceae, Celastraceae, Ceratophyllaceae, Chenopodiaceae, Costaceae, Elatinaceae, Leeaceae, Lythraceae, Malpighiaceae, Martyniaceae, Nyctaginaceae, Orchidaceae, Papaveraceae, Plumbaginaceae, Portulacaceae, Rutaceae, Smilaceae, Sterculiaceae, Tamaricaceae, Verbenaceae, Vitidaceae and Zygophyllaceae (Table 3).

Index of diversity

The index of diversity increased during the winter season, decreased during the summer season, and increased again during the rainy season. Such a seasonal trend was observed in all the plantations (Fig. 3). In *A.*

Table 3. Distribution of families, genera and species of surface herb flora in all the plantations at State Forest Research Institute Jabalpur

Name of Family	Number of species	Name of genera	Name of Family	Number of species	Name of genera
Acanthaceae	9	7	Leeaceae	1	1
Amaranthaceae	8	4	Liliacece	2	2
Apiaceae	1	1	Lythraceae	1	1
Apocynaceae	3	3	Malpighiaceae	1	1
Araceae	1	1	Malvaceae	17	7
Aristolochiaceae	1	1	Martyniaceae	1	1
Asclepiadaceae	3	3	Menispermaceae	2	2
Asteraceae	17	12	Mimosaceae	2	2
Averrhoaceae	1	1	Nyctaginaceae	1	1
Basellaceae	2	1	Orchidaceae	1	1
Begoniaceae	1	1	Oxalidaceae	5	3
Boraginaceae	1	1	Papaveraceae	1	1
Capparidaceae	2	2	Papilionaceae	12	6
Caryophyllaceae	2	2	Plumbaginaceae	1	1
Ceasalpinaceae	5	1	Poaceae	51	34
Celastraceae	1	1	Polygonaceae	3	3
Ceratophyllaceae	1	1	Portulacaceae	1	1
Chenopodiaceae	1	1	Rubiaceae	5	3
Commelinaceae	6	5	Rutaceae	1	1
Convolvulaceae	4	2	Scrophulariaceae	5	2
Costaceae	1	1	Smilaceae	1	1
Cucurbitaceae	3	3	Solanaceae	3	2
Cyperaceae	15	4	Sterculiaceae	1	1
Dioscoreaceae	4	1	Tamaricaceae	1	1
Elatinaceae	1	1	Tiliaceae	10	2
Euphorbiaceae	17	5	Verbenaceae	1	1
Fabaceae	20	9	Vitidaceae	1	1
Gentianaceae	3	2	Zingiberaceae	2	1
Lamiaceae	12	9	Zygophyllaceae	1	1

Table 4. Similarity index matrix (β diversity) of herbaceous flora among different plantations at State Forest Research Institute Jabalpur

	A. auriculiformis	*T. grandis*	*H. binata*	*E. camadulensis*	*A. procera*	*T. arjuna*
A. auriculiformis	-	0.72	0.64	0.62	0.69	0.61
T. grandis	0.72	-	0.68	0.59	0.39	0.54
H. binata	0.64	0.68	-	0.61	0.58	0.49
E.camadulensis	0.62	0.59	0.61	-	0.53	0.63
A. procera	0.69	0.39	0.58	0.53	-	0.43
T. arjuna	0.61	0.54	0.49	0.63	0.43	-

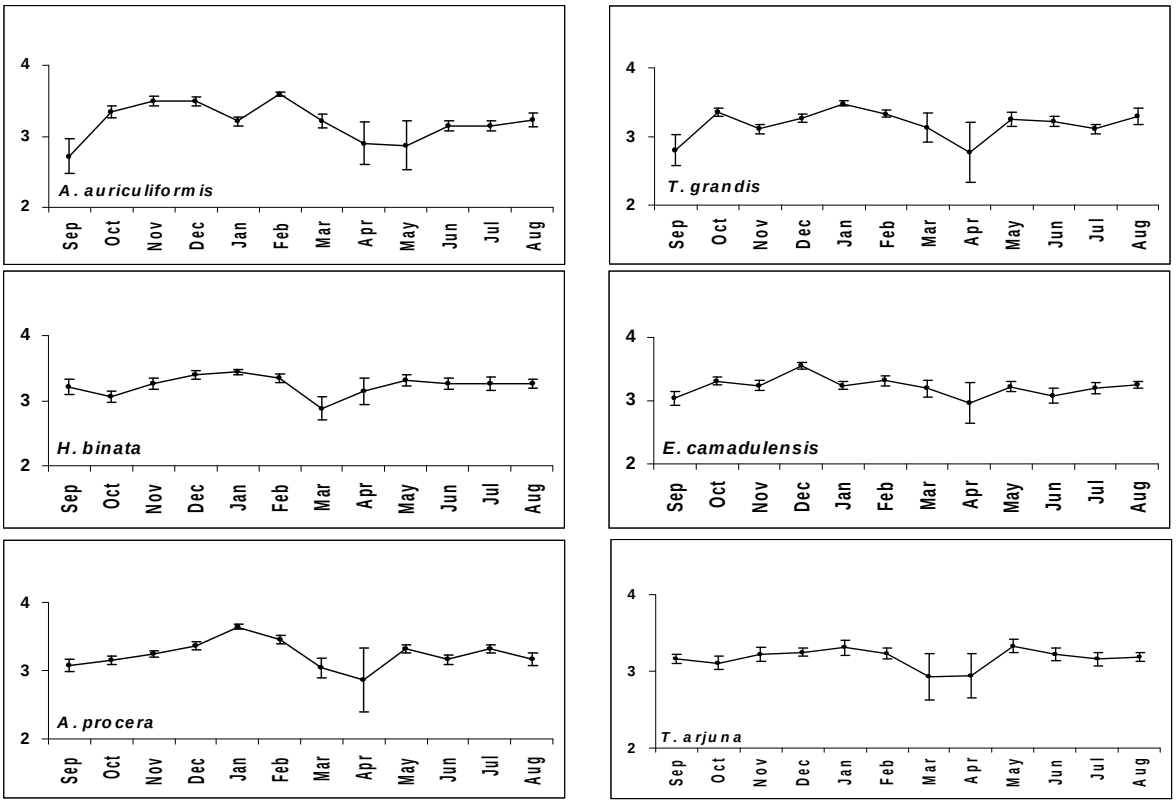

Fig. 3. Monthly variation in Shannon-Weiner index of diversity of ground flora in different plantations (Values are mean ± standard deviation)

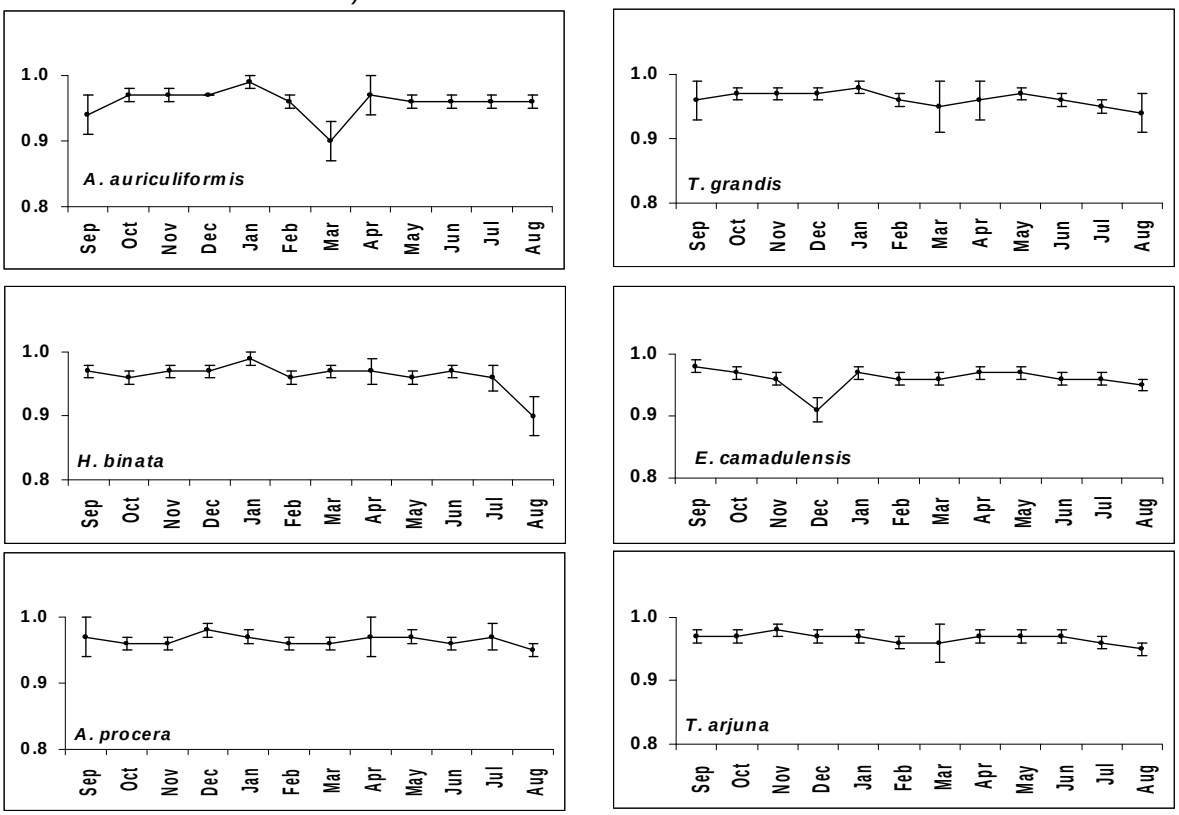

Fig. 4. Monthly variation in Shannon-Weiner index of equitability of ground flora in different plantations (Values are mean ± standard deviation)

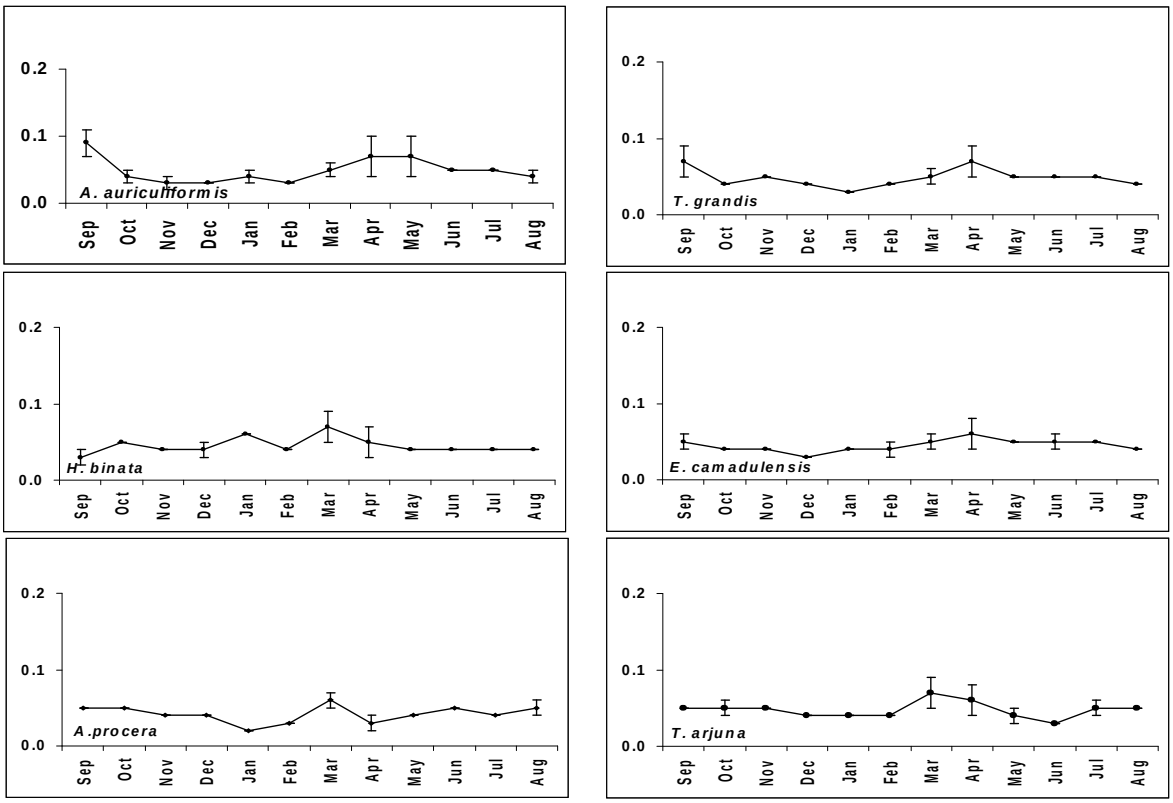

Fig. 5. Monthly variation in Simpson index of dominance of ground flora in different plantations (Values are mean ± standard deviation)

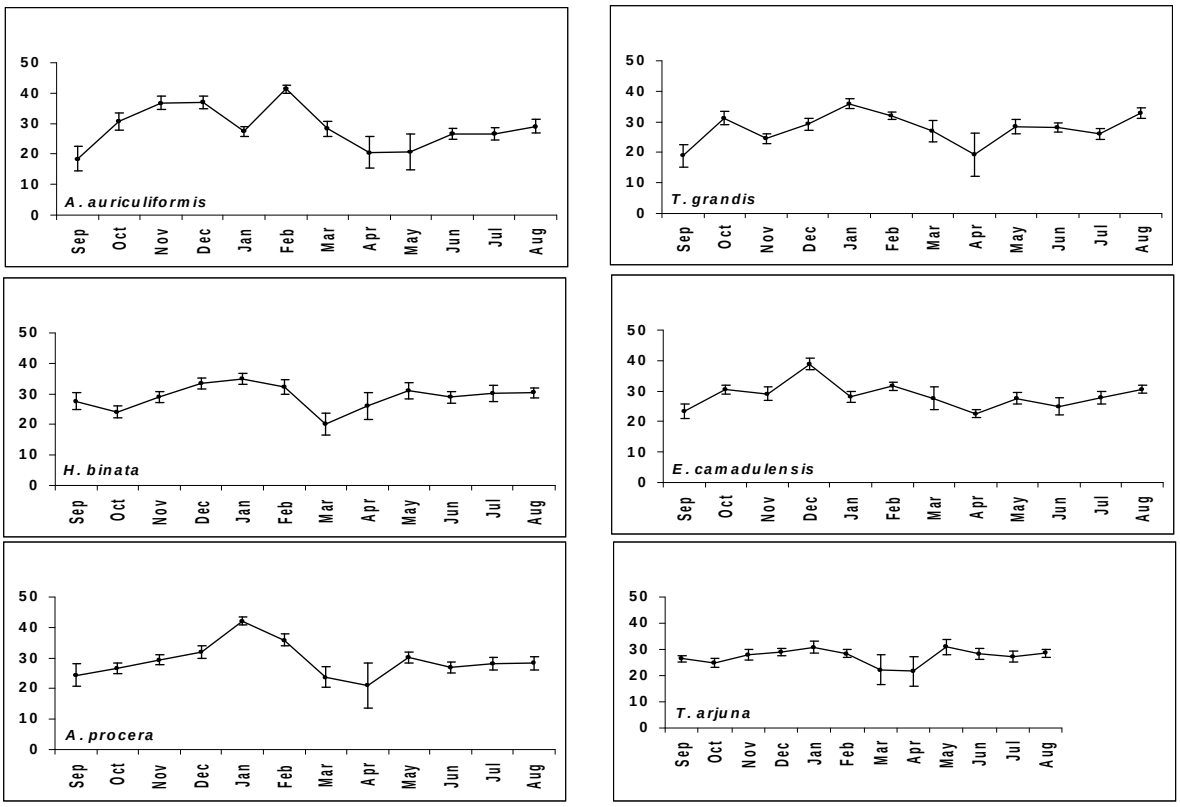

Fig. 6. Monthly variation in species richness of ground flora in different plantations (Values are mean ± standard deviation

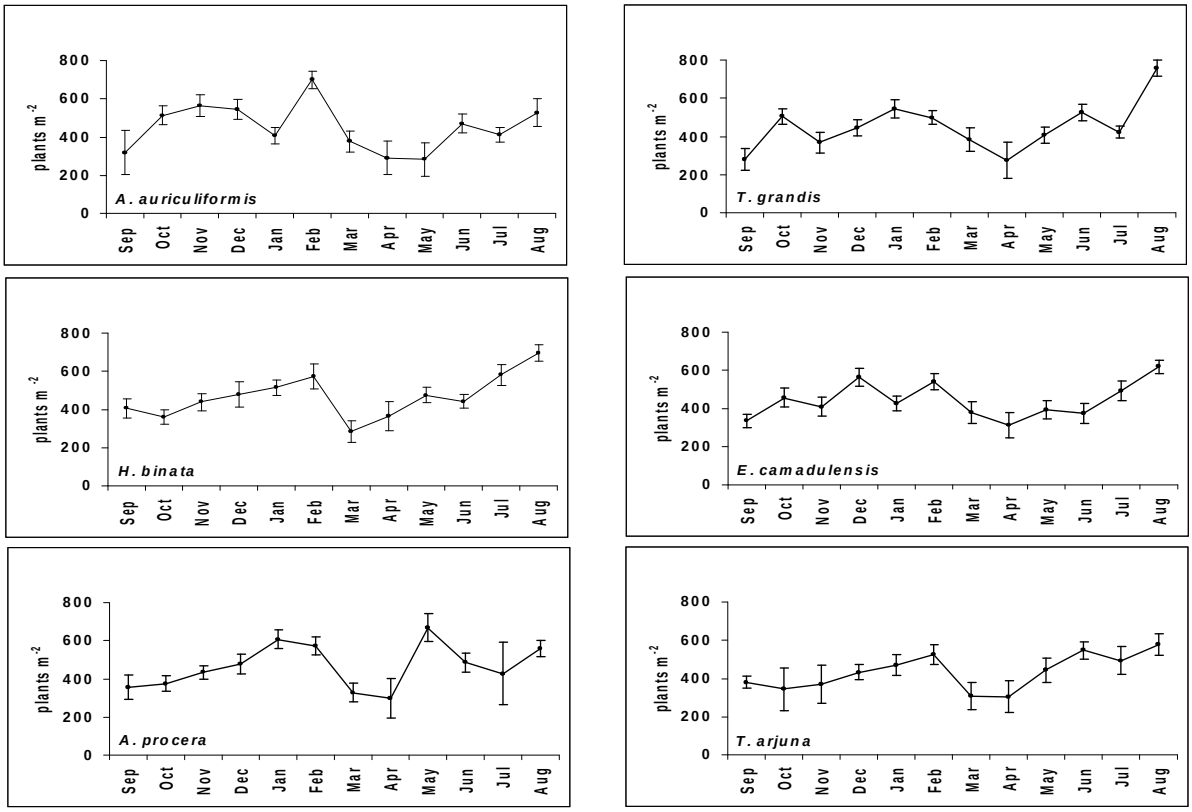

Fig. 7. Monthly variation in density (plants m^{-2}) of ground flora in different plantations (Values are mean ± standard deviation)

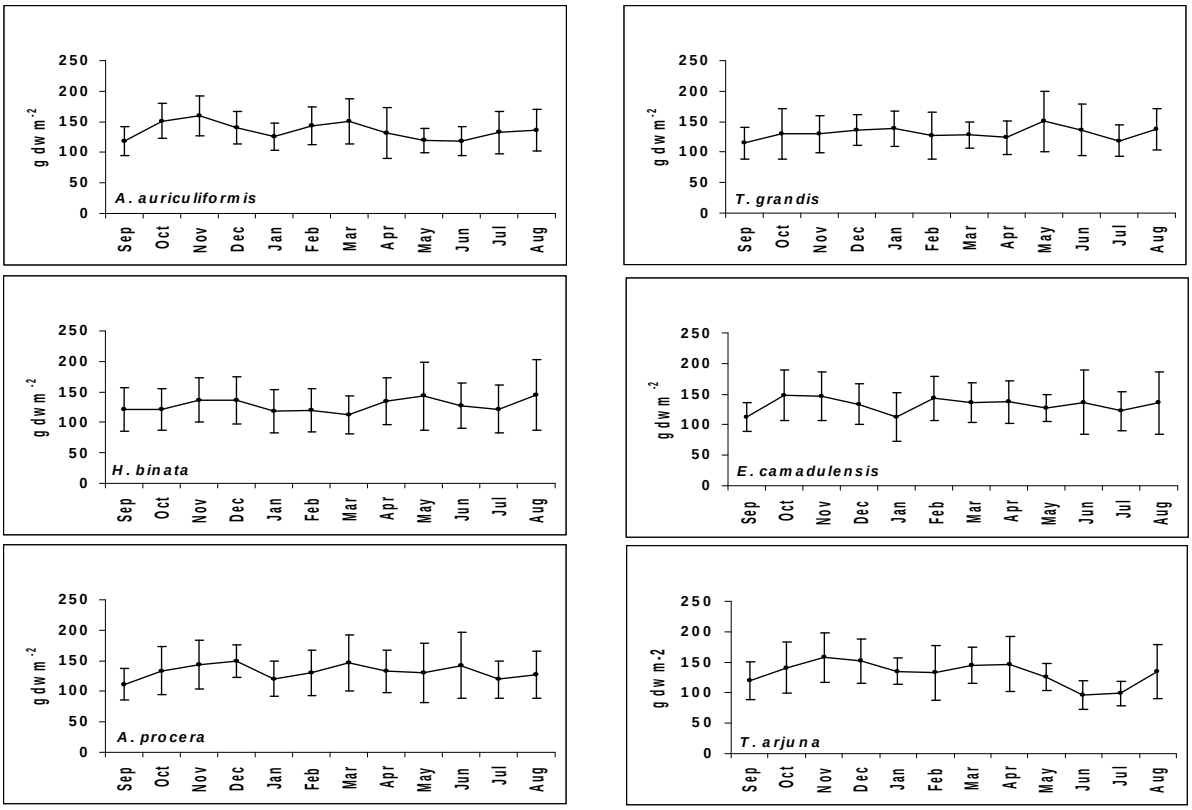

Fig. 8. Monthly variation in standing crop biomass (g dw m-2) of ground flora in different plantations (Values are mean ± standard deviation)

auriculiformis plantation, Index of diversity ranged from 1.98 to 3.66, with the maximum being observed during the period from October to February and the minimum from April to June. The area variability (measured as ratio of standard deviation to mean) was about 10% during the months of April, May and September, and less than 5% in the remaining months. In *T. grandis* plantation, it ranged from 1.68 to 3.57, with the maximum being recorded during the period from October to February and the minimum from March to May. The area variability was about 10% during the months of March, April, May, and September and less than 5% during the remaining months. In *H. binata* plantation, it ranged from 2.19 to 3.51, with the maximum being recorded during the period from November to February and the minimum from March and October. The area variability was always less than 10%. In *E. camadulensis* plantation, it ranged from 2.15 to 3.62, with the maximum being recorded from October to February and the minimum from March and May. The area variability was about 10% during the months of March, April, June and September and less than 5% in the remaining months. In *A. procera* plantation, it ranged from 2.13 to 3.68, with the maximum being observed from November to February and the minimum during March, April and September. The area variability was about 10% during the months of March, April and September and less than 5% in the remaining months. In *T. arjuna* plantation, it ranged from 2.05 to 3.44, with the maximum being recorded during the period from November to February and the minimum during March, July and October. The area variability was at least 10% during October, March, April and July and less than 5% in the remaining months (Fig. 3).

Index of equitability

The index of equitability did not record any significant monthly variation in different plantations (Fig. 4). It ranged from 0.84 to 1.0 in *A. auriculiformis*, 0.82 to 11.0 in *T. grandis*, 0.91 to 0.99 in *H. binata*, 0.92 to 0.99 in *E. camadulensis*, 0.87 to 0.99 in *A. procera*, and 0.88 to 1.0 in *T. arjuna* plantation. The values were generally less than 0.9 during summer and more than 0.9 during rainy season.

Index of dominance

The index of dominance increased during summer and decreased during winter season in all the plantations (Fig. 5). It was always less than 0.15. It varied from 0.1 to 0.15 in *A. auriculiformis*, 0.1 to 0.13 in *T. grandis*, 0.03 to 0.11 in *H. binata*, 0.03 to 0.13 in E. *camadulensis*, 0.03 to 0.08 in *A. procera*, and 0.04 to 0.14 in *T. arjuna* plantation.

Species richness

The species richness recorded similar seasonal pattern in different plantations, i.e. it increased during the winter, decreased sharply during the summer and increased again during the rainy season (Fig. 6). The maximum species richness was observed during the winter and the minimum during the summer season. It changed from 8 to 43 in *A. auriculiformis,* 6 to 38 in *T. grandis*, 12 to 37 in *H. binata*, 10 to 41 in *E. camadulensis*, 7 to 44 in *A. procera*, and 9 to 35 in *T. arjuna* plantation. The plantations like *A. auriculiformis* and *A. procera* recorded comparatively higher turnover of species as compared with that recorded in the remaining plantations.

Similarity index

The index of similarity of the surface herb flora in the *A. auriculiformis* with that of the other plantations was in the close range of 0.61 to 0.72, recording the maximum similarity with *T. grandis* and the minimum with *T. arjuna* plantation (Table 4). The similarity index of *T. grandis* with other plantations varied widely from 0.39 to 0.72, having the maximum similarity with *A. auriculiformis* and minimum similarity with *A. procera.* The index of similarity of *H. binata* plantation with that of other plantations was in the range of 0.49 to 0.68, showing high similarity with *A. auriculiformis* and *T. grandis* and low with *T. arjuna.* The herb flora of *E. camadulensis* plantation recorded a narrow range of similarity index (0.53 to 0.63) with other plantations. The index of similarity of *A. procera* with other plantations was in a broad range of 0.39 to 0.69, being the most similar with *A. auriculiformis* and the least similar to *T. grandis* and *T. arjuna.* The similarity index of *T. arjuna* plantation vis-a- vis other plantations was in the range of 0.43 and 0.63 (Table 4). The floristic composition of surface herb flora recorded in *A. auriculiformis* was highly similar to that of the other plantations, but that of *A. procera* was the least similar to that of the other plantations. Generally, the herbaceous flora of neighboring plantations, and even of barren lands, is reported to be highly similar by Verma et al. (2000), Pandey et al. (1988), Kunhikanan et al. (1998), Singh et al. (2004), Sonkar et al. (2005).

Density

The standing crop density of surface herb flora increased

sharply during the winter, decreased rapidly during the summer, and increased gradually during the rainy season. The herb density was the maximum in the winter and the minimum in the summer months (Fig. 7). Such a seasonal trend was observed in all the plantations. The herb density varied widely from 108 to 744 plants m^{-2} in *A. auriculiformis*, 46 to 840 plants m^{-2} in *T. grandis*, 168 to 728 plants m^{-2} in *H. binata*, 148 to 680 plants m^{-2} in *E. camadulensis*, 84 to 828 plants m^{-2} in *A. procera*, and 44 to 664 plants m^{-2} in *T. arjuna* plantation.

Standing crop biomass

The standing crop biomass of surface herb flora recorded insignificant seasonal variations but significant periodic changes within each month in all the plantations (Fig. 8). The biomass was the maximum in summer and the minimum in rainy months. It varied narrowly between 84.8 and 239.6 g dw m^{-2} in *A. auriculiformis*, 83.2 and 241 g dw m^{-2} in *T. grandis*, 80 to 238 g dw m^{-2} in *H. binata*, 81.2 to 239.6 g dw m^{-2} in *E. camadulensis*, 80.4 and 288.4 g dw m^{-2} in *A. procera*, and 60.2 and 239.8 g dw m^{-2} in *T. arjuna* plantation. The herbaceous biomass did not record significant differences among different plantations.

High values of Shannon-Weiner index of diversity (~3.0) and equitability (~1.0) strongly indicated towards the sound ecological state of the plantations. The index of diversity varied narrowly from 2.72 to 3.64 with the maximum (3.64) being noted in *A. procera* followed by that in *A. auriculiformis* (3.59), *E. camadulensis* (3.55), *T. grandis* (3.48), *H. binata* (3.44), and *T. arjuna* (3.33) plantations. The coefficient of dominance of herb species showed inverse relationship with the diversity index and ranged between 0.02 and 0.09. The maximum value (0.09) was recorded in *A. auriculiformis* plantation, followed by *T. grandis* (0.08), *H. binata* and *T. arjuna* (0.07), and *E. camadulensis* (0.06).

Kumar et al. (2001) have observed seasonal dynamics in the plant biodiversity and phytosociology of ground flora in *Acacia auriculiformis* plantation stands at two sites in Varanasi. Maximum plant growth in the region was recorded during July to October, with appearance of annuals completing their life cycle by October. Between two sites, the number of species at site- I was greater. Variability in numbers was noticed that was attributed to longer light protection, higher canopy coverage and higher litter fall deposition on the forest floor. Due to ombrothermic changes in different seasons, the vegetation of plantation stands was luxuriant in rainy and winter season while sparse during summer seasons. Studies have also been conducted on floral diversity in man made forest ecosystems (Sonkar et al. 2005; Singh et al. 2001).

Higher diversity index and lower coefficient of dominance may indicate the stability of community (Mc Intosh 1967). In this regard, the ground flora community of *A. procera* may be considered more stable than others. Similar results were reported reported by Sonkar *et.al* (2005). The index of equitability of the herbaceous ground flora did not show much variation in different plantations, which may be explained by similar climatic conditions of the study area. There was a large variation in index of species richness varying from an average of 18 to 42. The ground flora witnessed a very high turnover of the species according to the period, which was comparatively faster in *A. proceri* relative to that observed in other plantations. These results clearly denoted that life-form of the dominant tree species regulated the type and density of surface ground herbaceous flora. This may explain the observed insignificant differences in density and biomass of ground flora among different plantations together with their distinct floristic composition and species turnover rates. The highly diverse and ecologically healthy ground flora may facilitate self-sustenance of artificial forest plantations after threshold limits of time.

मानव निर्मित 25 वर्षो पुराने वृक्षारोपण में 6 विभिन्न प्रजातियों अकेशिया, सागौन, अंजन, यूकेलिप्टिस, अल्बेजिया तथा अर्जुन में जमीनी वनस्पतियों की जनसंख्या का तुलनात्मक अध्ययन किया गया । अध्ययन के दौरान सभी रोपण वृक्षों में 281 जमीनी वनस्पति, 171 जेनेरा तथा 58 कुल पाये गये । सर्वाधिक जमीनी वनस्पति अर्जुन में तथा अंजन में सबसे कम पाये गये । जमीनी वनस्पतियों की विविधता संकेतक में सर्वाधिक बदलाव देखा गया 2.72 से 3.74 । जमीनी वनस्पतियों की समानता संकेतक में कम बदलाव देखा गया 0.90 से 0.99 । जमीनी वनस्पतियों की गुणांक प्रबलता में विविधता संकेतक के अनुरूप विपरीत प्रभाव देखा गया । जमीनी वनस्पतियों की प्रजाति उपलब्धता में अधिक बदलाव पाया गया 18 से 42 । सर्वाधिक अल्बेजिया में तथा सबसे कम अर्जुन के वृक्षों में पाई गई । जमीनी वनस्पतियों के घनत्व में सर्वाधिक बदलाव देखा गया 274 से 758.8 पौध उ.2 । जमीनी वनस्पतियों के जैव भार में 60.2 से 288 ह कू उ.2 पाया गया । सर्वाधिक विविधता तथा समानता संकेतक स्वस्थ वृक्षारोपण को दर्शाते हैं । कम भौगोलिक क्षेत्र में समानता वृक्षारोपण में सर्वाधिक वनस्पतियों में परिवर्तन उच्च गुणवत्ता वृक्षारोपण को दर्शाता है ।

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Population dynamics of parasitic nematodes in soybean grown under climatic conditions of Kymore Plateau and Satpura Hills of Madhya Pradesh

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Abstract

Spiral nematode , *Helicotylenchus* spp. was predominant and widely distributed in the rhizosphere of soybean and population ranged from 25 to 2550/200 cm3 soil in six districts of Kymore Plateau and Satpura Hills viz., Chhindwara, Jabalpur, Narsingpur, Rewa, Satna and Seoni. Lesion nematode *Pratylenchus* spp*,* was encountered in 81 localities with the mean population of 395 nematode /200 cm3. Crop was severely infested with *Rotylenchulus reniformis* in Fanwani village of Jabalpur district which harboured 1500 nematdes/ 200 cm3 soil. Second stage Juveniles of *Heterodera* spp. were recorded from few soil samples from Rewa and Satna. Other nematode *viz., Tylenchorhynchus* spp*., Ditylenchus* spp*., Hoplolaimus indicus, Aphelenchus avenae* and *Xiphinema* spp. were also observed in rhizosphere of soybean.

Keywords: Soybean, nematode, *Helicotylenchus, Pratylenchus*, soil population, frequency

Cultivation of soybean during 2009-10 in Kymore Plateau and Satpura Hills of Madhya Pradesh has exceeded above 4.5 thousand hectares. The socio-economically important oilseed crop is exposed to attack by plant parasitic nematodes inflicting 10 percent loss in yield (Feldmesser 1971). Root knot, soybean cyst, lance, sting, spiral, root lesion and stubby root are often associated and responsible for severe damage to soybean under field conditions (Revios and Golden 1987).Ultimately providing the passage to secondary intruders information on the distribution of Plant parasitic nematode associated with soybean in Madhya Pradesh is not available. Therefore, present investigations were undertaken to record plant parasitic nematodes their occurrence and distribution in agro-ecosystem of Kymore Plateau and Satpura Hills of the state which occupy major area under Soybean cultivation.

Material and methods

A total of 214 soil samples were collected from 155 localitions using 2.5 diameter soil probes, from a depth of 50 cm areas cropped with soybean crop that exhibited symptoms of nematode infestations at initial visual stage. Composite samples of soil and root were collected from each field of Chhindwara (28), Jabalpur (36), Narsingpur (40), Rewa (30), Satna (35), and Seoni (45).

The composite homogenized 200 cm^3 soil samples were processed by using wet sieving and decanting technique (Christie and Perry 1951). Extracted nematodes were counted by using a Hawksley counting slide and identified as per characters provided by Siddqui (1986).

Results and Discussion

Two hundred fourteen soil samples yielded 11 different nematode genera and most of the samples contained more than one species and genus. Lesion nematode, (*Pratylenchus* spp.) the most common and widely occurring potential migratory endoparasite was associated with soybean rootlets from 81 localities under the survey with the mean population 395/200 cm3 soil. The frequency of occurrence was 62.5% as recorded in samples from Seoni followed by Satna (52.17 %) and Jabalpur (51.35%) districts (Table 2 and Fig 2). Samples of soybean from Tilsani, expressed poor vigour along with necrotic roots holding 3000 nematodes / 200 cm^3 also, however, fields of Chourai (2500). Parasiya (1625) and Baghraji (1400) showed poor crop growth. Thirty nine localities harboured average nematode population between 201-500, whereas nematode from 12 localities 501-1000 and from four localities above 1000 nematode. Revfios and Golden (1978) reported lesion and cyst

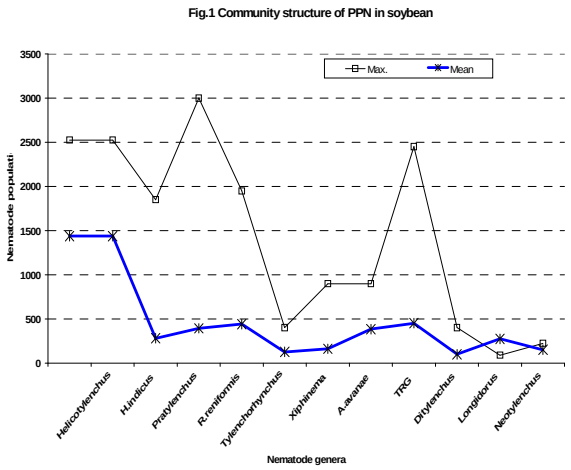
Table1. Frequency, Standard deviation and Population ranges of nematode associated with soybean in Kymore Plateau and Satpura Hills

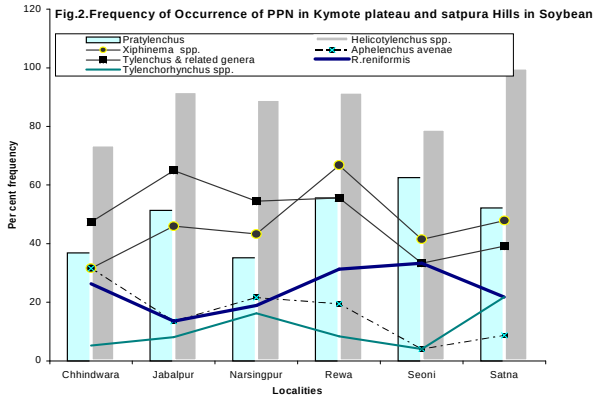
Associated genera	Population in different class intervals (No. of Localities)					Nematode population/ 200 cm^3 range			Standard deviation
	I	II	III	IV	Total	Min.	Max.	Mean	
Helicotylenchus spp.	37	63	34	19	153	25	2525	1437	11033
Hoplolaimus indicus	33	16	05	02	56	25	1850	281	297
Pratylenchus spp.	35	39	12	04	90	25	3000	394	476
Rotylenchulus reniformis	06	14	04	01	25	50	1950	440	401
Tylenchorhynchus spp.	16	09	01	02	28	25	400	126	126
Xiphinema spp	41	11	03	04	59	25	900	161	133
Other Nematodes									
Aphelenchus avenae	08	25	06	00	39	50	900	384	254
Tylenchus & related genera	26	28	07	07	68	75	2450	452	429
Ditylenchus spp.	11	02	0	0	13	25	400	98	113
Longidorus spp.	03	01	0	0	04	25	90	275	318
Neotylenchus spp.	06	02	0	0	08	75	225	150	70

*Class intervals (frequency) I =25-200; II=201-500; III=501-1000; IV= above 1000 Nematodes / localities

Table 2. District wise distribution of Plant Parasitic nematode in Soybean Crop in Madhya Pradesh

Nematode genera	Districts					
	Chhindwara	Jabalpur	Narsingpur	Rewa	Seoni	Satna
Pratylenchus spp	100-2500 578 (36.84)	50-300 563 (51.35)	100-600 332 (35.15)	25-1625 410 (55.55)	50-900 255 (62.5)	25-425 222 (52.17)
Rotylenchulus reniformis	50-900 390 (26.31)	50-1500 870 (13.51)	100-625 364 (18.91)	100-900 310 (31.27)	100-1000 359 (33.33)	125-175 520 (21.73)
Hoplolaimus indicus	25-900 310 (52.63)	50-650 290 (21.62)	50-1850 395 (43.24)	25-250 130 (36.11)	25-800 260 (41.66)	25-375 145 (32.17)
Helicotylenchus spp.	25-2525 494 (73.68)	25-2000 797 (91.89)	25-2075 553 (89.19)	25-1400 430 (91.66)	100-1175 431 (79.06)	125-1225 519 (100)
Tylenchorhynchus spp.	75-75 75 (5.25)	75-375 200 (8.10)	50-250 141 (16.21)	25-100 100 (8.33)	75-75 75 (4.00)	75-325 145 (21.73)
Xiphinema spp.	75-175 104 (31.57)	525-900 225 (45.95)	25-400 169 (43.24)	25-400 124 (66.66)	25-400 125 (41.46)	75-400 154 (47.82)
Aphelenchus avenae	50-550 262 (31.57)	100-900 375 (13.51)	200-900 478 (21.62)	150-600 346 (19.44)	400-400 400 (4.04)	150-900 525 (8.69)
Ditylenchus spp.	-	25-125 75 (5.4)	-	-	-	25-25 25 (8.69)
Longidorus spp.	50-50 50 (5.26)	50-50 50 (2.70)	25-25 25 (5.40)	-	25-25 25 (4.04)	-
Neotylenchus spp.	-	-	150-175 166 (8.10)	75-75 75 (2.77)	225-225 225 (4.04)	50-50 50 (4.34)
Tylenchus & related genera	100-1000 400 (47.36)	100-2450 610 (64.96)	50-1050 392 (54.50)	100-900 307 (55.55)	125-900 362 (33.33)	75-400 211 (39.13)





nematode in soybean from Mississippi and Lousiana USA.

The population of reniform nematode, *Rotylenchulus reniformis* was recorded from 14 localities and population was above threshold level (1500 and above) of damage with mean nematode population 440 /200 cm3. Nematode population was 900, 550, 1500, 1950, 625, 500, 575, 900, 550, and 1000 in Bangao, Katangi, Fanwani, Jabalpur, Baghraji, Meregaon, Rithi, Parasiya, Bandole and Peepardati localities respectively. The soybean crop grown in aforesaid exhibited stunted growth with chlorotic foliage and premature flowering. Samples collected from Satna (27.73) and Narsingpur (21.62) harboured higher frequency of occurrence than other surveyed districts. Widespread occurrence of potential migratory ectoparasite, *Helicotylenchus* spp. was recorded in soybean crop. The frequency of occurrence was 100, 91.89, 91.66, 89.19, 79.06, and 73.68 per cent in Satna, Jabalpur, Rewa, Narsingpur, Seoni and Chhindwara respectively (Table 2). The nematode population in 153 localities ranged between 25 to 2525 with mean population 1437 nematode / 200cm3 soils, whereas 63 localities harbored moderate (201 to 500) nematode population. Soybean samples from 19 locations exhibited poor vigour and growth in terms of stunting and pale colour foliage. In addition to the principal plant parasitic nematodes (Table 1 and Fig 1), nematode *viz., Hoplolaimus indicus* (52.62), *Tylenchorhynchus* spp. (27.73), *Xiphinema* spp. (66.66), *Ditylenchus* spp. (16.66), *Aphelenchus avenae* (31.57), few location contained *Neotylenchus* spp., *Tylenchus* and related genera (TRG). The distribution of *H. indicus* was found in 56 out of 69 localities. Its frequency of occurrence was 52.62 per cent in Chhindwara followed by 43.24 per cent in Narsingpur. Soil Samples from Tendukheda harboured 1850 nematode / 200 cm3 and the crop was with stunted growth and chlorosis in patches indicating hot spot of *H. indicus* infested pockets.

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Effect of botanicals, oil cakes and bio agents on root-knot (*Meloidogyne incognita*) management in chilli

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Abstract

Dry leaf powder @ 5g/ 500 cm^3 soil of ten botanicals, six oil cakes @ 1 ton/ha and three bioagents @ 0.4g/kg soil, improved plant growth and suppressed reproduction of *Meloidogyne incognita*. Among the botanicals, *Lantana camera*, *Azadirachta indica* and *Jatropha curcas* were effective in reducing root gall formation and enhancing plant growth significantly. Amendments of soil with neem, jatropha, and castor cakes @ 4g/plant have satisfactory managed juveniles of root knot. *Trichoderma viride* and *Paecilomyces lilacinus* were found superior over *P. fluorescens* in reduction of gall numbers and enhancing the plant growth.

Keywords: *Meloidogyne incognita,* glass house, management and chilli

Chilli (*Capsicum annuum* L.) vegetable cum spice is one of the most important commercial crops. It is widely used as spice and named as wonder spice under Indian conditions the crop occupied an area of 6.5 lakh ha. with 10.64 lakh tons production during 2005-06 (Anon 2005). Madhya Pradesh alone contributes an area of 46,658 ha with 42,459 production and 0.91 tons /ha productivity.

Root knot nematode (*Meloidogyne* spp.) has been a major threat in almost all the cultivated area in tropical and sub tropical regions. More than 150 species of *Meloidogyne* are reported that remained associated with 2000 plant species and cause approximately five per cent of global losses. During July, 2005 to Sept. 2006 an intensive survey was carried out in all the agro climatic regions of Madhya Pradesh and root knot nematode was identified as predominant nematode pest associated with chilli. The roots of chilli showed severe galling, stunted growth and yellowing of younger foliage due to the infection of *Meloidogyne incognita* (Kofoid and White Chitwood 1949).

Material and methods

The experiment was conducted by applying ten botanicals @ 5g/1.5 kg soil, six bio agents @ 0.4 g/pot and three oil cakes @ 10 per cent w/w application against *M. incognita.* The nematode population was obtained from Guna district of Madhya Pradesh (Table 1, 2 and 3) and single egg mass culture was maintained in chilli (var. Pusa Jwala). Steam sterilized soil was mixed with dry leaf powders of neem, jatropha, linseed, mustard, karanj and castor @ 10 per cent w/w in one set and bioagents *viz., Trichoderma viride*, *Paecilomyces lilacinus* and *Pseudomonas fluorescens* in second set of soil @ 0.4g/ kg soil untreated control for oil cakes and bio agents were also maintained. Soil mixed with carbofuran @ 0.4g/ kg served as standard check for bio control agents. The soil mixed with cakes and bio control agents was filled in ten cm earthen pots individually. Each pot was transplanted with 15 day old healthy seedlings of chilli (var. Pusa Jwala). On establishment of root, the seedlings were inoculated with second stage juveniles of *M. incognita* @ 2 J2 /g soil with replicated five times.

The pots were randomized on glass house bench following complete randomized design (CRD). Pots were irrigated with fresh tap water as and when required. Adequate plant protection measures were adopted to grow healthy crop.

Results and Discussion

Botanicals on nematode management

Dry leaf powders of *Azadirachta indica, Calotropis procera Datura metel, Hibiscus rosasinensis, Ipomoea carnea, Jatropha curcas, Lantana camera, Pongamia pinnata, Ocimum sanctum* and *Parthenium hysterophorus* were found significantly effective towards

Table 1. Efficacy of dry leaf powders of some plants against *M. incognita*

Treatments	Common names	Growth Parameters						Population	
		Shoot height (cm)	Fresh shoot wt. (g)	Dry shoot shoot wt. (g)	Fresh root wt. (g)	No. of gall/pl	No. of egg masses/ plant	Soil (200cc)	Root (5g)
Calotropis procera @ 5g/1.5kg soil	Akaua	18.30	3.82	1.88	2.28	27.60	24.00	616 (24.74)	614 (24.71)
Azadirachta indica @ 5g/1.5kg soil	Neem	7.06	0.84	0.26	0.68	6.80	6.20	786 (27.28)	340 (17.76)
Parthenium histerophorus @ 5g/1.5kg soil	Parthenium	20.40	4.14	2.50	2.74	14.80	13.00	201 (13.83)	162 (12.60)
Jatropha curcas @ 5g/1.5kg soil	Jatropha	9.48	0.76	0.22	0.36	8.80	8.20	141 (11.71	560 (23.27)
Datura metel @ 5g/ 1.5kg soil	Datura	19.92	5.24	2.94	3.16	15.60	13.40	88.8 (9.29)	86.6 (7.44)
Ipomea carneea @ 5g/ 1.5kg soil	Ipomea	14.62	2.90	0.88	1.78	48.20	45.80	88 (9.30)	203 (14.17)
Pongamia pinnata @ 5g/1.5kg soil	Karanj	21.60	4.18	3.14	2.34	68.20	63.40	167 (12.73)	256 (15.42)
Lantana camera @ 5g/ 1.5kg soil	Lantana	4.54	0.42	0.12	0.12	5.40	4.40	92 (9.46)	104 (10.14)
Hibiscus rosasinensis @ 5g/1.5kg soil	Gudhal	24.16	4.62	2.90	3.24	32.00	29.20	223 (14.15)	290 (15.58)
Ocimum sanctum @ 5g/1.5kg soil	Tulsi	20.12	4.76	1.72	2.88	27.40	24.60	203 (12.39)	203 (13.93)
Control		18.30	4.64	2.90	6.06	81.20	75.20	853 (28.13)	930 (30.37)
SEm±		2.30	0.97	0.61	0.83	5.89	5.42	2.03	1.50
CD (P= 0.05)		4.63	1.96	1.23	1.68	11.87	10.92	3.97	2.94

Table 2. Effect of oil cakes on reproduction of *M. incognita* and plant growth

Treatments	Growth Parameters						Population	
	Shoot height (cm)	Fresh shoot wt. (g)	Dry shoot shoot wt. (g)	Fresh root wt. (g)	No. of gall/pl	No. of egg masses/ plant	Soil (200cc)	Root (5g)
Castor @ 10 % w/w	16.92	3.18	0.40	1.66	21.60	17.60	320 (17.85)	174 (13.14)
Karanj @ 10 % w/w	14.88	2.08	0.28	1.18	12.00	9.20	252 (15.27)	205 (12.81)
Mustard @ 10 % w/w	19.70	5.76	1.10	3.08	45.20	40.20	512 (22.58)	702 (24.13)
Linseed @ 10 % w/w	24.90	6.32	2.12	4.58	48.80	44.2	591 (23.97)	634 (24.43)
Jatropha @ 10 % w/w	24.84	5.98	2.30	4.16	56.20	52.2	751 (26.73)	614 (24.71)
Neem @ 10 % w/w	19.56	4.60	1.36	3.04	8.00	7.00	151 (11.83)	114 (9.62)
Control	18.30	4.64	2.90	3.06	81.20	75.20	616	846
SEm±	3.91	0.83	0.85	0.76	0.69	0.67	2.57	4.38
CD (P= 0.05)	8.01	1.70	1.75	1.57	1.42	1.38	5.26	8.98

Table 3. Efficacy of bio-agents on multiplication of root knot

Treatments	Growth Parameters						Population	
	Shoot height (cm)	Fresh shoot wt. (g)	Dry shoot shoot wt. (g)	Fresh root wt. (g)	No. of gall/pl	No. of egg masses/ plant	Soil (200cc)	Root (5g)
Trichoderma viride @ 0.4g/kg soil	13.78	2.40	1.40	1.02	53.00	25.40	360 (19.18)	216.4 (14.54)
Paecilomyces lilacinus @ 0.4g/kg soil	14.80	2.54	1.48	1.50	58.60	49.40	372 (16.50)	331 (18.11)
Pesudomonas fluorescens @ 0.4g/kg soil	14.98	1.88	1.22	1.26	59.80	39.40	402 (20.05)	242 (15.44)
Carbofuran @ 0.4g/kg soil	14.92	1.94	1.08	0.94	59.60	50.00	371 (19.22)	386 (19.60)
Control	14.40	1.50	0.46	1.22	85.00	78.20	462.6 (21.43)	573.8 (23.74)
SEm±	1.21	0.32	0.19	0.27	10.32	8.53	1.98	1.59
CD (P= 0.05)	2.53	0.67	0.39	0.57	21.53	17.80	4.13	3.32

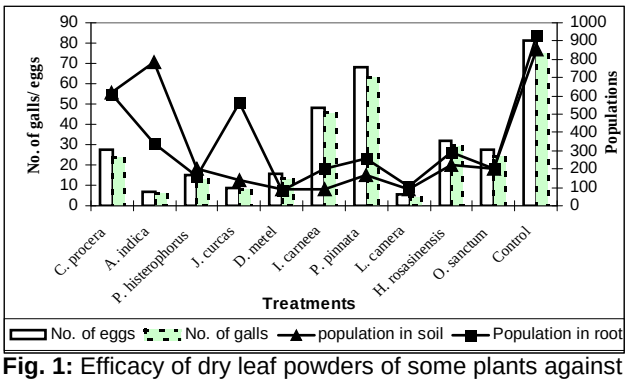

Fig. 1: Efficacy of dry leaf powders of some plants against *M. incognita*

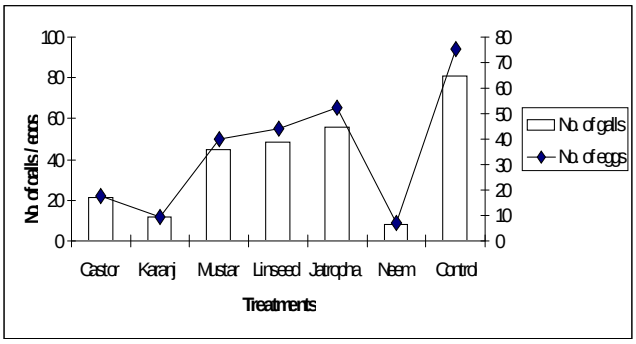

Fig. 2. Effect of Oil cakes on reproduction of *M. incognita* and plant growth

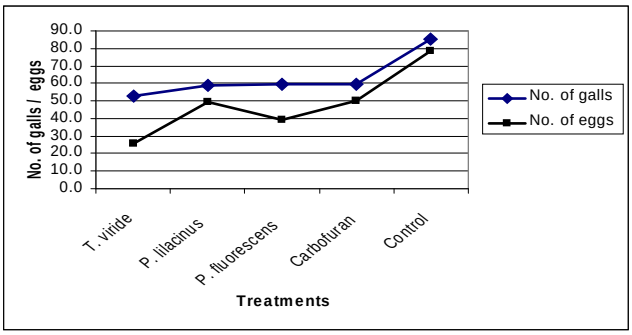

Fig. 3. Efficacy of bio-agents on multiplication of root knot

reduction of root knot population as compared to untreated control.

The total number of root galls were 5.40, 6.80 and 8.80 per plant in *Lantana camera*, *Azadirachta indica* and *Jatropha curcas,* respectively. The significant reduction in egg masses was noticed in all the treatments except *Pongamia pinnata* (63.40). However, least (4.40) egg masses development was recorded in *Lantana camera.* Population of *M. incognita* in soil and roots of all the treatments were observed in the range of 88 to 786 in soil, whereas juveniles were 86.6 to 614 / 5g root. The least soil population was observed in the *Datura metel* (88.8/200cm^3) whereas in root the number of juveniles were 86.6/5g root followed by *Lantana camera* (92/200 cm^3 and 104/5g root) and *Ipomoea carnea* (88.8/200 cm^3 and 203/ 5g root). All the treatments were statistically significant over control. Plant height was ranged from 4.54 to 24.16 cm. Maximum (24.16 cm) plant height was observed in *Hibiscus rosasinensis* followed by *Parthenium hysterophorus* (20.40) and *Ocimum sanctum* (20.12). The fresh shoot weight was evidenced that *D. metel* exhibited maximum (5.24 g) shoot weight followed by *Ocimum sanctum* (4.76) and *Hibiscus rosasinensis* (4.62). Maximum (3.24) fresh root weight was recorded in *Hibiscus rosasinensis,* whereas *Datura metel* (3.16) was next in order of fresh root weight. However, other treatments were also found superior over control (Table 1 and Fig.1).

Efficacy of oil cakes on root knot reproduction in chilli

Organic amendments with cakes *viz.,* Castor, karanj, mustard, jatropha, linseed and neem showed significantly reduction of *M. incognita* and improved the growth parameters (Table 2 and Fig. 2). The shoot height of chilli

was significantly increased due to incorporation of organic cakes. Performance of linseed cake was significantly superior (24.90 cm) over control while minimum 14.88 cm was recorded in karanj cake. The fresh shoot and root weights of chilli were maximum (6.32 and 4.58) in linseed whereas karanj cake showed minimum (2.08 and 1.18) shoot and root weight. The data on dry weight basis indicated that jatropha was found most effective over control and rest of the treatments had maximum (2.30 g) dry weight. The significant reduction in both number of galls/root system and egg masses were observed in all the treatments except in jatropha where more galls and eggs were 56.2 and 52.2 respectively.

Chilli plant treated with neem cake was best among the treatments in terms of reducing galls (8) and egg masses (7) over control. Although, all the treatments were significantly superior in reducing soil and root population of *M. incognita.* Neem cake was very effective towards reducing nematode population in soil (151) and root (114) followed by karanj (252) in soil and 205 root.

Efficacy of bio-agents on multiplication of root knot

Significant differences in shoot height in different treatments. The data on shoot height indicated that treatments with *Pseudomonas fluorescence* was superior (14.98) followed by Carbofuran (14.92) and *Paecilomyces lilacinus* (14.80) respectively (Table 3 and Fig. 3).

Soil treatment with *Trichoderma viride* and *Paecilomyces lilacinus* were statistically at par with each other in respect to the fresh shoot weight (1.94 and 2.54 g). Similar observation with regard to dry shoot weight was also noted in *Paecilomyces lilacinus* treated pots. Maximum (1.48 g) dry shoot weight was noted with *P. lilacinus* but was at par with *Trichoderma viride* (1.40 g). Significant and maximum fresh root weight (1.50 g) was observed in *Paecilomyces lilacinus* while minimum (0.94 g) was recorded in Carbofuran.

The number of galls/ plant was significantly less in *Trichoderma viride.* Rest of the treatments exhibited reduced galling ranged from 58.60 to 59.80. Significant reduction in egg masses/ root system was observed in all the treatments over control. Treatment *Trichoderma viride* was found best (25.40) among all the treatments. Maximum number of eggmasses was obtained in carbofuran (50.00) followed by *P. lilacinus* (49.40). The Population of *M. incognita* was inhibited by *T. viride* (360 N) followed by carbofuran (371) and *P. lilacinus* (372). The lowest root population (216.40) was recorded in *T. viride* followed by *P. lilacinus* (242) while minimum reduction (386) was recorded in carbofuran. Application of different botanicals, leaf powders and bio agents significantly reduced the population of *M. incognita* and improved the shoot height (cm), fresh and dry weight of shoot, fresh weight of root, number of galls, egg masses.

Among the botanicals, *Lantana camera*, *Azadirachta indica* and *Jatropha curcus* significantly reduced development of galls and improved the growth parameters of chilli. Incorporation of neem, jatropha, and castor cakes @ 4g/plant have satisfactory managed root knot nematode. Bio agents *T. viride* and *P. lilacinus* were found superior over *P. fluorescens* and untreated control towards reduction of galls and enhancing the plant growth. Earlier several studies have been conducted and proved efficacies of botanicals, oil cakes and bio agents in suppressing the *M. incognita* (Prasad et al 1964; Goswami and Vijayalakshmi 1986; Pathak and Saikia 1999; Sankaranarayanan et al 1999; Vadhera et al 2000; Ahmed and Choudhary 2004; Khan and Verma 2004; Patel and Patel 2007; Sartaj et al 2007).

दस वानस्पतिक पौधे (5 ग्राम/500 घन से.मी.) शुष्क चूर्ण, छ खली (4 ह/पौधे) तथा तीन जैविक नियंत्रक (0.4 ग्राम/किलो मृदा) की दर से *मेलाइडोगायनी इनकागनिटा* के प्रजनन को शमन करते है तथा पौधों में उन्नति करते पाये गये हैं। *लैन्टाना कमेरा, अझादिरक्टा इंडिका* तथा *जट्रोफा करकस* के वानस्पतिक चूर्ण जड़ ग्रंथि के साधक के अतिरक्ति मिर्च के पौधों की उन्नति करते देखे गये। नीम, जट्रोफा तथा अरण्ड की खली से जड़ ग्रंथि के नवजात का शमन को देखा गया। *ट्राइकोडरमा विरिडी* तथा *पिसीलोमाइसीस लीलासिनस* जैविक नियंत्रक *सुडोमोनास फ्लोरेसेन्स* की अपेक्षा जड़ ग्रन्थि की संख्या के शमन के अतिरिक्त पौध ो की उन्नति में विशिष्ठ पाये गये।

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Pathogenic potential of root knot nematode (*Meloidogyne incognita)* on lentil and its effects on plant age

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Abstract

An experiment, to determine pathogenic potential of root knot nematode (*Meloidogyne incognita)* on lentil and its influence on plant age, was conducted in pots underglass house conditions. All the plant growth parameters were declined at 1000 J_2/pot where as at highest inoculum level (10,000 J_2/pot) the plant became stunted with significant reduction in growth parameters. The inoculum threshold level of *M. incognita* on lentil was recorded $2J_2$/g soil. All the stages of lentil were penetrated by root knot nematode. Lowest level of inoculum at the initial stages of crop can result in substantial damage to the crop.

Key words: *Meloidogyne incognita*, Lentil, Pathogenicty, Plant age

Lentil (*Lens culinaris* L.) is an important pulse crop of State and is sown under varied situations and soils, in all parts of country either as sole or mixed crop. It is also planted after rice as other crop in some regions. In Madhya Pradesh lentil is cultivated in light as well as black heavy soils. Lentil occupies nearly 1.51 m ha in country with 0.95 m tonnes production and 629 kg productivity. Madhya Pradesh occupies 0.582 m ha area with 0.293 m tonnes production and 503 kg productivity which is nearly 30.80 percent of the total production in the country,(Anon 2006)

The root-knot nematode, *Meloidogyne incognita* (Kofoid and White,1919) Chitwood 1949, has been encountered in some of the lentil growing areas that plays as one of the limiting factors affecting crop growth and production. Yield losses due to the nematode was estimated to 5 percent (Haider et al*.* 2003). The present investigations ware undertaken under glass-house conditions to confirm the pathogenic potential of *M. incognita* and subsequent influence on lentil plant age.

Materials and methods

Confirmation of pathogenic potential of root-knot nematode on lentil

Bold and healthy seeds of Lentil (cv. JL3) were sown in 10 cm diameter earthen pots holding 500 cm^3 steam sterilized soil. In each pot, two seeds were sown at an even depth of two cm. After emergence single seedling was retained. Seven days after when seedlings attained a height of eight cm the pots were inoculated with series of inoculum levels of root-knot nematode. The second stage juveniles of *M. incognita* were obtained from the culture previously maintained on lentil plants. Serial dilutions were prepared to obtain levels of desired inocula in logarithmic series viz. 0, 10, 100, 1,000 and 10,000 larvae that were dispersed individually in 10 ml of sterile water. In control pots ten ml of sterile water alone (with no nematode population) was applied.

Inoculation of lentil seedlings with desired level of inoculum were carried out by removing the soil from the rhizosphere in radius of 2.0-2.5 cm and dispersing the required populations by dispenser holding appropriate populations in ten ml water. After inoculation, the roots were covered with a thin layer of fresh steam sterilized soil. Each treatment was replicated five times and randomized on glass house bench. These pots were irrigated with 100 ml of fresh tap water as per requirement. The glass house temperature ranged between 28-32^{0}C during the course of investigation. The experiment was terminated at 45 day after inoculation.

Effect of root knot nematode on plant age

The experiment was conducted in 10 cm earthen pots containing 500 cm^3 sterilized soil. The lentil seedlings of three different ages viz. 7(S_1), 14(S_2) and 21(S_3) days were chosen for the experiment. Each treatment was replicated five times and randomized.

Results and Discussion

Confirmation of pathogenic potential of root-knot nematode on lentil.

There was a gradual stunting of plants when inoculated with *M. incognita.(*Table 1) In the treatment where highest population (10,000 J_2/plant) of the nematode was added plants exhibited chlorosis and defoliation. The plant looked sick and devitalized with marked retarded growth. The plant height in the treatment was noted to be 11.60 cm. There was a gradual reduction in plant height as the inoculum level increased. Maximum (19.20 cm) plant height was recorded with control which was superior over all other treatments. Minimum (11.60 cm) plant height was observed in the treatment where 10,000 nematodes were incorporated with the soil followed by 1,000 J_2/plant where the height was recorded to be 16.20 cm.

There was a gradual decrease in root length as the inoculum level increased. Maximum (12.00 cm) root length was noted in control, which was superior over all other treatments (Table 1). Minimum (7.40 cm) root length was noted with 10,000 J_2/plant followed by 1000 J_2/plant (9.20 cm) and 10.80 cm in 100 J_2/plant. Reduction in the root length (11.60 cm) was also noted in the minimum inoculum level. (10 J_2/plant)

There was reduction in fresh shoot weight of lentil plants with increase in inoculum level. Significantly reduced shoot weight (0.31 g) was noted with 10,000 J_2/ plant followed by 1000 J_2 (0.41 g) and 100 J_2/plant (0.43 g). Although the fresh shoot weight in control (0.65 g) and 10 J_2/plant (0.49 g) were statistically at par but reduction was also noted in this treatment on fresh weight basis.

On dry weight basis, maximum (0.33 g) shoot weight was recorded with control which was superior over all the treatments. Minimum (0.16 g) shoot weight was recorded with 10,000 J_2/plant followed by 1,000 J_2/ plant (0.17 g). Reduced dry shoot weights were also recorded in 10 J_2/plant (0.24 g) and 100 J_2/plant (0.20 g).

The fresh root weight of the lentil plant was adversely affected by the nematode infection. Minimum (0.22 g) root weight was recorded with 10,000 J_2/plant followed by 1000 J_2/plant (0.34 g). Reduced root weights were also recorded in 10 and 100 J_2/plant which were recorded to be 0.39 and 0.33 g respectively. Maximum fresh root weight was recorded with control (0.49 g).

Least (8.6) root galls were noticed with minimum inoculum level (10J_2/plant) and increased with an increase in the inoculum level. The number of root galls was maximum (60.6) in 10000 J_2/plant followed by 1,000 J_2/plant (51.8). Only 22.4 galls were recorded in the treatment of 100 J_2/plant were incorporated.

Maximum (59.2) egg masses per plant were recorded with 10,000 J_2 followed by 1,000 J_2/plant (53.2). Minimum (8.2) egg masses were recorded in 10J_2/ followed by 100J_2/ plant (20.2) against no egg masses

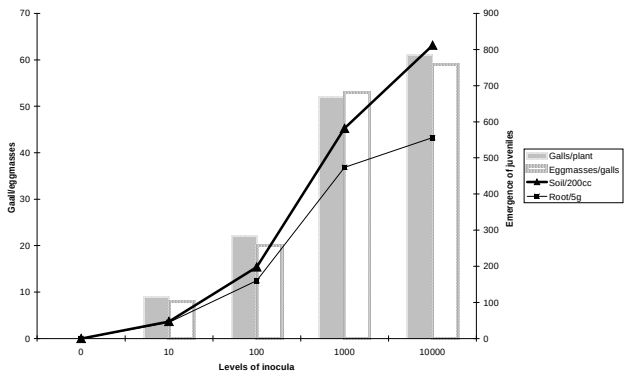
Table 1. Influence of different levels of inocula on growth parameters of lentil and reproduction of *M. incognita*

Inoculum level	Shoot ht. (cm)	Root length (cm)	Shoot wt. (g)		Root wt. (g)	No. of galls	No. of egg masses	Nematode population		
			Fresh	Dry				Soil	Root	Total
Control	19.20*	12.00	0.65	0.33	0.49	0.0 (0.71)**	0.0 (0.71)	0.0 (0.71)	0.0 (0.71)	0.0 (0.71)
10	18.40	11.60	0.49	0.24	0.39	8.6 (3.00)	8.2 (2.93)	47.0 (6.80)	45.4 (6.72)	92.4 (9.58)
100	19.00	10.80	0.43	0.20	0.33	22.4 (4.73)	20.2 (4.45)	198.0 (13.69)	160.6 (12.36)	358.6 (18.52)
1000	16.20	9.20	0.41	0.17	0.34	51.8 (7.20)	53.2 (7.32)	582.0 (24.06)	474.0 (21.74)	1056.0 (32.49)
10000	11.60	7.40	0.31	0.16	0.22	60.6 (7.80)	59.2 (7.71)	812.0 (28.37)	556.0 (23.51)	1368.0 (36.88)
SEm ±	1.39	0.98	0.04	0.03	0.04	0.26	0.28	1.09	0.86	1.25
CD (P=0.05)	4.11	2.89	0.13	0.09	0.12	0.77	0.81	3.20	2.54	3.38

* Mean of five replications

** Figure in parentheses are square root transformed values

Fig.1 Influence of different levels of inocula of *M.incognita*



in control.

Minimum (47.0) nematode population in soil was recorded with minimum inoculum level of 10 J_2/plant and increased with an increase in inoculum level. The numbers of nematode were maximum (812.0) in 10,000 J_2/plant followed by 1000 J_2/plant (582.0). One hundred ninety eight nematodes were recorded in 100 J2/plant.

Maximum (556.0) nematodes in plant root were recorded in 10,000 J_2/plant followed by 1,000 J_2/plant (474.0). Minimum (45.4) nematodes were recorded in 10 J_2/plant followed by 100 J_2/plant (160.6) against no nematodes in control.

Similar findings were brought forward by Birat (1968) in case of okra with *M. incognita* and Reddy (1975) in chickpea with *M. javanica*. Inhibitory effects of root knot nematode on chickpea are reported (Dhawan and Sethi 1976; Gaur and Prasad 1980 Mani and Sethi 1984). They reported that an incoculum level of 2J_2/g soil was found to be damaging threshold. In present investigations 1000 nematodes / 500 g soil were found to be pathogenic on lentil (cvJL 3).

Effect of root knot nematode on plant age

All the stages (S_1, S_2 and S_3) of the plant growth were susceptible to root-knot nematode. The plants under S_1 and S_2 receiving maximum levels of inoculum were collapsed within 20 days of inoculation hence the data on plant growth parameters could not be recorded.

The plant height was significantly reduced at all the levels of inoculum and stages of plant growth except in the highest level of inoculum at S_1 and S_2 where the plants died due to heavy infection of root-knot. Maximum height was recorded in control for S_1 (18.0 cm), S_2 (19.00 cm) and S_3 (21.80 cm) stages and least in S_3 (14.60 cm) at maximum inoculum level. There was a gradual reduction in plant height for all the stages as the inoculum level increased. A decline was recorded in the plants inoculated with 1000 J_2/plant for all the stages which was lower than control and rest of the treatments.(Table 2)

Maximum root length was recorded with uninoculated control and minimum with 10,000 J_2 in S_1 (8.60 cm). Reduction in root length was observed in all the stages of plant growth inoculated with 1,000 J_2. The root lengths in this treatment ware 10.80 and 11.40 cm for S_2 and S_3, respectively. There was a gradual decline in shoot weight (fresh) in all the stages of the plant growth as the levels of inoculum increased. A decline in fresh shoot weight was noticed in 1,000 J_2 level of inocula at all the stages. Maximum (0.61 g) fresh shoot weight was recorded in uninoculated (control) for all the stages which was significantly superior over rest of the treatments followed by 10 and 100 J_2 levels which were at par with each other.

On dry weight basis, maximum (0.29 g) shoot weight was recorded in un inoculated (control) which was superior over rest of the treatments for all the stages. 1,000 J_2 level showed sharp decline when compared to 100 J_2 inoculum level followed by 10 and 100 J_2 levels for all the three stages of plant growth. Minimum (0.15

Table 2. Effect of plant age and levels of inocula of *M. incognita* on lentil plant growth and nematode multiplication

Inoculum l level	Shoot ht. (cm)			Root length (cm)			Shoot wt. (g)						Root wt. (g)		
									Fresh			Dry			
	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
0	18.00*	19.00	21.80	10.40	12.40	12.40	0.42	0.46	0.61	0.19	0.23	0.29	0.48	0.44	0.62
10	15.20	16.60	17.00	11.40	12.40	16.40	0.43	0.48	0.62	0.24	0.22	0.35	0.43	0.40	0.47
100	13.60	16.00	15.80	9.60	11.40	11.00	0.38	0.40	0.51	0.24	0.19	0.24	0.38	0.38	0.45
1000	11.80	14.60	17.20	8.60	10.80	11.40	0.32	0.36	0.51	0.15	0.17	0.26	0.32	0.34	0.49
10000	0	0	14.60	0	0	10.60	0	0	0.34	0	0	0.17	0	0	0.41
SEm ±	1.03	1.15	1.55	0.90	1.06	1.17	0.04	0.04	0.04	0.03	0.02	0.03	0.03	0.04	0.05
CD (P=0.05)	3.05	3.39	4.59	2.65	3.13	3.45	0.12	0.12	0.12	0.08	0.06	0.09	0.10	0.13	0.15

*S_1 = 7 days old seedlings S_2 = 14 days old seedlings S_3 = 21 days old seedlings

g) shoot weight was recorded in S_1 in 1,000 J_2 level.

Minimum (0.32 g) root weight was recorded in the plants inoculated with 1000 J_2 inoculum level S_1. Maximum (0.62 g) root weight was recorded for uninoculated S_3 which was significantly superior over rest of the treatments. The root weight in 1,000 J_2 level had drastically declined at S_1 (0.32 g) followed by 0.24 and 0.49 in S_2 and S_3 respectively.

The number of galls increased in 1,000 J_2 level which was recorded to be 30.8 in S_1, 41.0 in S_2 and 33.4 in S_3. The gall numbers were again declined in the survived plants of S_3 (52.2) inoculated with 10,000 J_2.

The numbers of egg masses/plant were gradually and significantly increased with increase in inoculum level of 1,000 J_2 for all the stages. At this level maximum number of egg masses/plants was recorded with S_2 (39.8) followed by S_1 (35.0) and S_3 (30.6). Similar trend was also observed for 100 J_2 level. Minimum 13.4 egg masses were recorded at S_3 and Maximum (20.0) at S_2 followed by 15.0 at S_1 stages. This trend was again observed at 10 J_2 levels.

Minimum (49.0) nematode population in soil was recorded in S_2 with minimum inoculum level of 10 J_2/ plant and increased with increase in inoculum level. The numbers of nematode were maximum in S_3 (1264.0) in 10,000 J_2/plant. As such no nematode population was recorded in control.

The number of nematode increased in 1,000 J_2 level, which was recorded to be 866.0 in S_3, 870.0 in S_2 and 900.0 in S_1. The nematodes in root/plant were again declined in the survived plants of S_3 1324.0 inoculated with 10,000 nematodes/plant.

The root-knot nematode continues to penetrate the roots at all the stages of plant growth. Even lowest level of inoculum at initial stages of the crop can result substantial damage at the later stage of the crop. These results confirm the findings of Pandey (1984) on mung bean; Jadhav and Kurundkar (1991) on okra and Eapen (1992) on cardamom who reported that young seedlings were more susceptible to root-knot than mature plants.

जड़ ग्रंथि सूत्रकृमि (मीलायडोगायनी इनकागनीटा) की रोग जनकता का मसूर पर प्रभाव ज्ञात करने के लिये एक प्रयोग गमलों में कांचघर वातावरण में किया गया। पौधे के समस्त वृद्धि गुणों में 1000 डिम्भक/गमला के संक्रमण के कारण कमी पाई गई, जबकि 10000 डिम्मक पर पौधों में बौनापन पाया गया । मसूर पर जड़ग्रथि सूत्रकृमि की रोग जनकता २ डिंम्भक/ग्राम मृदा आंकी गई। मसूर के पौधे की सभी अवस्थायें जड़ ग्रंथि सूत्रकृमि के प्रभेदन हेतु अनुकूल पाई गई। पौधे की आरंभिक अवस्था में सूत्रकृमि की निम्न संख्या के द्वारा होने वाले संक्रमण के कारण मसूर की फसल पर कुप्रभाव देखा गया।

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Tolerence of *Trichoderma viride* to fungicides under artificial conditions

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Abstract

Nine fungicides namely carbendazim, hexaconazole, thiophanatemethyl, copper oxychloride, mancozeb, propineb, carbendazim + mancozeb, metalaxyl +mancozeb and iprodione + carbendazim were evaluated at lower concentration than the recommended dose to study the tolerance by *T. viride*. Copper oxychloride was least toxic followed by propineb to the growth and sporulation. Study indicate that these fungicides may be applied safely as seed treatment along with bioagent *T. viride*. Carbendazim, alone and in mixture proved highly toxic and not advocated for seed or soil application along with *T viride*.

Keywords: Fungicides, Tolerance, poison food technique

Use of chemicals for the control of plant diseases has debatable because of the costs involved and related adverse effect on environment (Madhavi et al. 2008). The focus on the management of plant diseases has been shifted from chemical pesticides to biocontrol to reduce environmental hazards and to minimize the risk of development of pesticides tolerance strains of plant pathogens. *Trichoderma* spp had been established as potential biocontrol agents during past few decades have created a new milestone in non-chemical plant disease management system and organic farming (Pan and Bhagat 2008). Integration of pesticides and biocontrol agents has been the subject of research over the years. Integration of biological and chemical control methods has the potential to control plant pathogens with minimal interference in the natural biological equilibrium (Papavizas 1985). Biological approach can be successful if the biocontrol agents are compatible with fungicides and biopesticides. (Papavizas 1985). Hence, the present study was conducted to evaluate the tolerance of *Trichoderma viride* with commonly used fungicides, which could in future be recommended as possible combination in integrated disease management program me.

Material and methods

The Investigation were conducted in Department of Plant Pathology Tirhut College of Agriculture, Dholi, Muzaffarpur (RAU Pusa, Bihar) during the year 2006-07. Commercial formulation of nine fungicides were evaluated to observe the sensitivity against *T. viride*. The fungicides selected carbendazim (Bavistin), hexaconazole (Contaf), thiophanate methyl (Topmost) of systemic group, mancozeb (Indofil- M 45), copper oxychloride (Blitox 50), propineb (Antracol) of protective group and carbendazim + mancozeb (Companion), metalaxyl + mancozeb (Matco 8- 64) and iprodione + carbendazim (Quintal) of mixture of systemic and protective fungicides were evaluated for growth inhibition of *T. viride* by poisoned food technique on potato dextrose agar medium (Nene and Thapliyal 1993). Potato dextrose agar medium poisoned with different fungicides were poured into sterilized petridishes @ 20 ml / plate and allowed to solidify. After solidification 5 mm culture disc of *T. viride* cut from 3 days old culture were placed in the center of poured plates. Potato dextrose agar medium not amended with any fungicide but inoculated with test fungus served as control. The treatments were replicated thrice. All the plates were incubated at 28 ±1^{0}C. Observations on colony diameter were recorded after 48 hours and 72 hours of incubation. Percent inhibition of growth over check was calculated

by using the formula described by Vincent (1947). Sporulation was recorded after 72 h of incubation. To count the number of spores of *T. viride* per ml of suspension, 5 mm disc *T. viride* was cut with sterilized cork borer from each replication , washed with camel brush in 2 ml of water and again in 3 ml of water. Finally 5 ml fungal spore suspension was obtained. Ten observations were taken from each replication and number of spore / ml was counted using haemocytometer. Per cent data were transformed in Angular transformation for statistical analysis. The data were statistically analysed using Completely Randomized Design.

Results and Discussion

All the nine fungicides were evaluated at lower concentrations than the recommended dose to study the tolerance by *T. viride*. Carbendazim, hexaconazole, carbendazim + mancozeb and iprodione + carbendazim at all concentrations completely inhibited the growth of *T. viride.* (Table- 1). Copper oxychloride was least toxic to *T. viride* as it inhibited the growth of *T. viride* to a extent of 2.5, 14.8 and 22 .6 percent at 200, 500 and 1000 µg/ml, respectively. The results obtained are in aggrement with finding of Karpa gavalli (1997) who stated that copper oxychloride was least inhibitory to radial growth of *T. harzianum* and *T. viride*. Thiophanate methyl, mancozeb and mixture of metalaxyl + mancozeb showed 27.1 to 73. 9 percent inhibition of growth of *T. viride*. Pandey and Upadhyay (1998) also reported that *T. viride* and *T. harzianum* were highly sensitive to carbendazim. Desai and Kulkarni (2004) reported that carbendazim,

Table 1. Effect of fungicides on growth and sporulation of *T. viride*

Fungicides	Concentrations (µg/ml)	Colony dia. (mm)*after 72hr 72 hrs	Growth inhibition over check (%) 72 hrs	No. of spores/ml (x 10^6)	Inhibition of spore production over check
Systemic					
Carbendazim (Bavistin)	25	0.00	100(90)	0.00	0.00
	50	0.00	100(90)	0.00	0.00
	100	0.00	100(90)	0.00	0.00
Hexaconazole (Contaf)	25	0.00	100(90)	0.00	0.00
	50	0.00	100(90)	0.00	0.00
	100	0.00	100(90)	0.00	0.00
Thiophanatemethyl (Topmost)	25	40.67	54.67 (47.67)	9.47	20.21
	50	34.67	61.34 (51.56)	8.47	28.64
	100	23.33	73.98 (59.34)	6.93	41.61
Non systemic					
Copper oxychloride (Blitox- 50)	200	87.33	2.58 (9.02)	9.53	19.71
	500	76.33	14.86 (22.66)	7.47	37.06
	1000	69.33	22.67 (28.43)	5.47	53.91
Mancozeb (Indofil M- 45)	200	57.67	35.68 (36.68)	4.53	61.83
	500	47.00	47.58 (43.61)	3.47	70.76
	1000	36.67	59.11 (50.25)	2.27	80.87
Propineb (Antrocol)	200	67.67	24.53 (29.69)	8.07	32.01
	500	58.67	34.57 (36.01)	4.93	58.46
	1000	52.33	41.63 (40.18)	3.07	74.13
Systemic + contact					
Carbendazim +Mancozeb (Companion)	200	0.00	100(90)	0.00	0.00
	500	0.00	100(90)	0.00	0.00
	1000	0.00	100(90)	0.00	0.00
Metalaxyl + Mancozeb (Matco 8-64)	200	65.33	27.13 (31.38)	4.47	62.34
	500	59.33	33.83 (35.56)	3.20	73.04
	1000	50.33	43.86 (41.48)	2.53	78.68
Iprodine + Carbendazim (Quintal)	200	0.00	100(90)	0.00	0.00
	500	0.00	100(90)	0.00	0.00
	1000	0.00	100(90)	0.00	0.00
PDA as control		90.00	-	11.87	-
CD at 5 %		2.03	-	0.36	-
CV		3.79	-	6.40	-

* Average of 3 replications

** Figure in parenthesis are Sin angular transformation value

chlorpyriphos and thiram were highly inhibitory to *T. harzianum* at (500, 1000 and 2000 ppm) however, captan and metalaxyl at 500 ppm were comparatively safe to *T. harzianum*.

Sporulation of *T. viride* was completely inhibited by carbendazim, hexaconazole, carbendazim + mancozeb and iprodione + carbendazim at all the three concentrations (Table- 2).Through, sporulation was affected by all the fungicides, but in copper oxychloride the inhibition of sporulation was minimum i.e 19.7, 37.0 and 53.9 at 200, 500 and 1000 µg/ml, respectively. In remaining fungicides the percent inhibition of spore production by *T. viride* was influenced by fungicides and ranged from 32.0 to 80.8 .Pandey and Upadhyay (1998) reported that *T. viride* and *T. harzianum* were highly sensitive to carbendazim and completely inhibited the sporulation at 10 ppm. Gupta etal (1999) reported that the *T. pseudokoningii* was compatible with Dithane M-45 at 0.1 percent. Desai et al. (2002) also reported that carbendazim + mancozeb, carbendazim, carboxin, metalaxyl + mancozeb, mancozeb and tricyclozole at 500 and 1000 ppm inhibits the growth and sporulation of *T. viride*. The percent inhibition of radial growth and sporulation at 500 ppm were 2.8 to 100 percent and 42.3 to 100 percent similarly at 1000 ppm were 4.49 to 100 percent and 3 to 100 percent, respectively. The 100 per cent inhibition of radial growth and sporulation was recorded upon treatment with carbendazim, companion and tricyclazole. Tiwari and Srivastava (2003) reported complete inhibition of sporulation of *T. viride* and *T harzianum* by thiram and carbendazim

नौ फफूंदनाशको जैसे कार्बेन्डाजिम, हैक्साकोनाजोल, थायोफनेट मिथाइल, कॉपर आक्सीक्लोराइड, मानकोजेब, प्रोपीनेन, कार्बेन्डाजिम + मानकोजेब, मेटालेक्सिल + मानकोजेब और आइप्रोडियान + कार्बेन्डाजिम की अनुशंसित मात्रा से कम मात्रा का परीक्षण, ट्राइकोडरमा वीरिडी के सहिष्णुता के लिए किया गया । कॉपर ऑक्सीक्लोराइड और प्रोपीनेव इसके विकास और बीजाणु उत्पादन को सबसे कम प्रभावित किया। अध्ययन द्वारा यह निष्कर्ष निकला कि इस फफूंदनाशको को ट्राइकोडरमा वीरिडी के साथ मिलाकर बीजोपचार किया जा सकता है। कार्बेन्डाजिम से अकेले या मिलावट में ट्राईकोडरमा पर बहुत ज्यादा हानिकारक प्रभाव पड़ता है। अतः इनको ट्राईकोडरमा वीरिडी के साथ बीजोपचार या मृदा उपचार के लिए अनुशंसित नहीं किया जाना चाहिए।

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Comparative efficacy of new and recommended insecticides against soybean defoliators and stem borers

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Abstract

Studies were carried out during the year *kharif* 2007 and 2008 at research field of All India Co ordinated Research Project on Soybean Main branch Sehore (M.P.) to evaluate the bio efficacy of new and recommended insecticides *viz.,* Rynaxypyr 20 SC, Spinosad 40 SC, Methomil 40 SP, Trizophos 40 EC, Quinalphos 25 EC against soybean defoliators and stem borers. In the study of efficacy of new and commonly recommended insecticides against defoliators and stem borers of soybean concluded that, higher doses of new insecticides like Spinosad 45EC@ 187.5ml/ha, rynaxypyr 20 SC @ 150 ml/ha were very effective and at par with commonly recommended insecticides viz. triazophos 40 EC @ 800ml/ha and quinalphos 25 EC @ 1.5ml/ha and Methomil 40SP @ 1kg/ha. These insecticides were found effective and recorded less than 0.00 to 1 larvae /mrl. and kept crop free from larval population up to 60 days. Further, Spinosad45SC @ 187.5ml/ha, recorded lowest stem tunnelling (3.10%) caused by maggot of stem fly. Triazophos 40 EC @ 0.800 ml/ha recorded significantly minimum plant infestation caused by girdle beetle (15.59%). All the insecticides gave better yield than control. The highest mean yield 1972 kg / ha was recorded with quinalphos 25 EC @ 1.5 lit/ha which was 636 kg (47.60 %) more than the control. other treatments gave additional yield ranged from 485 to 609 kg/ha. Spraying of quinalphos was economical and most remunerative recorded 1: 6.2 ICBR.

Keywords: *Chrydeixis acuta, Geosonia gemma, Melanagromyza sojae, Oberiopsis brevis*

Soybean [*Glycine max* (L.) Merrill] is now a cash crop and has occupied important place in agriculture and oil economy of the country. Soybean has occupied first rank among oil seed in India since 2005 onwards. The area under soybean cultivation has increased from 8.12 million ha. to 8.87 million ha. and production from 7.96 million tons to 9.46 million tones i.e. about 9.2% and 18.7% in 2006-07 and 2007-08 respectively which is a speculiar increase. In the year 2009 total area and production of soybean is 9.05 million ha. and production 9.60 million tons /ha respectively. It has been experienced that in last 2-3 years the soybean crop is facing various challenges and losing its attraction among the farmers because of reduced yield. Among the various factors responsible for the low yield, the insect-pests have been considered to be of prime importance Singh and Singh (1999). Singh and Verma (1992) reported 150 insect-pests damaging soybean in Madhya Pradesh and about a dozen of them have been reported causing serious damage to soybean from sowing to harvesting. Amongst these, grey semilooper (*Gesonia gemma* Swinhoe), and green semilooper (*Chrysodeixis acuta* Walker) defoliate the plants at vegetative and grown up stages. The stem fly (*Melanagromyza sojae* Zehnter) and girdle beetle (*Obereopsis brevis* Swed.) bore the main stem and branches.

For successful management of these insect-pests, it is necessary that the recommended insecticides should be economical ,effective and eco-friendly. The insecticides like quinalphos 25 EC, triazophos 40 EC and monocrotophos 36 SC have been recommended to check the infestation of various insect pests (Singh and Singh 1988, 1990). But of late, farmers and extension officers of State Government of Madhya Pradesh reported failure of some of these insecticides against some existing and new insect-pests. With these points in mind, some new insecticides and commonly recommended insecticides were evaluated against the major pests of soybean for their better management with objective to test the comparative bio-efficacy of new and commonly recommended insecticides for defoliators and stem borers of soybean.

Materials and methods

The field experiment, in randomized block design with nine treatments *viz.,* Rynaxypyr 20 SC (@100ml and150 ml/ha), Spinosad 40 SC (@125 ml, 162.5 ml and 187.5

ml/ha), Methomil 40 SP (@1 kg/ha), Trizophos 40 EC (@800 ml/ha), Quinalphos 25 EC (@1500 ml) and untreated as control, was conducted during *kharif* season of 2007 and 2008 at Research Farm of R.A.K. College of Agriculture, Sehore, Madhya Pradesh. The treatments were replicated four times. Soybean variety JS 335 was sown on July 3rd 2007 and June 26th 2008 in the respective years in plots of 5.0 x 2.8, each having 7 rows 40 cm apart. Spraying of insecticides was done twice at 35 and 60 days after germination. Observations on semiloopers were taken before treatment and five days after treatment by shaking the plants on muslin cloth at three places of one meter row length of each treatment and counting the number of larvae. Ten plants were marked and numbers of girdled plants by girdle beetles were recorded during observations. The plants were uprooted and split open vertically to record the incidence of stem fly, *M. sojae* and the tunnel length caused by its maggots. Similarly yield from each plot was also recorded and converted to kg/ha.

Results and Discussion

Effect on larval population of grey Semilooper, *Gesonia gemma* (Swinhoe)) and green green semilooper, (C*hrysodeixis acuta* (Walker)

The larval population of grey semilooper (*Gesonia gemma*) ranged from 4.41 to 5.99 larvae/mrl one day before the first spray treatment in the year 2007 while it was 16.11 to 19.85 larvae/ mrl in the year 2008. There was no incidence of green semilooper (*Chrysodeixis acuta*) at the time of first spray treatment when the crop was only 35 days old during both the years. At 5 days after first spray treatment, all the insecticides in both the years were significantly superior in comparison to untreated control in reducing the larval population of grey semilooper. During the year 2007,higer doses of new insecticides ranaxypyr 20 SC @ 150 ml/ha, spinosad 40 SC @ 162.5 and 187.5 ml/ha, methomil 40 SP @ 1 kg/ha, and already recommended triazophos 40 EC @ 800 ml/ha and quinalphos 25 EC @ 1.5 ltr/ha were very effective and recorded 0.00 larvae/mrl as compared to untreated control (8.49 larvae/mrl), while lowest doses of new insecticides , spinosad 40 SC @ 125 ml/ha and ranaxypyr 20 SC @ 100 ml/ha were also effective recorded 0.99 and 1.24 larvae/mrl respectively at 5 DAT during the year 2007. Further, in the year 2008, again similar trend was observed .during first spray treatment. Among the insecticides, Methomil 40SP @1kg/ha recorded significantly lowest larval population and at par with all the treatments recorded less than 1 larvae /mrl at that time untreated control had highest population of 3.16 larvae/mrl. Earlier, Khandwe et al.(1992) reported that the quinalphos (0.025%) and formothion (0.025%) are highly toxic,and both causing 100 per cent egg mortality of grey Semilooper, *Rivula sp*.Singh and Singh(1994a) also reported, monocrotophos 36 SC @0.036% triazophos (0.04%)and fenvalrate (0.01%) highly toxic against the grey semilooper on soybean. Further, Singh (1995) reported triazophos (0.04%), acephate (0.07%), chlorpyrifos (0.05%), methomyl (0.04%), ethion (0.1%) endosulfan (0.07%) and quinalphos 0.05% as highly toxic against the grey semilooper on soybean up to 15 days after treatments. In present finding triazophos (0.04%) was also effective, recorded less than 1 larvae /mrl.It is also supported by the finding of Singh and Singh (1994a) and Singh (1995).

Further the population of grey semilooper (*Gesonia gemma*) and green semilooper (*Chrysodeixis acuta*) was appeared between 50 to 55 days after germination in 2007 and 2008, respectively. Hence the second treatment was given at 60 days crop stage.Their population ranged from 4.83 to 6.24 larvae/mrl during 2007 and 6.33 to 7.02 larvae/ mrl in 2008 at one day before the 2nd spray treatment, and their population was identical in all the plots in both of the years. Again all the insecticidal treatments were significantly effective and recorded less than one larvae/mrl as compared to untreated control at 5DAT. During the year 2007 methomil 40 SP @ 1 kg/ha, trizophos 40 EC @ 800 ml/ ha recorded significantly lowest population (0.16l/mrl) where as control plot recorded highest population (5.98 larvae/mrl) while during 2008 year methomil 40SP @ 1kg/ha, and spinosad 45EC@ 187.5ml/ha kept crop free from larval population. Similarly, lower doses of spinosad 45 SC, rynaxypyr 20SC, triazophos 40 EC @ 800ml/ha and quinalphos 25 EC @ 1.5ml/ha were also found effective and recorded less than 1 larvae /mrl. Whereas control plot recorded highest population (6.66 larvae/ mrl).Singh and Singh (1990) reported cypermethrin (0.015%), deltamethrin (0.001%) and quinalphos (0.05%) highly toxic against the larvae of *Chrysodeixis acuta* and found free from larval population up to 30 days after treatment, where as monocrotophos @ 0.4kg a.i./ ha (Mishra et al. 1995) and cypermethrin 0.01%, quinalphos 0.05%, deltamethrin 0.00125% Rajput et al. (1996) have been reported effective against larvae of green semilooper in different parts of the country. Dubey et al. (1998) reported triazophos better than microbial agents against the grey and green semilooper. Earlier, Singh and Singh (1990) reported cypermethrin (0.015%), deltamethrin (0.001%) and quinalphos (0.05%) highly toxic against the larvae of C*hrysodeixis acuta* and found free from larval population upto 30 days after treatment,

Table 1. Effect of different insecticides against green and grey semiloopers of soybea

S.No	Treatments	Dose/ha	First Spray at 35 DAG (Population of *G.gemma*)			Second Spray at 60 DAG (Population of *G. gemma* & *C. acuta)*		
			2007 5 DAT	2008 5 DAT	Mean	2007 5 DAT	2008 5 DAT	Mean
1.	Rynaxypyr 20 SC	100ml	1.24 (1.20)	0.83 (1.13)	1.03 (1.16)	1.24 (1.04)	0.41 (0.92)	0.82 (0.98)
2.	Rynaxypyr 20 SC	150 ml	0.00 (0.70)	0.33 (1.03)	0.16 (0.86)	0.41 (0.93)	016 (0.85)	0.28 (0.89)
3.	Spinosad 40 SC	125 ml	0.99 (1.14)	0.89 (1.11)	0.94 (1.12)	0.49 (0.99)	0.25 (0.83)	0.74 (0.91)
4.	Spinosad 40 SC	162.5 ml	0.33 (0.89)	0.41 (0.93)	0.33 (0.89)	0.33 (1.03)	0.08 (0.75)	0.20 (0.89)
5.	Spinosad 40 SC	187.5 ml	0.00 (0.70)	0.33 (0.92)	0.16 (0.86)	0.24 (0.84)	0.00 (0.70)	0.12 (0.77)
6.	Methomil 40 SP	1 kg	0.00 (0.70)	0.24 (0.84)	0.12 (0.77)	0.16 (0.80)	0.00 (0.70)	0.08 (0.75)
7.	Triazophos 40 EC	800 ml	0.00 (0.70)	0.41 (0.93)	0.20 (0.81)	0.16 (0.85)	016 (0.85)	0.24 (0.84)
8.	Quinalphos 25 EC	1500 ml	0.00 (0.70)	0.49 (0.97)	0.29 (0.89)	0.41 (0.92)	0.24 (0.84)	0.32 (0.88)
9.	Control	-	8.49 (2.98)	3.16 (1.90)	5.82 (2.44)	5.98 (2.53)	6.66 (2.63)	6.32 (2.58)
	SEm±		0.11	0.12		0.08	0.03	0.05
	CD at 5%		0.36	0.37		0.25	0.10	0.17

where as monocrotophos @ 0.4kg a.i./ha (Mishra et al. 1995) and cypermethrin 0.01%, quinalphos 0.05%, deltamethrin 0.00125% Rajput et al. (1996) have been reported effective against larvae of green semilooper in different parts of the country.The effectiveness of chlorpyrifos 20 EC with tank mixed cypermethrin 5 EC has been reported against semilooper on soybean

Table 2. Effect of different insecticides on the infestation of Stem Fly and Girdle beetle of Soybean

S.No	Treatment	Doseml/ha	Stem fly (% stem tunneling at harvest)			Girdle beetle (% plant infestation)		
			2007	2008	Mean	2007	2008	Mean
1.	Rynaxypyr 20 SC	100	4.41 (11.94)	7.08 (15.36)	5.74 (13.65)	3.74 (10.77)	21.36 (27.45)	12.55 (19.11)
2.	Rynaxypyr 20 SC	150	2.60 (9.25)	3.20 (10.23)	2.90 (9.74)	2.42 (7.66)	20.44 (26.85)	11.43 (17.25)
3.	Spinosad 40 SC	125	3.98 (10.81)	4.11 (11.64)	4.02 (11.22)	2.90 (8.15)	21.21 (27.37)	12.05 (17.76)
4.	Spinosad 40 SC	162.5	3.32 (10.44)	3.98 (10.85)	3.65 (10.64)	2.96 (8.46)	17.74 (24.85)	10.35 (16.65)
5.	Spinosad 40 SC	187.5	2.29 (8.50)	3.10 (10.02)	2.69 (9.26)	2.48 (8.68)	15.74 (23.30)	9.11 (15.99)
6.	Methomil 40 SP	1 kg	3.73 (10.08)	4.72 (12.43)	4.22 (11.25)	2.18 (7.16)	16.70 (24.04)	9.44 (15.60)
7.	Trizophos 40 EC	800	3.16 (10.08)	4.00 (10.38)	3.58 (10.19)	2.07 (7.05)	15.59 (23.13)	8.83 (15.09)
8.	Quinalphos 25 EC	1500	3.70 (10.86)	5.32 (13.91)	4.51 (12.38)	3.31 (10.06)	20.19 (26.64)	11.75 (18.36)
9.	Control	-	9.35 (17.82)	15.18 (22.84)	12.26 (20.33)	10.41 (18.51)	44.77 (41.95)	27.59 (30.23)
	SEm±		0.62	0.39	0.50	2.05	1.05	1.55
	CD at 5%		1.95	1.16	1.55	6.19	3.08	4.63

Table 3. Yield and economics of new and recommended insecticides

S.No.	Treatments	Mean yield of both years	Additional yield over control	Per cent increase yield over control (%)	Additional returns (Rs/ha)	Cost of insecticides (Rs/ha)	Net returns (Rs/ha)	B:C ratio
1	Rynaxypyr 20 SC@100ml/ha	1856	520	38.9	7800	3000	4800	1 : 1.60
2	Rynaxypyr 20 SC@150 ml /ha	1906	570	42.66	8550	4200	4350	1 : 1.03
3	Spinosad 40 SC@125ml/ha	1805	469	35.10	7035	4156	2879	1 : 0.69
4	Spinosad 40 SC@162.5 ml/ha	1835	499	37.35	7485	5164	2321	1 : 0.44
5	Spinosad 40 SC@187.5 ml/ha	1945	609	45.58	9135	5884	3251	1 : 0.55
6	Methomil 40 SP@1 Kg/ha	1911	575	43.03	8625	3276	5349	1 : 0.63
7	Trizophos 40 EC@800ml /ha	1821	485	36.30	7275	1196	6079	1 : 5..0
8	Quinalphos 25 EC@1500ml /ha	1972	636	47.60	9450	1306	8144	1: 6.20
9	Control	1336	-		-	-	-	-

Rate **of insecticides**: Rynaxypyr 20 SC@ Rs.1840 /150 ml, Spinosad 40 SC @ Rs 1080/75ml, Methomil 40 SP@ Rs 340/250 g, Trizophos 40 EC@ Rs 400/liter, Quinalphos 25 EC@ Rs 250/liter, Labour cost @ Rs 139/day, Prices of soybean Rs 15/kg

(Yadav et al. 2001).

Effect on stem fly, *Melanagromyza sojae* (Zehntner) and girdle beetle, *Obereopsis brevis* (Swedenbord) infestation

During both years no seedling mortality was observed at 7 to10 DAG. Stem tunnelling caused by maggots of stem fly ranged from 2.29 to 4.72 % during 2007 while 3.10 to 5.32% during 2008 in different insecticidal treatments as compared to 6.12 and 15.18% respectively stem tunnelling in untreated control. In the year 2007 spinosad 45 SC @125, 162.5 and 187.5 ml/ha, methomyil 40 SP @ 1 kg/ha, trizophos 40 EC @ 800 ml/ha and quinalphos 25 EC @ 1.5 ltr/ha were effective in reducing stem tunneling, while in 2008, spinosad 45 SC @ 187.5ml/ha, recorded lowest stem tunnelling (3.10%) which was at par with all the treatment except lowest dose of rynaxypyr 20SC@ 100 ml/ha which recorded 7.08 per cent tunnelling. Stem tunnelling was very low in general during the year 2007 and 2008 as against 43.70 to 50.28 per cent reported by the various workers (Singh and Singh, 1990; Kundu and Shrivastava 1991). Earlier monocrotophos and quinalphos (Singh and Singh 1990), quinalphos (Parsai et al. 1991) and monocrotophos (Kundu and Shrivastava 1991; Latha et al.1993) have been reported effective in checking the plant infestation and stem tunnelling caused by maggots of stem fly. Seed treatment with EC formulation of endosulfan quinalphos and chlorpyrifos @ 15ml/kg seed had been reported effective against the infestation of *Melanagromyza sojae* in Orissa (Sontakke 1995). Further, Sharma et al. (1997) found monocrotophos and fenvalerate as effective in reducing larval population of agromyzids.Salunke et al. (2004) reported that per cent stem tunneling was lowest in phorat 10 G @10kg/ha.and Dahiphale et.al (2007) reported tunnelled stem length was significantly less with soil application of phorate 10G @10kg/ha .followed by in carbofuran seed treatment with thiamethoxam 70WS (6g/kg) and spraying of thiamethoxam 25 WG (100g/ha). Similarly, during 2008 plant infestation caused by grub of girdle beetle ranged from 2.07 to 3.74 in different treatments as compared to 10.41 % in control. In the year 2008 the incidence of girdle beetle was increased recording 15.59 to 21.36 % in different treatments as compared to 44.77% in control. Methomyil 40 SP and trizophos 40 EC recorded significantly minimum plant infestation 2.07 and 2.08 respectively and both were at par with all insecticidal treatments, except untreated control in the year 2008, while Triazophos 40 EC recorded significantly minimum plant infestation (15.59%), which was at par with all the remaining insecticidal treatments in the year 2008. Earlier Parsai et al.(1990) reported that the crop damage by girdle beetle was lowest with quinalphos (2.9%) followed by phosalone (3.19%) and endosulfan(4.53%). (Rajput et al. (1996) and Salunke (1999) reported that a specified no. of plant were damaged by girdle beetle when phorate 10G was applied at 10 & 15 kg/ha in the furrows at the time of sowing. Similarly Dahiphale et al. (2007) reported that sowing application of phorate showed significantly less damaged followed by carbofuran soil applicaion (30kg/ha), imidacloprid spray (100ml/ha) and chlorpyrifos (1.5ltr/ha).

Yield and Economics

Grain yield was statistically identical in all treatments, including untreated control. Yield ranged from 1567.67 to 2025.00 kg/ha in 2007 and 1106 to 1988.76 kg/ ha in 2008. During 2007 grain yield was maximum in quinalphos 25 EC @1.5 lit /ha and in 2008 it was

maximum in spinosad 45SC @ 187.5ml/ha and minimum in untreated control during both years. Other remaining insecticidal treatments also recorded good yield ranged from 1800 to 1975 kg/ha in 2007 and 1720 to1847.50 kg/ha in 2008 respectively. On the basis of two years data (Table 3) it is concluded that all the insecticides gave better yield than control.The highest mean yield 1972 kg / ha was recorded with quinalphos 25 EC @ 1.5 lit/ha which was 636 kg (47.60 %) more than the control. Other treatments gave additional yield ranged from 485 to 609 kg/ha. Spraying of quinalphos was economical and most remunerative recorded 1: 6.2 ICBR. This was followed by triazophos 40 EC (1: 5.0) and lowest dose of ranaxypyr 20 SC (1: 1.6).

Higher grain yield of soybean as a result of effective chemical control of insect pests with quinolphos (0.05%) and monocrotophos (0.04%) (Singh and Singh, 1990),endosulfan (Venkateshan and Kundu, 1994), monocrotophos and quinolphos (0.05%) (Rajput *et. al.,* 1996) quinolphos (0.05%) (Patil et a*l*.2003) have been reported in different areas of soybean in India. Further reducing of 30.26% grain yield by *Melanagromyza sojae* (Singh and Singh, 1990) has been reported at Sehore.

Yadav *et al*. (2001) reported maximum grain yield in plot treated with chlorpyrifos 20 EC with tank mixed cypermethrin 5 EC followed by quinalphos 20AF and lambda cyhalothrin 5 EC soybean. In present findings among different insecticidal treatments, Quinalphos 25 EC@1500ml /ha recorded highest grain yield (mean of both years1972kg/ha),This is also supported by the findings of Yadav *et al*.(2001) Dahiphale et.al (2007) reported that the seed yield of soybean significantly increased with the application of phorate 10G @ 10 kg/ ha followed by thiamethaxam spray @ 100g/ha.

नये एवं पूर्व अनुशंसित कीटनाशक जैसे रेनाक्सीपायर 20 एस.सी. स्पीनोसेड 40 एस.सी., मिथोमिल 40 एस.पी., ट्रायजोफॉस 40 ई.सी. एवं क्विनालफॉस 25 ई.सी. का सोयाबीन के पत्ती भक्षक एवं तना छेदक कीटों के विरूद्ध प्रभाव ज्ञात करने के लिए प्रयोग अखिल भारतीय अनुसंधान परियोजना के अन्तर्गत, आर.ए.के.कृषि महाविद्यालय, सीहोर के कृषि प्रक्षेत्र पर खरीफ 2007 एवं 2008 में किये। परीक्षण के द्वारा ज्ञात हुआ कि नये कीटनाशक, रेनाक्सीपायर 20 एस.पी. 150 मि.ली./हेक्टर एवं स्पीनोसेड 40 ई.सी. 187-5 मि.ली./हेक्टर सर्वाधिक रूप से प्रभावशाली रहे एवं पूर्व अनुशंसित कीटनाशक जैसे ट्रायजोफॉस 40 ई.सी. 800 मि.ली., क्विनालफॉस 25 ई.सी., 1.5 मि.ली., एवं मिथोमिल 40 एस.पी. 1 किलो/हेक्टर से सांख्यिकी रूप से समतुल्य रहे। ये सभी कीटनाशक प्रभावी रहे एवं इनमें हरी एवं भूरी अर्धकुण्डलक इल्लियों की संख्या शून्य से एक इल्ली/मीटर पाई गई एवं 60 दिनों तक फसल इल्लियों के प्रकोप से सुरक्षित रही। नये कीटनाशकों में स्पीनोसेड 20 एस.सी 187-5 मि.ली./हेक्टर से उपचारित प्रखंडों में तना मक्खी से प्रकोपित तना सुरंग सबसे न्यूनतम (3.10%) रही। इसी प्रकार चक्रभृंग कीट का प्रकोप ट्रायजोफॉस 40 एस.सी. 0.800 मि.ली./हेक्टर द्वारा उपचारित प्रखंड में सबसे न्यूनतम (15.59%) पाया गया। सर्वाधिक उपज (1972 किलो/हेक्टर) क्विनालफॉस 25 ई. सी. द्वारा उपचारित प्रखड में प्राप्त हुई जो अनुपचारित प्रखंडों से 47.60% (636 किलो/हेक्टर) अधिक रही। अन्य कीटनाशकों में उपज 485-609 किलो/हेक्टर, अनुपचारित प्रखंड से अधिक आंकी गई। आर्थिक दृष्टि से सर्वाधिक लाभ (8144 रूपये/हेक्टर) तथा लाभलागत अनुपात 1:6-2 क्विनालफॉस 25 ई.सी. में प्राप्त हुआ।

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Correlation of yield and attributing characters in Dolichos bean under conditions of Jabalpur, Madhya Pradesh

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Abstract

The present investigation was carried out with 25 treatments viz., 23 genotypes and 2 checks in Randomized Complete Block Design (RCBD) using three replications of Dolichos bean at JNKVV, Jabalpur. In all sixteen characters were considered for correlation analyses. The results indicated that pod yield per plant recorded highly significant and positive correlation with number of spikes per plant, days taken to first flowering, days taken to 50 % flowering, days taken to first pod harvest, 25 pod weight, pod length, pod width, pod girth and 1000 seed weight and number of flowers per cluster showed significant negative association. The chances of upgrading genotype of dolichos bean can be achieved by simultaneous selection of these characters.

Key words: Correlation, Dolichos bean, selection

Dolichos bean (*Dolichos lablab* L.), vegetable is grown for fresh consumption as well as dry seeds are used as pulse. Regional preferences are predominantly playing an important role in its cultivation. The green pods are mostly consumed under South Indian conditions, whereas white and green pods are preferred in eastern and northern parts, respectively. Perennial climbing strain with long pods and annual bushy erect with smaller pods are two groups of *Dolichos lablab* species available in India.

A wide range of variability exists in pod shape, size and colour and other agronomic characters in Dolichos bean. The most important among attributes of a plant is its yielding ability. For rational approach to the improvement of yield, it is essential to have detailed information on the association among different yield components. Correlation of quantitative attributes would help in choosing component characters that are positively correlated, hence the investigation was conducted.

Materials and methods

The investigations were conducted at Vegetable Research Farm, Department of Horticulture, JNKVV, Jabalpur (M.P.). A total of 25 treatments (23 genotypes + 2 checks), were arranged and allotted in plots randomly using RCBD with 3 replications. Soil of the experimental field was sandy loam with normal organic matter and good drainage. Soil has low organic carbon (0.55), available nitrogen, available phosphorus and high potassium with soil pH 7.3. The observations were recorded from five randomly selected plants in each replication. Correlation coefficient was calculated in all possible combinations taking all the characters in to consideration at genotypic, phenotypic and environmental levels by using the formula as proposed by Miller et al. (1958).

Results and discussion

Results indicated that in general, genotypic correlation coefficient were of higher magnitude than the corresponding phenotypic ones and similarly, phenotypic correlation coefficient was higher as compared to environmental correlation coefficient (Table 1). The findings were in agreement to Dahiya et al. (2000), Tyagi et al. (2000), Santosh et al. (2002) and Saini et al. (2005). The results of phenotypic correlation coefficient have been discussed only as the genotypic and environmental correlations were mostly influenced by the environmental conditions, hence phenotypic correlation will give the correct idea about the association between two variables.

Highly significant and positive correlation of pod yield per plant was recorded with number of spikes per plant, days taken to first flowering, days taken to 50 % flowering, days taken to first pod harvest, 25 pod weight, pod length, pod width, pod girth and 1000 seed weight.

Table 1. Phenotypic and genotypic correlation coefficient for sixteen characters in Indian bean genotypes

Characters		Flowers/ cluster	Spikes/ plant	Days to 1st flowering	Days to 50% flowering	Days to 1st pod harvest	Pods/ cluster	Seeds/ pod	25 pod wt. (g)	Pod length (mm)	Pod width (cm)	Pod girth (mm)	1000 seed wt.	Protein% in pod	Pod yield/ plant (g)	Pod yield/ plot(kg)	Pod yield/ha (kg)
Flowers/cluster	G	1.000	-0.774	-0.743	-0.800	-0.815	0.247	-0.288	-0.557	-0.623	-0.428	-0.301	-0.638	-0.069	-0.874	-0.875	-0.875
	P	1.000	-0.732**	-0.686**	-0.755**	-0.768**	0.181	-0.17	-0.505**	-0.577**	-0.409**	-0.254**	-0.607**	-0.063	-0.830**	-0.830**	-0.831**
Spikes/plant	G		1.000	0.607	0.653	0.596	0.131	0.238	0.525	0.552	0.473	0.151	0.465	0.098	0.77	0.770	0.772
	P		1.000	0.565**	0.613**	0.564**	0.9**	0.119	0.479**	0.530**	0.450**	0.11	0.434**	0.095	0.723**	0.723**	0.726**
Days to 1st flowering	G			1.000	0.873	0.792	-0.216	0.106	0.363	0.468	0.459	0.341	0.645	0.159	0.669	0.669	0.672
	P			1.000	0.832**	0.742**	-0.132	0.037	0.327**	0.444**	0.452**	0.320**	0.617**	0.138	0.639**	0.639**	0.642**
Days to 50%flowering	G				1.000	0.896	-0.373	0.327	0.533	0.655	0.513	0.322	0.646	0.187	0.66	0.660	0.664
	P				1.000	0.877**	-0.261**	0.164	0.509**	0.632**	0.487**	0.269**	0.640**	0.182	0.653**	0.654**	0.658**
Days to1st pod harvest	G					1.000	-0.375	0.343	0.349	0.523	0.339	0.261	0.700	0.346	0.675	0.675	0.677
	P					1.000	-0.238**	0.181	0.323**	0.507**	0.332**	0.230*	0.691**	0.329**	0.667**	0.667**	0.670**
Pods/cluster	G						1.000	0.288	-0.343	-0.124	-0.435	-0.385	-0.332	0.174	-0.289	-0.289	-0.291
	P						1.000	0.053	-0.241**	-0.086	-0.265**	-0.198	-0.228*	0.095	-0.197	-0.198	-0.199
Seeds/pod	G							1.000	0.186	0.388	-0.172	0.271	0.407	0.537	-0.044	-0.043	-0.036
	P							1.000	0.123	0.209*	-0.088	0.052	0.224*	0.250**	-0.019	-0.019	-0.019
25 pod weight (g)	G								1.000	0.772	0.823	0.442	0.548	-0.258	0.685	0.685	0.688
	P								1.000	0.743**	0.575**	0.355**	0.526**	-0.239*	0.657**	0.657**	0.660**
Pod length (cm)	G									1.000	0.437	0.252	0.672	-0.076	0.593	0.593	0.596
	P									1.000	0.426**	0.227*	0.656**	-0.074	0.580**	0.580**	0.584**
Pod width (mm)	G										1.000	0.392	0.426	-0.292	0.644	0.644	0.649
	P										1.000	0.375*	0.412**	-0.281**	0.622**	0.622**	0.627**
Pod girth (mm)	G											1.000	0.491	-0.141	0.234	0.235	0.235
	P											1.000	0.437**	-0.126	0.208*	0.208*	0.208*
1000 seed weight (g)	G												1.000	0.026	0.606	0.606	0.608
	P												1.000	0.024	0.605**	0.605**	0.607**
Protein % in pod	G													1.000	-0.089	-0.089	-0.090
	P													1.000	-0.087	-0.087	-0.087
Pod yield/ plant(g)	G														1.000	1.000	1.000
	P														1.000	0.999**	0.999**
Pod yield /plot (kg)	G															1.000	1.000
	P															1.000	0.999**
Pod yield /ha. (kg)	G																1.000
	P																1.000

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

Negative and significant association was recorded with number of flowers per cluster. These findings are in close proximation to that of Samal et al. (1995), Mishra et al. (1996), Mehta et al. (1997), Arya and Rana (1999), Chand (1999), Tikka et al. (2003), Yadav et al. (2003), Pan et al. (2004), Singh et al. (2004), Anbumalarmathi et al. (2005), Mittal and Singh (2005) and Ali et al. (2005). Thus, indicating that the importance of these characters in selection.

The number of flowers per cluster showed negative and significant association with pod yield per hectare, pod yield per plot, pod yield per plant, days taken to 50 % flowering, number of spikes per plant, days taken to first pod harvest, days taken to first flowering, 1000 seed weight, pod length, 25 Pod weight, pod width and pod girth. This indicating that increase in one trait may generally be accompanied by corresponding decrease in the other. These results are in close conformity with the findings of Reddy (1992).

Significant and positive correlation of number of spikes per plant was recorded with pods per cluster, pod yield per hectare, pod yield per plot, pod yield per plant, days taken to 50 % flowering, days taken to first pod harvest, days taken to first flowering, 1000 seed weight, pod length, 25 pod weight and pod width. Selection for yield is increased due to increase in number of spikes per plant. These results are also in agreement with the findings of Prakash et al. (2003), Venkatesan (2003), Anbumalarmathi et al. (2005) and Ali et al. (2005).

Days to first flowering showed significant and positive association with days taken to 50 % flowering, days taken to first pod harvest, pod yield per hectare, pod yield per plot, pod yield per plant, 1000 seed weight, pod width, pod length, 25 pod weight and pod girth. Findings were similar to the results obtained by Samal et al. (1995) and Tikka et al. (2003). Selection for days to first flowering may lead to increase in characters showing positive association and ultimately increase in pod.

Days to 50% flowering expressed significant and positive correlation with days to first harvest, pod yield per hectare, pod yield per plot, pod yield per plant, 1000 seed weight, pod length, 25 pod weight, pod width and pod girth. Whereas, significant negative correlation was shown with pods per cluster. The results confirmed the findings of Samal et al. (1995), Arya and Rana (1999) and Mittal and Singh (2005). Pod yield can be increased by increasing days to 50 % flowering indirectly by increasing pods per cluster. Days to first pod harvest showed positive and significant correlation with 1000 seed weight, pod yield per hectare, pod yield per plot, pod yield per plant, pod length, pod width, 25 Pod weight, protein % in pod and pod girth. Significant and negative association was noted with pods per cluster. These findings are in agreement with the findings of Arya and Rana (1999).

However, pods per cluster showed significant negative association with pod width, 25 Pod weight and 1000 seed weight.

Seed per pod showed significant and positive correlation with protein % in pod, 1000 seed weight and pod length. It indicates that increase in these characters would result in increase in seeds per pod. These findings are in agreement with the findings of Tikka et al. (2003), Yadav et al. (2003) and Singh et al. (2004). Weight of 25 pod expressed significant and positive correlation with pod length, pod yield per hectare, pod yield per plot, pod yield per plant, pod width, 1000 seed weight and pod girth, Whereas, protein % in pod showed negative association. This is indicative of fact that the increase in 25 Pod weight may result in increase in pod length, pod yield per hectare, pod yield per plot, pod yield per plant, pod width, 1000 seed weight and pod girth. Similar findings are also reported by Samal et al. (1995), Mishra et al. (1996), Tikka et al. (2003), Yadav et al. (2003), Singh et al. (2004) and Anbumalarmathi et al. (2005).

Highly significant positive correlation of 1000 seed weight was exhibited with pod yield per hectare, pod yield per plot and pod yield per plant. Similar findings are also reported by Chand (1999), Tikka et al. (2003), Singh et al. (2004), Anbumalarmathi et al. (2005) and Mittal and Singh (2005). Pod yield per plot showed positive and highly significant correlation with pod yield per hectare. These findings are supported by Dhiman et al. (1991) and Samal et al. (1995).

Thus, it can be concluded that correlation studies indicated chances of upgrading dolichos bean genotype by simultaneous selection through number of spikes per plant, days taken to first flowering, days taken to 50% flowering, days taken to first pod harvest, 25 pod weight, pod length, pod width, pod girth, and 1000 seed weight.

सेम (डोलीकोस बीन) की 23 प्रजातियों (जीनोटाइप) के मूल्यांकन के पश्चात यह पाया गया कि उन्नयन हेतु सतत् सलेक्शन जरूरी है । प्रत्येक पौधे से उपज बढ़ाने हेतु फली संख्या, पचास प्रतिशत फूलों के पहुँच समय, 25 फलियों का वजन, फली की लम्बाई, फली की चौड़ाई,

1000 दानों का वजन आदि गुणों का धनात्मक प्रभाव मिला । फूलों की संख्या प्रति क्लस्टर गुण का ऋणात्मक प्रभाव मिला ।

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Effect of different temperatures and desiccants on quality of yellow button type chrysanthemum flowers

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Abstract

Studies were conducted to standardize the suitable desiccants for hot air oven drying of yellow button type chrysanthemum (*Dendranthema grandiflora* Tzvelev) for improved display quality of flowers. The experiment was laid out in factorial CRD with five desiccants *viz*., silica gel, calcium chloride, copper sulphate, sand and borax and three drying temperatures *viz*., 40 ^{0}C, 50 ^{0}C and 60 ^{0}C. The overall quality of dried flowers was judged by a panel of 5 judges and ranked based on their appearance, colour and texture. Among the different desiccants silica gel embedded flowers scored the maximum points for good appearance (7.367) whereas, the flowers embedded in copper sulphate scored the maximum points for bright flowers (7.144). The maximum points for smooth petal texture at all the drying temperatures were observed in silica gel embedding (7.367). The overall quality of flower petals was better maintained (aesthetically acceptable flower shape, size and texture) at a low temperature (40 ^{0}C) for all the desiccants tried.

Key words: Embedding materials, temperature, quality

Flowers have been associated with mankind from the dawn of civilization and in the modern era they have become an integral part of human life as love for flowers is a natural instinct. Dried flowers are eco-friendly, biodegradable and retain their beauty as well as everlasting value (Puri 1995). Dried flowers look near to natural and are available year round as they can resist the heat of summer and cold of winter and can be cherished for years. Thus drying can be a creative work for preserving the flowers in their actual shape for a much longer period. Button type chrysanthemum flowers are more popular among the florists as they are available in wide spectrum of colours, shapes, sizes and forms. Keeping this in view, the present investigation was undertaken to standardize the most suitable desiccant for hot air oven drying of Yellow button type chrysanthemum flowers.

Material and methods

The present investigation was conducted at the laboratory of Department of Floriculture and Landscaping, KNK College of Horticulture, Mandsaur (MP) during 2008-2009. The experiment was laid out in a completely randomized design with factorial concept (Factorial CRD) and the treatments were replicated thrice. The temperature inside the laboratory ranged between 25±5 ^{0}C with Relative Humidity between 60 and 70%. Chrysanthemum flowers were harvested from the floriculture green house when they attained the commercial stage of harvest (Pandya and Saxena 2001). Flowers with uniform stem length were weighed and placed in the aluminium trays containing the desiccants *viz.,* silica gel (e_1), calcium chloride (e_2), copper sulphate (e_3), sand (e_4) and borax (e_5). The aluminium trays containing the desiccants and flowers were subjected to three drying temperatures *viz.,* 40 ^{0}C (t_1), 50 ^{0}C (t_2) and 60 ^{0}C (t_3) until the flowers attained a constant weight. A panel of 5 judges assessed the quality parameters of dried flowers like appearance, colour and texture by means of sensory evaluation by scoring on a ten-point scale. The appearance of flowers was scored as 1-3 (deformed), 4-6(shrunk), 7-9 (normal), the flower colour was scored as 1-3(dull), 4-6(normal), 7-9 (bright) and the flower texture as 1-3 (brittle), 4-6 (rough) and 7-9 (smooth). Based on the cumulative scores ranks were given and best treatment combination was observed on the basis of improved physico-chemical aspects of dried yellow button type chrysanthemum flowers.

Results and Discussion

The quality of dried flowers was affected by the desiccants used, the drying duration and temperature. The chrysanthemum flowers dried at a lower temperature (40 ^{0}C) were qualitatively superior by maintaining a better

flower shape, size and texture than the flowers dried at a comparatively higher temperature (50 ^{0}C and 60 ^{0}C) with all the desiccants tried (Table 2). The mean maximum moisture loss took place at 60 ^{0}C followed by 50 ^{0}C. The drying process is characterized by the simultaneous transfer of heat and mass (water). The water from the internal parts of the material is transferred to the surface adequately. Gradually the moisture content at the surface decreases as the drying time increases. As a result less free water is available at the surface which leads to depletion of available moisture at the surface and leads to falling rate drying period.

Reduction in flower diameter

The silica gel embedded flowers recorded the minimum flower size reduction i.e., 0.13, 0.17 and 0.21 at 40^0, 50^0 and 60 ^{0}C respectively (Table 1) and the maximum moisture loss at all the drying temperatures *viz*. 40^0, 50^0

Table 1. Reduction in diameter (cm) yellow flowers after drying

Factors/treatments	40^{0}C (t_1)	50^{0}C (t_2)	60^{0}C (t_3)	Mean (e)
Silica gel (e_1)	0.13	0.17	0.21	0.17
Calcium chloride (e_2)	0.36	0.36	0.39	0.37
Copper sulphate (e_3)	0.16	0.23	0.24	0.21
Sand (e_4)	0.21	0.24	0.26	0.24
Borax (e_5)	0.26	0.28	0.30	0.28
Mean (t)	0.23	0.26	0.28	
Treatments	SE(m)	C.D. at 5%	SE(d)	
Temperatures (t)	0.0060	0.0172	0.0084	
Desiccants (e)	0.0077	0.0222	0.0109	
Interaction (t x e)	0.0133	N.S.	0.0189	

and 60^{0}C. Singh et al. (2004) reported that flower size reduction was due to moisture loss from the cells. Hence, reduction in flower size was higher at elevated temperatures. Aravinda and Jayanthi (2004) reported that the button type chrysanthemum flowers treated with silica gel and sand retain their shape even after drying. Similarly Bhalla et al. (2006) reported that silica gel embedding of chrysanthemum resulted in high quality flowers and better retention of flower size. Desh Raj and Gupta (2003) reported silica gel as the best absorbent for removal of moisture from the flowers and foliages.

Singh and Dhaduk (2005) reported silica gel as the fastest desiccant without any deterioration in flower quality. In the present study it was observed that silica gel embedded flowers scored the maximum points for

Table 2 Sensory evaluation of Yellow flowers

Factors/Treatments		Appearance				Colour				Texture			
		40 ^{0}C (t_1)	50 ^{0}C (t_2)	60 ^{0}C (t_3)	Mean (e)	40 ^{0}C (t_1)	50 ^{0}C (t_2)	60 ^{0}C (t_3)	Mean(e)	40 ^{0}C (t_1)	50 ^{0}C (t_2)	60 ^{0}C (t_3)	Mean(e)
Silica gel	(e_1)	8.067	7.200	6.833	7.367	7.933	7.000	6.367	7.100	7.100	6.767	6.533	6.800
Calcium chloride	(e_2)	5.533	4.100	2.967	4.200	5.233	4.567	3.233	4.344	4.233	3.733	3.033	3.667
Copper sulphate	(e_3)	7.900	6.800	6.000	6.900	7.933	6.967	6.533	7.144	6.533	6.133	5.733	6.133
Sand	(e_4)	7.767	6.900	6.033	6.900	7.433	6.833	6.367	6.878	5.400	5.033	4.167	4.867
Borax	(e_5)	7.373	6.667	5.733	6.667	6.933	6.467	5.833	6.411	6.800	6.533	5.467	6.267
Mean	(t)	7.373	6.333	5.513		7.093	6.367	5.667		6.013	5.640	4.987	
Treatments		(t)	(e)	(t x e)		(t)	(e)	(t x e)		(t)	(e)	(t x e)	
SE(m)		0.0672	0.0868	0.1503		0.0409	0.0528	0.0915		0.0400	0.0516	0.0894	
C.D. at 5%		0.1942	0.2507	0.434		0.1182	0.1526	0.264		0.1156	0.1492	0.258	

good appearance (7.367) followed by the flowers embedded in copper sulphate and sand which were at par (6.900). Among the interaction effect, silica gel at 40 ^{0}C scored the maximum points (8.067) for good appearance. Safeena et al. (2006) reported that embedding the flowers in silica gel prevents the direct removal of moisture from flowers and acts as an intermediate and consequently prevents the shrinkage of the flower and degradation of colouring pigments that could take place when petal tissues are exposed to high temperatures without embedding

The present investigation revealed that at lower temperature (40 ^{0}C) the quality attributes like smooth petal texture, proper shape and size of the embedded flowers were better as compared to the flowers embedded at a comparatively higher temperatures (50 ^{0}C and 60 ^{0}C). In terms of colour the flowers embedded in copper sulphate scored the highest points (7.144) for brighter looking flowers followed by the flowers embedded in silica gel (7.100). Westland (1992) reported that silica gel and sand maintained better quality flowers and retained brighter flowers. Peggy (1978) reported silica gel as the most appropriate desiccant for proper colour retention of flowers. The flowers embedded in silica gel recorded the maximum points for smooth petal texture of chrysanthemum flowers (6.800). Among the interaction effects, the flowers embedded in silica gel at 40 ^{0}C scored the highest points (7.100). Safeena et al. (2006) reported that good colour, appearance and texture were recorded in the flowers dried at 40 ^{0}C, since at this temperature moisture is removed in a steady rate without affecting the structural integrity. Flower drying at higher temperature of 50 ^{0}C and 60 ^{0}C significantly damaged the quality parameters of the flowers and resulted in petal fall. Bhutani (1999) observed that the flowers retained a smooth texture when embedded in silica gel. Similar results were observed by Dhatt et al. (2007) who reported that embedding the rose buds in silica gel retains the smooth petal texture of the flowers. Thus it can be concluded from the present investigation that silica gel as a desiccant is the most suitable embedding material for better acceptable flower quality like good appearance and smooth texture of flower petals whereas copper sulphate as a desiccant was the most suitable embedding material for obtaining brighter flower.

अध्ययन करने के लिए गर्म हवा ओवन फूलों का प्रदर्शन गुणवत्ता में सुध ार के लिए पीले बटन प्रकार गुलदाउदी (*Dendranthema grandiflora* Tzvelv) के सुखाने के लिए उपयुक्त desiccants मानकीकरण के लिए आयेजित की गई । प्रयोग भाजय CRD में रखी गई पाँच desiccants अर्थात् के साथ, सिलिका जेल, कैल्शियम क्लोराइड, कॉपर सल्फेट, रेत और बोरेक्रस और तीन सुखाने तापमान अर्थात 40^0, 50^0 60 ^{0}C & C सूखे फूलों की समग्र गुणवत्ता के ५ जजों के एक पैनल द्वारा न्याय किया गया था और उनकी उपस्थिति, रंग और बनावट के आधार पर स्थान पर रही । विभिन्न desiccants सिलिका जैल एम्बेडेउ फूल के अलावा अच्छी उपस्थिति है (7.367) के लिए अधिक्तम अंक अर्जित किये जबकि, कॉपर सल्फेट में एम्बेडेड फूल उज्जवल फूल (7.144) के लिए अधिक्तम अंक अर्जित किये । सभी तापमान पर चिकनी पत्ती बनावट के लिए अधिक्तम अंक सिलिका जैल एम्बेडिंग (7.367) में मनाया गया । फूलों की पंखुड़ियों की समग्र गुणवत्ता को बेहतर की कोशिश की desiccants के लिए एक कम तापमान (40 ^{0}C) में बनाए रखा गया था aesthetically स्वीकार्य फूल आकार, आकार और बनावट ।

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Morphological study of a watershed using Remote Sensing and GIS approach

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Abstract

Water availability is considered to be one of the key factors for rapid development and urbanization. However, the over exploitation of water resources has resulted in a condition of unsustainability and environmental degradation. Each watershed has a number of distinctive characteristics, which govern the amount of precipitation received and runoff produced. The morphometric analysis of a watershed plays an important role in deciding the hydrological behavior such as runoff, soil erosion sediment delivery ratio etc. of a watershed. The Gusuru river watershed in Part of Panna and Satna district of Madhya Pradesh was considered for such a study. Remote Sensing data were used for the preparation of updated drainage map. Various linear, aerial and relief parameters of the study area were determined using Geographical Information System (GIS). It was observed that the first order streams constitute 57.34 per cent of the total stream length whereas remaining 2nd , 3rd , 4th , 5th and 6th order streams constitute 22.98 per cent, 6.81 per cent, 5.65 per cent,, 3.54 per cent and 3.64 per cent respectively.

Keywords: GIS, remote sensing, watershed, geomorphology, morphometric analysis

Water is one of the most critical of natural resources. However, there is growing water crisis today, which is precipitating social and political turmoil in the society. Increased human activity and growing requirements on the one hand and limitations in supply on the other hand, have made it absolutely necessary to pay a closer attention to all aspects of water resources. Assessing, planning and managing water resources for sustainable use have become an important issue especially in water scarcity region.

The Gusuru river watershed is forested and hilly watershed of the part of Satna and Panna district of Madhya Pradesh presents a case in point. According to recent studies the region suffers a variable water crisis with once perennial currents becoming seasonal or even drying up entirely (Sharma 2010). In the region the problem is compounded by the fact that traditional agriculture activities relied long on substantial inputs from the surrounding forests in the form of fodder, wood for agricultural implements and litter for animal feeding. Together with the collection of fuel wood and grazing by animals in the forest these have led to severe degradation of the remaining forestland. Thus, the classic distinction between hydrologically benign forestland and mismanaged agricultural/grazing land tends to become obscured. So, the scope of the problem is much wider then the hydrological or ecological aspects. Therefore, such an approach should address the conservation and management of the physical (soil, water etc.) and biological (forest, cattle, crops etc.) resources in the area by ensuring people's participation through taking their views and interests explicitly into account. Hence, information pertaining to hydrological behavior will be of immense help.

The morphological and climatic characteristics of a basin govern a hydrological response to a considerable extent. The morphological characteristic of a basin represents its attributes, which may be employed in synthesizing hydrological response. The importance of morphological factors can not be overlooked in accurate

prediction of runoff. Basin characteristics when measured and expressed in quantified morphometric parameters can be studied for the influence on runoff. Hence, linking of the morphologic parameters with the hydrological characteristics of the basin can lead to simple and useful procedure to simulate the hydrologic behavior of various basins, particularly the ungauged one. Interpretation and quantitative analysis of various drainage parameters enables qualitative evaluation of surface runoff, infiltration and susceptibility to erosion within the basin. Chalm et al. (1996) have established the relationships between hydrologic and geomorphological variables using statistical methods.

An attempt has been made by Singh (1994) to incorporate remote sensing for the evaluation of some of the morphohydrological characteristics of Jojri basin. Sharma et al (2010) have done morphometric analysis of Kanahiya Nala watershed using GIS package Arc GIS 9.3 and observed that the methodology is very efficient for estimation of geomorphological parameters. Studies conducted by Sharda et al. (1993) and Prasad et al. (1997) reveled that remote sensing and GIS techniques are of great use in characterization and prioritization of watershed area.

Remote sensing has emerged as a powerful tool in recent past for natural resources assessment with the ability of obtaining systematic, synoptic, rapid and repetitive coverage. GIS has made remote sensing a unique technology and widened the spectrum of remote sensing application in natural resources management. Considering all these aspects an attempt has been made to study the geomorphology of Gusuru river watershed with the help of remote sensing and GIS approach.

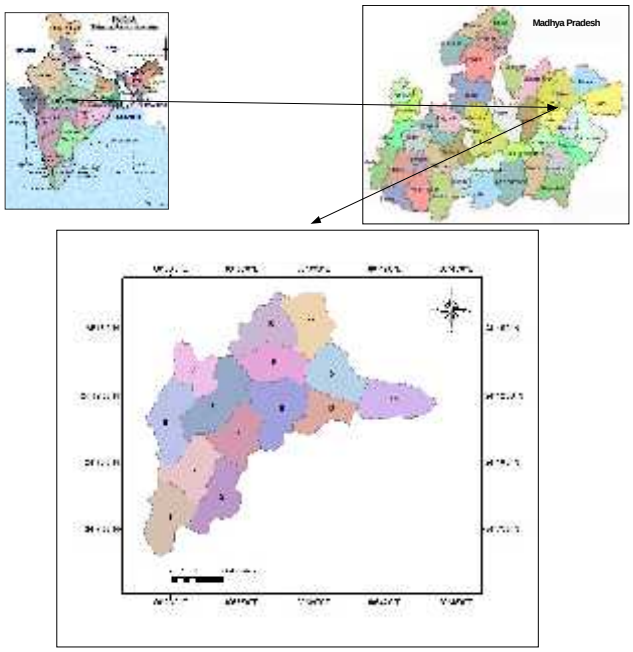

Fig. 1 Location Map of Study area

Study area

The study area Gusuru river watershed lies between latitude 24^0 6' 32.75" and 24^0 16' 24.07" N and longitude 80^0 32' 50.23" E and 80^0 37' 31.14" E in the part of Panna and Satna district of Madhya Pradesh (Fig 1). The maximum and minimum elevation encountered in the watershed is 628 m and 339 m above mean sea level respectively. The watershed encompasses an area of 155 km^2. Temperature ranges between minimum of 40 ^{0}C during December or January months and the maximum of 45 ^{0}C in May or June. Average annual precipitation is 1100 mm and is concentrated mostly between mid June to mid September with scattered winter rains during late December and January months.

Morphometric Parameters

Various important morphometric parameters used in this study for analysis are described below.

Stream Order

The most commonly used method for stream ordering (u) as suggested by Strahler (1964) was used for this study. The rules for stream ordering using this method are:

- Streams that originate at a source are defined to be first order streams.
- When two streams of order u join a stream of order u+1 is created.
- When two streams of different order join the channel segment immediately downstream has the higher of the order of the two joining streams.
- The order of the basin is the order of the highest stream.

Stream number (N_u)

Stream number is the number of stream segments of various orders. It is inversely proportional to the stream order.

Bifurcation ratio

Bifurcation ratio (R_b) is the ratio of the number of streams of given order u to the higher order u+1.

$$R_b = \frac{N_u}{N_{u+1}} \quad (1)$$

R_b characteristically ranges from 3.0 to 6.0 for watersheds in which the geological structure does not distort the drainage pattern. Abnormally high bifurcation ratio might be expected in region of steeply dipping rock strata.

Total stream length (L_a)

Total stream length is the length of all the stream having order u. The total stream length divided by the number of stream segments of the order gives the mean stream length for that order.

Watershed perimeter (P_r)

Watershed perimeter is the length of the watershed boundary.

Maximum length of watershed (L_b)

Maximum length of watershed is the distance between watershed outlet and the farthest point in the watershed.

Form factor (R_f)

Form factor is the ratio of the basin area (A) to the square of the maximum length of the basin (L_b).

$$R_f = \frac{A}{L_b^2} \quad (2)$$

Drainage density (D_d)

Drainage density is defined as the total length of the streams of all the orders of a basin to the area of the basin. The drainage density gives an idea of the physical properties of the underlying rocks. Low drainage density occurs in regions of highly resistant and permeable sub soil materials with dense vegetation and low relief, where as high drainage density is prevalent in regions of weak, impermeable sub surface materials which are sparsely vegetated and have high relief (Strahler 1964).

Stream frequency (S_f)

Stream frequency is the number of streams per unit area of the basin. It mainly depends upon the lithology of the basin and reflects the texture of the drainage network.

Elongation Ratio (R_e)

It is defined as the ratio between the diameter of a circle with the same area that of the basin to the maximum length of the basin, and is computed as

$$R_e = \frac{2}{L_b}\sqrt{\frac{A}{\pi}}$$

The elongation ratio ranges from 0.6 to 1.0 over a wide variety of climatic and geological environments. Values nearing 1.0 are typical of regions of low relief, where as values in the range of 0.6 to 0.8 are generally associated with strong relief and steep ground slopes.

Circulatory Ratio (R_c)

It is the ratio of the watershed area and the area of circle of watershed perimeter (P_r). Circular basins with low bifurcation ratio produce a sharp peak. It is computed as

$$Rc = \frac{12.57\ A}{P_r^2} \quad (4)$$

Maximum Watershed Relief (H)

It is the maximum vertical distance between the lowest and highest points of a watershed. It is also known as total relief.

Relief Ratio (R_h)

It is the total relief of watershed divided by the maximum length of the watershed. It is an indicator of the potential energy available to move water and sediment down the slope.

Ruggedness Number (R_N)

It is defined as the product of the maximum watershed relief and its drainage density. It gives an idea of overall roughness of a watershed, and is computed as

$$R_N = H \times D_d \quad (5)$$

Relative Relief (R_r)

It is the ratio of the maximum watershed relief to the perimeter of the watershed.

For morphometric analysis area, perimeter, maximum length of basin, drainage map, stream length of each order, numbers of streams of each order and watershed relief values are required. These inputs were derived by using GIS software. Once these inputs were obtained, then by making use of the mathematical formulae as discussed above, all the necessary parameters for morphometric analysis were calculated.

Materials and methods

Base map of the study area was prepared using the Survey of India (SOI) toposheets no 63D/11, 63D/12 and 63D/16. Remote sensing data (toposheet basis) of IRS-P6 LISS-III of the study area acquired on 25-10-2007

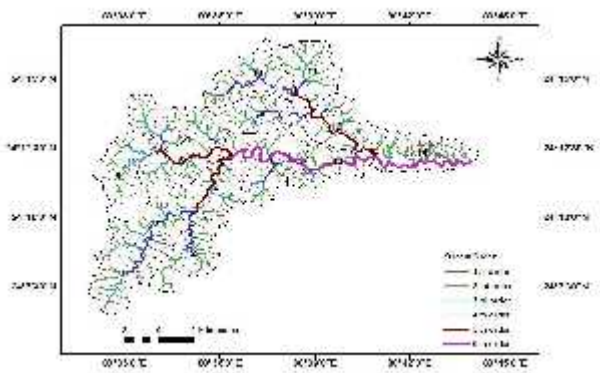

Fig 2 Drainage map of study area

were procured. The geocoded satellite data was procured from National Remote Sensing Agency, Hydrabad. Digital image processing techniques were applied on the images, making use of spatial and radiometric enhancement techniques in order to remove shadow and for proper tone and texture of the image. Then the watershed boundary of the study area was delineated using the SOI toposheet on 1:50000 scale and remote sensing data.

The delineated watershed boundary was further subdivided into the micro-watersheds and then micro-watersheds boundary along the drainage network was selected for morphometric analysis. The input parameters for morphological studies such as area, perimeter, elevation, stream length etc. were obtained directly in Arc GIS software using query based algorithm. Other morphological parameters were calculated using formulae based on input values.

ERDAS IMAGINE 9.1 image processing software was used for image processing operation and Arc GIS 9.3 software was used for GIS analysis.

Result and Discussion

The drainage ordering map based on Strahler (1964) suggests that the Gusuru river watershed is a 6th order stream (Fig 2). The GIS analysis shows that 1st order streams are 748, 2nd order streams are 190, 3rd order streams are 42, 4th order streams are 12 and 5th order streams are 4 in numbers.

The total stream length of the different order reveals that the total stream length in the study is 530.754 km. Out of the total streams length; first order streams constitute 57.34 per cent of the total stream length whereas remaining 2nd, 3rd, 4th, 5th and 6th order streams constitute 22.98 per cent, 6.81 per cent, 5.65 per cent,, 3.54 per cent and 3.64 per cent respectively.

The delineated watershed was further divided into 14 micro-watersheds. All the computed morphometric are presented in Table 1 and 2. It can be seen that relief ratio value ranges from 0.019 to 0.046 for micro-watershed 1 and 9 & 14 respectively. High value of relief is an indication of quick depletion of water which results in large peak and steep limb hydrograph and higher soil loss. The relative relief values ranges from 0.006 for micro-watershed 1 to 0.017 for micro-watershed 9.

The micro-watershed 14 has maximum ruggedness number i.e. 1.134 while micro-watershed 1 has the minimum value of RN i.e. 0.304. The micro-watershed 14 has overall high roughness.

The elongation ratio value ranges between 0.634 for micro-watershed 13 to 0.868 for micro-watershed 8. Higher value of elongation ratio for micro-watershed 8 indicates mature to old stage topography. According to elongation ratio index, micro-watershed 11 and 12 have an oval shape, micro-watershed 1,3,4,5 and 10 have less elongated shape and micro-watershed 2, 6, 13 and

Table 2 Micro-watersheds wise Morphometric Parameters

Micro watershed No.	Area (km^2)	Perimeter (km)	Elevation (m) Max.	Elevation (m) Min.	Relief (m)	Total Streams (km)	No. of of watershed length (km)	Max length stream
1	11.813	15.095	628.00	538.00	90.00	74	4.72	39.83
2	10.706	15.438	608.00	479.00	129.00	66	5.61	35.25
3	11.134	15.626	606.00	478.00	128.00	59	5.07	35.61
4	10.506	14.205	568.00	418.00	150.00	70	4.63	34.95
5	14.472	18.500	609.00	417.00	192.00	116	5.91	50.47
6	12.574	16.787	605.00	478.00	127.00	48	5.83	30.85
7	7.895	13.294	609.00	477.00	132.00	45	4.09	25.10
8	14.723	17.826	566.00	358.00	208.00	108	4.99	54.03
9	10.185	14.237	606.00	358.00	248.00	64	5.35	33.95
10	11.580	17.155	613.00	478.00	135.00	86	5.65	39.61
11	11.076	15.151	584.00	358.00	226.00	62	4.84	36.38
12	11.487	13.801	564.00	358.00	206.00	72	4.73	38.12
13	7.785	13.802	547.00	358.00	189.00	57	4.97	30.35
14	9.249	15.414	566.00	339.00	227.00	72	4.93	46.19

Table 3 Micro-watersheds wise Computed Morphometric Parameter

Micro watershed	S_f	D_d	R_r	R_h	R_N	R_f	R_e	R_c	R_b
1.	6.264	3.372	0.006	0.019	0.304	0.530	0.822	0.651	3.889
2.	6.165	3.293	0.008	0.023	0.425	0.340	0.658	0.564	4.115
3.	5.299	3.199	0.008	0.025	0.409	0.433	0.743	0.573	3.521
4.	6.663	3.328	0.011	0.032	0.499	0.490	0.790	0.654	3.833
5.	8.016	3.488	0.010	0.032	0.670	0.414	0.726	0.531	3.646
6.	3.817	2.454	0.008	0.022	0.312	0.370	0.686	0.560	3.643
7.	5.700	3.180	0.010	0.032	0.420	0.472	0.775	0.561	3.417
8.	7.335	3.670	0.012	0.042	0.763	0.591	0.868	0.582	3.681
9.	6.284	3.334	0.017	0.046	0.827	0.356	0.673	0.631	3.705
10.	7.426	3.421	0.008	0.024	0.462	0.363	0.680	0.494	4.005
11.	5.598	3.285	0.015	0.047	0.742	0.473	0.776	0.606	3.208
12.	6.268	3.319	0.015	0.044	0.684	0.513	0.809	0.758	3.113
13.	7.322	3.899	0.014	0.038	0.737	0.315	0.634	0.513	3.495
14.	7.785	4.994	0.015	0.046	1.134	0.381	0.696	0.489	3.759

14 have elongated shape.

The circular ratio values ranges from 0.489 (minimum) for micro-watershed 14 to 0.758 (maximum) for micro-watershed 12. High value of circular ratio correlates to mature and old stage of topography.

Micro-watersheds having circular to oval shape allow quick disposal of runoff, and result in high peaked and narrow hydrograph; while elongated shape of micro-watersheds allows slow disposal of water, and result in broad and low peaked hydrograph.

The bifurcation ratio values ranges from 3.113 (minimum) for micro-watershed 12 to 4.115 (maximum) for micro-watershed 2. Higher value for micro-watershed 2 indicates a high runoff, less infiltration and mature nature of topography, which is the resultant of variation in higher and lower order segments. This reflects geologic and tectonic characteristics of area.

The stream frequency ranges between 3.817 for micro-watershed 6 to 8.016 for micro-watershed 5. The drainage density ranges from 2.454 (minimum) for micro-watershed 6 to 4.994 (maximum) for micro-watershed 14. Low value of drainage density for micro-watershed 6 indicates that it has highly resistant and impermeable sub soil materials with dense vegetation cover and low relief, whereas high value for micro-watershed 14 indicates a situation conducive for quick disposal of runoff and region of weak sub surface materials, high relief

and sparse vegetation.

Conclusion

The conventional method of morphometric analysis is time consuming, tedious and error prone. Integration of remote sensing and GIS allows reliable, accurate and updated database on morphometric parameters of watershed. The morphometric analysis of different micro-watersheds within a watershed shows their relative characteristics with respect to hydrologic response.

पानी की उपलब्धता को एक तेजी से विकास और शहरीकरण के लिये महत्वपूर्ण करकों में से एक माना गया है। हालांकि, जल संसाधनों के दोहन पर unsustainability और पर्यावरण क्षरण की शर्त पर हुई है। प्रत्येक वाटरसेड की विशेषता अलग-अलग होती है जो कि वर्षा की मात्रा ओर उसमें होने वाले अपवाह को नियंत्रित करती है। मारफोमेट्रिक अध्ययन किसी वाटरसेड में अपवाह भू-क्षरण, सेडिमेंट डिलेवरी रेसियो आदि हाइड्रोलोजिकल बिहेवियर को निश्चित करने एक महत्वपूर्ण भूमिका निभाता है। यह अध्ययन मध्यप्रदेश के पन्ना एवं सतना जिले की गुसरू नदी वाटरसेड में किया गया है। रिमोट सेंसिंग डेटा का उपयोग अपडेटेड ड्रेनेज मैप के लिये किया गया है। जी.आई. एस. पद्धति द्वारा अध्ययन क्षेत्र के विभिन्न लीनियर, एरियल और रिलिफ पैरामीटर को निकालने के लिये किया गया है। यह देखा गया है कि स्ट्रीम की कुल लंबाई का 57.34 प्रतिशत प्रथम आर्डर स्ट्रीम, 22.98 प्रतिशत द्वितीय आर्डर स्ट्रीम, 6.81 प्रतिशत तृतीय आर्डर स्ट्रीम, 5.65 प्रतिशत चतुर्थ आर्डर स्ट्रीम, 3.54 प्रतिशत पांचवा आर्डर स्ट्रीम एवं 3.64 प्रतिशत छटवां आर्डर स्ट्रीम है।

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Geomorphometric study of Gusuru river watershed using Remote Sensing & GIS technique

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Abstract

Geomorphometric study of a watershed plays a very important role in assessing the hydrological behavior of the ungauged watersheds or in inadequate data situations. Therefore, in this study morphometric analysis and prioritization of forteen micro-watersheds of Gusuru river watershed, which is a tributary of Tons river considered for this study. The morphometric parameters considered for the analysis are stream order , stream length, , stream frequency, bifurcation ratio, form factor, circulatory ratio, elongation ratio, drainage density, ruggedness number, length of overland flow, relative relief, relief ratio, average slope and compactness coefficient all these parameters are determined in Remote Sensing & GIS environment. After analysis of morphometric parameters compound parameter values are calculated and prioritization rating of forteen micro- watersheds is carried out. The micro-watershed 9 has lowest compound parameter value i.e 5.07 is likely to be subjected to a maximum soil erosion; hence it requires immediate attention for provisions of soil conservation measures.

Keywords: GIS, water shed and Prioritization

Land degradation has become a global issue due to soil erosion by various agents/process is highly alarming. India possesses the highest percent of cultivated area (about 46 %) in the world but its crop productivity is invariably very low in comparison to other agriculturally advanced countries. According to an estimate 175 Mha of land in India constituting about 53 percent of the geographical area (329 Mha), suffers from deleterious effect of soil erosion and other forms of land degradation. Active erosion caused by water and wind alone account for 150 Mha of land, which amounts to loss of 5.3 MT of subsoil per year. In addition remaining 25 Mha land have been degraded due to ravine, gullies, shifting cultivation, salinity, alkalinity and water logging. The problem has to be looked upon prudently and a strategic approach has to be followed to mitigate the severity of the problem.

For the efficient and sustainable management of land and water resources one has to look for the sustainable unit. So that these resources can be handled and managed effectively, collectively and simultaneously. A watershed is an ideal unit for management of these natural resources for mitigation of the impact of natural disasters for achieving sustainable development. An accurate understanding of the hydrological behavior of watershed is important for the effective management. Intensive study of individual watershed is therefore necessary for developing management plan, which require immense data. In India most of the watershed is ungauged one. So, the Geomorphometric analysis of watershed can play an important role in inadequate data situations. Morphometric characteristics of represents its attributes and can be helpful in synthesizing its hydrological behavior (Pandey et al. 2004).

Integrated use of remote sensing and GIS techniques can be used in soil erosion assessment and studies on prioritization of sub watersheds for development. The input parameters required for soil erosion modeling can be generated by remote sensing. Geographical information system helps in creation of database for the watershed which is very much useful for carrying out spatial analysis there by helping the decision makers in framing appropriate measures for critically affected area. Sediment yield and soil erosion studies using GIS and remote sensing technologies have been carried out by many investigators. Desmukh et al. (2007) used GIS technique for automatically calculating the MUSLE parameters for Bandha catchment of upper

Damoder valley in Jharkhand state.

Studies conducted by Sharda et al. (1993), Prasad et al. (1997) and Sharma et al. (2007) reveled that remote sensing and GIS techniques are of great use in characterization and prioritization of watershed area. Morphometric analysis could be used for prioritization of micro watersheds by studying different linear and aerial parameters of the watershed even without the availability of soil maps (Biswas et al. 1999). Morphometric analysis requires measurement of linear features gradient of channel network and contributing ground slopes of the drainage basin. Thakker et al. (2007) carried out study on morphometric analysis and prioritization of miniwatershed in Mohr watershed, Gujrat using remote sensing and GIS techniques. In the present study morphometric analysis and prioritization of micro-watersheds are carried out for forteen micro-watersheds of Gusuru river watershed of Satna and Panna district, Madhya Pradesh by using RS and GIS techniques.

Study Area

Gusuru river watershed is located in Part of Panna and Satna district of Madhya Pradesh and covers an area of 155 km^2 and is bounded between 80^0 32' 50.23" E and 80^0 37' 31.14" E longitude, 24^0 6' 32.75" and 24^0 16' 24.07" N latitude (Fig 1). The maximum and minimum elevation encountered in the watershed is 628 m and 339 m above mean sea level respectively.

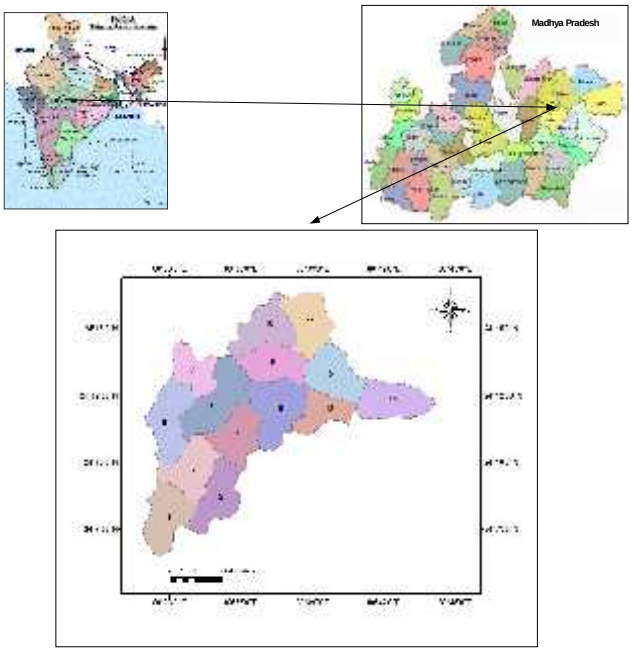

Fig. 1 Location Map of Study area

Materials and methods

In the present study morphometric analysis and prioritization of micro-watersheds of Gusuru river watershed is carried out based on the integrated use of remote sensing and GIS techniques. Base map of the study area was prepared using Survey of India (SOI) toposheets 63 D/11, 63 D/12 and

63 D/16 on 1:50000 scale. IRS P6 LISS III satellite imagery with 23.5 m spatial resolution acquired on 25th October 2007 with Row-100 and Path-55 was used as source data. The remotely sensed data was geometrically corrected and resampled taking toposheets as reference. Image enhancement techniques were applied to extract the drainage layer from FCC (False Colour Composite) for better interpretation of the stream order. The digitization of drainage was carried out using ARC/INFO tools. The stream ordering was carried out using Strahler (1957) stream ordering technique. The study area was divided into micro-watersheds. The fundamental parameters namely; stream length, area, perimeter, number of streams, and basin length were derived in GIS environment. The morphometric parameters for the delineated watershed area were calculated using formula suggested by Horton (1945), Strahler (1964), Schumn (1956) and Miller (1953) given in Table 1.

The morphometric parameters values namely; stream order , stream length , stream frequency, bifurcation ratio, form factor, circulatory ratio, elongation ratio, drainage density, ruggedness number, length of overland flow, relative relief, relief ratio, average slope and compactness coefficient calculated using above formulae. Prioritization rating of all the micro-watersheds of Gusuru river watershed was carried out by calculating the compound parameter values. The micro-watershed with lowest compound parameter value was given the highest priority.

Result and Discussion

The drainage and micro-watershed map of Gusuru river watershed is presented in Fig 2. After analysis of the drainage map, it was found that the Gusuru river watershed is of 6th order type. The fundamental parameters namely; stream length, area, perimeter, basin length, and number of stream of each of the micro-watersheds are shown in Table 2. Computed morphometric parameters are presented in Table 3.

Lower R_b values are the characteristics of structurally less disturbed watershed without any

Table 1. Formula for Computation of Morphometric Parameter

Morphometric Parameters	Formula	Reference
Stream order (u)	Hierarchical rank	Strahler (1964)
Stream Length (L_u)	Length of the stream	Horton (1945)
Mean Stream Length (L_{sm})	$(L_{sm}) = L_u / N_u$ Where, L_{sm} = Mean Stream Length L_u = Total stream length of order u N_u = Total number of stream segment of order u	Strahler (1964)
Bifurcation Ratio (R_b)	$R_b = N_u / N_{u+1}$ Where, R_b = Bifurcation Ratio N_u = Total number of stream of segment of order u N_{u+1} = Total number of stream of segment of next higher order	Schumn (1956)
Mean Bifurcation Ratio (R_{bm})	R_{bm} = Average of bifurcation ratio of all order	Strahler (1964
Basin length (L_b)	$L_b = 1.312 * A0.568$ Where, L_b = Length of basin (km) A = Area of basin (km^2)	Nookaratnam et al. (2005)
Drainage density (D_d)	$D_d = L_u / A$ Where, D_d = Drainage density L_u = Total stream length of order u A = Area of basin (km^2)	Horton (1945)
Stream Frequency (F_s)	$F_s = N_u / A$ Where, N_u = Total number of streams of all order A = Area of basin (km^2)	Horton (1945)
Texture ratio (T)	T = N / P Where, T = Texture ratio N_1 = Total number of streams of all order P = Perimeter (km)	Horton (1945)
Form factor (R_f)	$R_f = A / L_b^2$ Where, R_f = Form factor A = Area of basin (km^2) L_b = Length of basin (km)	Horton (1945)
Circulatory ratio (R_c)	$R_c = 4 \Pi A / P_2$ Where, R_c = Circulatory ratio A = Area of basin (km^2) P = Perimeter (km)	Miller (1953)
Elongation ratio (R_e)	$R_e = (2/L_b) * (A/\Pi)^{0.5}$	Schumn (1956)
Compactness coefficient (C_c)	$C_c = 0.2821 P/A^{0.5}$ Where, C_c = Compactness coefficient P = Perimeter (km) A = Area of basin (km^2)	Horton (1945)
Ruggedness Number	$R_N = H \times D_d$ Where, R_N = Ruggedness Number H = Maximum watershed relief (m) D_d =Drainage density	
Relief ratio	$R_h = H \times L_{db}$ Where, R_h = Relief ratio H = Maximum watershed relief (m) L_b = Length of the basin	
Relative relief	$R_r = R_h \times P$ Where, R_r = Relative relief R_h = Relief ratio P= Perimeter of the basin	
Length of Over land flow	$L_o = 1/ 2 D_d$ Where, L_o = Length of Over land flow D_d =Drainage density	
Average Slope of watershed	$S_a = \frac{H \ L_{ca}}{10 \ A}$ Where, S_a = Average Slope of watershed H = Maximum watershed relief L_{ca} = Length of the Contour A = Area of Watershed	

distortion in drainage pattern (Nag 1998). The micro-watershed 2 has maximum (R_b = 4.115) while micro-watershed 12 has minimum R_b (R_b = 3.113). The value of R_b for micro-watersheds shows that influence of geological structure on the drainage network is negligible.

The micro-watershed 8 has maximum value (R_f = 0.591) while micro-watershed 13 has minimum value of R_f (R_f = 0.315). Low value of farm factor indicates elongated shape of micro-watersheds.

The micro-watershed 8 has maximum value (R_e = 0.868) while micro-watershed 13 has minimum value of R_e (R_e = 0.634). The range of Elongation ratio values of micro-watersheds show that these micro-watersheds are elongated in shape.

The micro-watershed 12 has maximum value (R_c = 0.758) while micro-watershed 14 has minimum value R_c (R_c = 0.489). According to Miller range micro-watersheds are elongated in shape have low discharge of runoff and high permeability subsoil condition.

The micro-watershed 14 has maximum value of (D_d = 4.994) while micro-watershed 6 has minimum D_d (D_d = 2.454). Low value of D_d for micro-watershed 6 indicates that it has the region underlain by highly permeable subsoil material with dense vegetative cover and low relief. Micro-watershed 14 has high value of D_d indicates well developed network and torrential runoff result intense flood, whereas, high Dd value also indicate a situation conductive for quick disposal of runoff, region of weak subsurface material, high relief and sparse vegetation (Nautiyal 1994).

The micro-watershed 5 has maximum (F_s = 8.016), while micro-watershed 6 has minimum Fs (F_s =3.817). The relief ratio value ranges from 0.019 to 0.046 for micro-watershed 1 and 9 & 14. respectively. The micro-watershed 14 has maximum ruggedness number (R_N = 1.134) while micro-watershed 1 has the minimum value of R_N (R_N = 0.304). The micro-watershed 14 has overall high roughness. The micro-watershed 8 has maximum (T = 6.058) while micro-watershed 6 has minimum T (T = 2.859). The micro-watershed 5 has maximum value (C_c = 2.111) while micro-watershed 1 has minimum value of C_c (C_c = 1.329).

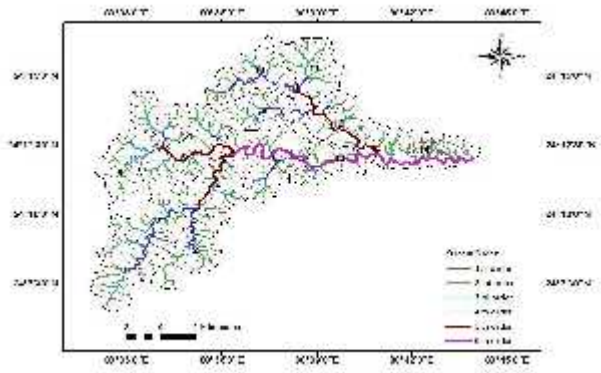

Fig 2 Micro-watershed boundary and drainage

Micro-watershed 6 has maximum (L_o= 0.204 km) and micro-watershed 14 has minimum (L_o= 0.100 km) length of overland flow among fourteen micro-watersheds. The average slope of micro-watershed varies from 7.089 per cent for micro-watershed 1 to 22.295 per cent for micro-watershed 12.

The resource considerations for implementation of watershed management programme for various other

Table 2 Micro-watersheds wise Morphometric Parameters

Micro watershed No.	Area (km^2)	Perimeter (km)	Elevation (m) Max.	Elevation (m) Min.	Relief (m)	Total Streams (km)	No. of Total of watershed	Max length stream length (km)
1	11.813	15.095	628.00	538.00	90.000	74	4.720	39.836
2	10.706	15.438	608.00	479.00	129.000	66	5.610	35.257
3	11.134	15.626	606.00	478.00	128.000	59	5.070	35.614
4	10.506	14.205	568.00	418.00	150.000	70	4.630	34.959
5	14.472	18.500	609.00	417.00	192.000	116	5.910	50.471
6	12.574	16.787	605.00	478.00	127.000	48	5.830	30.859
7	7.895	13.294	609.00	477.00	132.000	45	4.090	25.105
8	14.723	17.826	566.00	358.00	208.000	108	4.990	54.032
9	10.185	14.237	606.00	358.00	248.000	64	5.350	33.953
10	11.580	17.155	613.00	478.00	135.000	86	5.650	39.613
11	11.076	15.151	584.00	358.00	226.000	62	4.840	36.386
12	11.487	13.801	564.00	358.00	206.000	72	4.730	38.126
13	7.785	13.802	547.00	358.00	189.000	57	4.970	30.351
14	9.249	15.414	566.00	339.00	227.000	72	4.930	46.192

reasons pertaining to administrative or even political consideration may limit the implementation to few micro-watersheds. Even otherwise, it is always better to start management measure from the highest priority micro-watershed, which makes it mandatory to prioritize the micro-watersheds available. Watershed prioritization is thus ranking of different micro-watershed according to order in which they have to be taken for treatment and soil conservation measures. Hence, it was necessary to evolve suitable mechanism for prioritizing the micro-watersheds.

For the prioritization of micro-watersheds ranking of micro-watersheds was determined. The highest value of geomorphological parameters i.e. stream frequency, length of overland flow, drainage density, texture ratio, relative relief, relief ratio, average slope of watershed and ruggedness number among forteen micro-watersheds was given rating of 1, the next highest value was given a rating of 2, and so on as the geomorphological parameters generally show positive correlation with soil erosion (Biswas et al 2002; Nooka Ratnam et al 2005; Thakkar and Dhiman 2007). The lowest value was rated last in the series number.

For the basin shape parameters i.e. form factor, circulatory ratio elongation ratio and compactness coefficient the lowest value was given a rating of 1, the next lowest value was given a rating of 2, and so on as the basin shape parameters generally show negative correlation with soil erosion (Biswas et al 2002; Nooka Ratnam et al 2005; Thakkar and Dhiman 2007).

Table 4 presents the ranking and final prioritization of micro-watersheds based on geomorphometric parameters.

To facilitate the phase wise implementation, all the

Table 3 Micro-watersheds wise Computed Morphometric Parameter

Micro watershed	Fs	Lo	Dd	T	Rr	Rh	Sa	RN	Rf	Re	Cc	Rc	Rb
1.	6.264	0.148	3.372	4.902	0.006	0.019	7.089	0.304	0.530	0.822	1.239	0.651	3.889
2.	6.165	0.152	3.293	4.275	0.008	0.023	9.275	0.425	0.340	0.658	1.331	0.564	4.115
3.	5.299	0.156	3.199	3.776	0.008	0.025	8.121	0.409	0.433	0.743	1.321	0.573	3.521
4.	6.663	0.150	3.328	4.928	0.011	0.032	13.524	0.499	0.490	0.790	1.236	0.654	3.833
5.	8.016	0.143	3.488	6.270	0.010	0.032	12.890	0.670	0.414	0.726	1.372	0.531	3.646
6.	3.817	0.204	2.454	2.859	0.008	0.022	7.467	0.312	0.370	0.686	1.335	0.560	3.643
7.	5.700	0.157	3.180	3.385	0.010	0.032	8.680	0.420	0.472	0.775	1.335	0.561	3.417
8.	7.335	0.136	3.670	6.058	0.012	0.042	20.115	0.763	0.591	0.868	1.311	0.582	3.681
9.	6.284	0.150	3.334	4.495	0.017	0.046	17.845	0.827	0.356	0.673	1.259	0.631	3.705
10.	7.426	0.146	3.421	5.013	0.008	0.024	9.998	0.462	0.363	0.680	1.422	0.494	4.005
11.	5.598	0.152	3.285	4.092	0.015	0.047	14.566	0.742	0.473	0.776	1.284	0.606	3.208
12.	6.268	0.151	3.319	5.217	0.015	0.044	22.295	0.684	0.513	0.809	1.149	0.758	3.113
13.	7.322	0.128	3.899	4.130	0.014	0.038	20.416	0.737	0.315	0.634	1.395	0.513	3.495
14.	7.785	0.100	4.994	4.671	0.015	0.046	11.553	1.134	0.381	0.696	1.430	0.489	3.759

Table 4 Prioritization of Micro-watersheds

Micro-watershed	Fs	Lo	Dd	**T**	Rr	Rh	Sa	**RN**	Rf	Re	Cc	Rc	Rb	Compound parameter	Final priority
1	9	9	6	6	14	14	14	14	13	13	3	12	3	10.00	14
2	10	5	10	9	10	12	10	10	2	2	8	7	1	7.38	8
3	13	3	12	12	11	10	12	12	8	8	7	8	10	9.69	12
4	6	7	8	5	7	8	6	8	11	11	2	13	4	7.38	8
5	1	11	4	1	8	7	7	7	7	7	11	4	8	6.38	4
6	14	1	14	14	13	13	13	13	5	5	10	5	9	9.92	13
7	11	2	13	13	9	9	11	11	9	9	9	6	12	9.53	11
8	4	12	3	2	6	5	3	3	14	14	6	9	7	6.76	5
9	7	8	7	8	1	2	4	2	3	3	4	11	6	5.07	1
10	3	10	5	4	12	11	9	9	4	4	13	2	2	6.76	5
11	12	4	11	11	3	1	5	4	10	10	5	10	13	7.61	10
12	8	6	9	3	2	4	1	6	12	12	1	14	14	7.07	7
13	5	13	2	10	5	6	2	5	1	1	12	3	11	5.84	3
14	2	14	1	7	4	3	8	1	6	6	14	1	5	5.53	2

micro-watersheds are prioritized on the basis of morphometric analysis. The compound parameter values of forteen micro-watersheds of Gusuru river are calculated and prioritization rating is shown in Table 4. The micro-watershed 9 with a compound parameter value of 5.07 receives the highest priority (one) with the next in the priority is micro-watershed 14 and having the compound parameter value of 5.53. Highest priority indicates the greater degree of erosion in the particular micro-watershed and it becomes potential candidate for applying soil conservation measures. Thus, soil conservation measures can first be applied to micro-watershed 9 and then to other depending on their priority.

Conclusion

The quantitative morphometric analysis was carried out in forteen micro-watersheds of Gusuru river watershed, using RS & GIS technique for determining the linear, aerial and relief aspects of micro-watersheds. The conventional methods of morphometric analysis are time consuming, tiresome and error prone, while use of RS & GIS technique allows for more reliable and accurate estimation of similar parameters of watersheds. The morphometric analysis of different sub watersheds shows their relative characteristics with respect to hydrologic response of the watershed. The results of morphometric analysis show that micro-watershed 9 and 14 are possibly having high erosion. Hence, suitable soil erosion control measures are required in these micro-watersheds to preserve the land from further erosion.

अनगेजड वाटर सेड या जहॉं पर हाइड्रोलोजिकल डेटा नापने की सुविधा उपलब्ध न हो, उन जगहों के हाइड्रोलोजिकल बिहोवियर को समझने के लिये ज्योमोरफोमेट्रिक अध्ययन एक अहम् भूमिका रखता है। अतः यह शोध कार्य टोन्स नदी की उपसरिता गुसरू नदी पर किया गया है। जिसमें गुसरू नदी के चौदह माइक्रोवाटर सेड की मारफोमेट्रिक विश्लेषण के उपरांत उनका प्रायरटाजेसन किया गया है। इस अध्ययन में जो मोरफोमेट्रिक पैरामीटर लिये गये हैं वे इस प्रकार हैं– स्ट्रीम आर्डर, स्ट्रीम लंबाई, स्ट्रीम फ्रिक्वेंसी, बाइफरकेसन रेसियो, फार्म फेक्टर सरकुलेटरी रेसियो, इलोनगेशन रेसियो, ऐवरेज स्लोप, ड्रेनेज डेनसिटी, रग्गडनेस नंबर, लेंथ आफ ओवरलेंड फलो, रिलेटिव रिलीफ, रिलीफ रेसियो, ऐवरेज स्लोप और कम्पेकटनेस कोफिसियेन्ट। ये सभी पैरामीटर रिमोट सेसिंग एवं जी.आई.एस. द्वारा निकाले गये हैं। मारफोमेट्रिक पैरामीटर निकालने के बाद कंपाउड पैरामीटर वेल्यू निकाली गयी है। उसके आधार पर माइक्रोवाटरसेड का प्रायरटाइजेशन किया गया हैं। माइक्रो वाटर सेड 9 की कंपाउड पैरामीटर वेल्यू 5.07 है अतः इस माइक्रो वाटर सेड में सबसे ज्यादा भूक्षरण होगा। इसलिये इस माइक्रो वाटर सेड में भू संरक्षण उपायों को सर्वप्रथम प्रारंभ करने की जरूरत है।

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Effect of ratio (n/v) on optimizing clearance angle and weeding efficiency

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Abstract

A study was conducted on clearance (d) angle as a design parameter of L shaped tractor PTO operated rotary tool attachable to the tractor PTO weeding machine. The parameter clearance angle (d) of the rotary tool was tested against the ratio of revolutions per minute (n) and forward speed (v) for different lengths of tools during weeding operation with the rotary tool. Often the said tool fails to serve the purpose as negative clearance angle at lower ratios of n/v fails to eliminate the weed plant due to poor penetration of the tool in the soil which causes walking out of the tool from the soil. Therefore the clearance angle (d) was studied against the range of n/v from of 2:1 to 14:1. It was evaluated to optimize the clearance angle (d) as a design parameter. An equation for rotary tool was developed and used to compute the clearance angle (d) for optimum value for the tractor PTO operated rotary weeding tool. These theoretically optimized results showed that optimum value of clearance angle (d) (5.25 to 5.84 degree clearance angle) was on keeping the n/v ratio between 8:1 and 12:1.

The field test revealed that for ratio of n/v from 8:1 to 12:1 led to 87- 90 per cent weed elimination and the clearance angle (d) remained in the range of 5.25 degree to 5.84 degree. Results suggest that for optimization and efficient operation, the tool needs to be operated between the ranges of ratios of 8:1 to 12:1 to achieve maximum weed elimination.

Keywords: clearance angle (d), optimization, power take off, ratio of RPM vs. forward speed, rotary tool

The removal of undesired plants is the most critical field operation, after sowing of the crop that affects the final yields if not accomplished effectively. The yield loss due to weed infestation in soybean has been reported to the tune of 20-77 per cent (Muniyappa et al.1986, Tiwari and Kurchania, 1990, Kurchania et al. 2001). Substantial yield loss can be avoided by efficient management of weed plants. Manually operated tools and tractor drawn sweep type weeders work on the principle of horizontal shearing of the soil and are limited to slicing the soil thus usually fail to prevent re-establishment of the weed plants. In order to perform efficient weed management, an attempt was made to develop a rotary weeding machine. The basic principle in the working of the rotary weeding machine is provision of centrifugal force acting on to cut the soil, uproot and cut the weed plant, and throw the cut slice of soil. This sequence is repeated continuously.

One of the important design parameter is clearance angle of the tool which depends upon rpm and forward speed of the prime mover responsible for pulling the machine and revolution per minute of the rotary tool. The direction of rotation of the tool is a basic rotary design parameter, and is used inline with the common practice in the country to use only the forward direction of rotation (the rotary tool follows the direction of travel of the tractor wheels).

The present study was aimed at optimization of *clearance angle (*d*)* as design parameter of the tool to optimize the weeding efficiency by tractor power take off (PTO) operated rotary weeding tool. A mathematical equation was developed for the *clearance angle (*d*)* as design parameter, which permits to decide optimum range of operation and performance can be decided and selected immediately for production of rotary tools for specific soil and field conditions. Optimization of the design parameter of the tractor PTO operated tool is helpful in designing and development of rotary weeding tool for different operating speeds, soil conditions and moisture conditions.

In rotary tool, the tool is fixed at predetermined drilled holes on the flange, which is welded on the shaft of the rotary machine, thus having a control over cutting angle. The transfer of power directly to soil by using

tractor rather than through inefficient drawbar has some inherent advantages of rotary or active powered tools for considering them as an alternative to tractive tools.

Smaller clearance angle were formed when the ratio of rpm and forward speed were low. The optimisation of clearance angle of weeding tool would enable to design of the tool to solve the problems associated with the various types of weed elimination situations. It would realise the true potential of the mechanization of weeding methods.

Material and methods

The study comprised of (i) development of equation for *clearance angle (*d*)* of the L shaped tool, (ii) validation of the developed equation for *clearance angle (*d*)* as design parameter, and (iii) optimisation of *clearance angle (*d*)* as design parameter and with field observations for three years.

Forward speed of the tool was controlled with the help of a gear selection with the ground PTO type tractors. The tool rpm was controlled with the help of PTO speed which was taken from independent PTO system of the tractor. The *clearance angle (*d*)* (Fig 1) was measured as and angle between tangent to the formed trochoid and the line passing through the sharpness angle made by the tool / tools operated by the tractor power take off operated rotary machine.

Study on the major design parameter of weeding tool i. e. clearance angle (d) was conducted for different speed of rotary tool and the prime mover (n/v). The length of the cutting tool was taken R = 30 cm and R = 28 cm which were mounted on a flange fixed on a shaft of the tool. The cutting tool was made of spring steel (5 mm thickness). Number of tools (z=3) per flange was taken for the study.

Clearance angle (d):

This developed equation helps to select clearance angle (d) under suitable limits against n/v so that the tool cuts a slice with minimum of effort and does not leave slice holding the weed plant. Thus, following assumptions were [illegible] of the

$$\delta = \beta - \cos^{-1}\left(\frac{30}{R}\sqrt{\frac{H(2R-H)}{900 - 60\pi\xi(R-H) + (R\pi\xi)^2}}\right)$$

Where, H = Depth of soil, R= length of the tool, d= n/v ,n = number of revolution of the tool, v = forward velocity of machine (cm/sec),z=number of tools

Validation of the equation for clearance angle (d) of the tool

Validation was conducted by changing the values of n/v by changing values of n and keeping v constant and calculating the clearance angle (d) cut by the tool. The data was recorded on revolutions per minute and forward speed for 3 tools on the flange of the rotary shaft of the tractor PTO driven machine.

The data of different values of n, v and z was put in the equation to calculate the clearance angle (d) and graph was drawn (Fig. 2). The result from data and the graph clearly depict that with the increase in n/v the

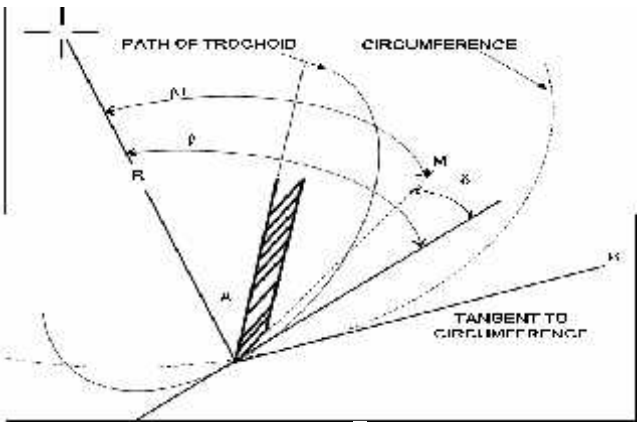

Fig. 1 Clearance angle (δ) vs n/v R =30 cm

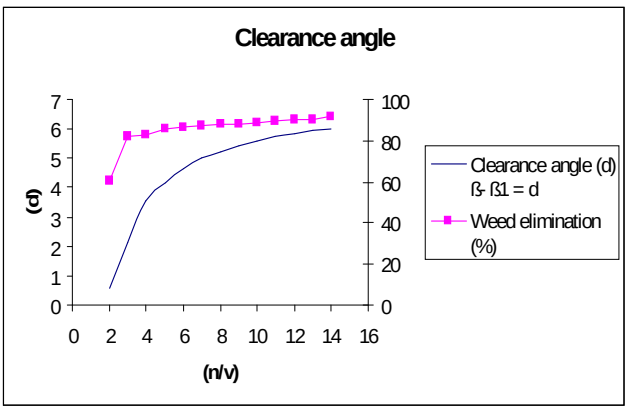

Fig. 2 Clearance angle (δ) vs n/v R =30 cm

clearance angle (d) increases and vice versa. Thus, the developed equation was found to be valid for different ratios of n/v. Sakai and Hai (1982) reported that the clearance angle at the untilled side surface of the lengthwise blade is an important parameter for the design of rotary blade.

Optimization of clearance angle (d) of the tool

Optimum range of n/v for the clearance angle (d) was achieved with changing the n/v by changing the forward speed of the machine which is operated with the prime mover (tractor). The equation of clearance angle was tested with the change of n/v for different values of n and keeping v constant to find out clearance angle for optimization with the change of revolutions per minute of the tool which respect to its forward speed. The optimization of clearance angle was evaluated with the performance of weed count different lengths of tools. The values of the clearance angle) of three sets were used in the equation developed for finding out the clearance angle to establish the optimum value or range of n/v. Field testing was conducted to collect data for measurement of bite length against n/v and elimination of weeds. The tests were conducted for three sets for each tool. The data for the clearance angle (d) against different ratios n/v of the tractor power take off operated rotary tool was analyzed.

The clearance angle (d) of the tool was computed after obtaining the sample from the field after the operation of the different number of tools with various ratios of n/v. The number of weeds were collected before and after the operation of the tool and recorded with different forward speeds and revolutions per minute from 10 randomly selected places from ten replicated plots (each plot- 50 m x 2.25 m) for each of the above two treatments. The bite length data from each plot was recorded.

The clearance angle (d) of the tool made with the uncut soil was in the field test with weed elimination percentage. The data of weeds/m^2 was recorded. The pattern followed by the change of ratio upon the length of cut was evaluated. Test was conducted with tool length R = 30 cm. Forward speed selected for the study was v = 20 cm / seconds which was kept constant. This revolution per minute of the tool was varied from n = 20 onwards. The above said data was selected to vary the ratio of n/v and the clearance angle (d) of the tool was recorded for the study.

Results and Discussion

The testing of the equation developed was accomplished to compute clearance angle (d), for different ratios of rotary rpm and forward speed. The study clearly indicates that the clearance angle (d) variation affects the change in the percentage of weed elimination. Increase or decrease in the length of tool on the same flange with the same ratio of n/v was found to be directly proportional to the clearance angle (Table 1).

The ratio of n /v, 8:1 to 12:1 was in the range in which the clearance angle (d) as per the developed

Table 1. Effect of ratio (n/v) on optimizing clearance angle (δ) and weeding efficiency

RPM (n)	Forward speed (v) (cm/sec)	Ratio of (n/v)	Length of tools R-30 cm		Length of tools R-28 cm	
			Predicted clearance angle (δ) (cm)	Weed elimination (%)*	Predicted clearance angle (δ) (cm)	Weed elimination (%)*
40	20	2	0.57	60.25	-1.36	21.00
60	20	3	2.13	82.30	1.63	68.00
80	20	4	3.56	83.00	3.04	82.00
100	20	5	4.16	85.80	3.87	84.00
120	20	6	4.65	86.50	4.41	85.50
140	20	7	4.99	87.50	4.71	86.50
160	20	8	5.25	87.70	5.07	87.00
180	20	9	5.45	88.30	5.12	87.50
200	20	10	5.61	88.80	5.46	88.50
220	20	11	5.73	89.50	5.61	89.50
240	20	12	5.84	90.00	5.72	90.00
260	20	13	5.93	90.50	5.82	91.50
280	20	14	6.01	91.50	5.86	92.00

**Mean of three years*

equation revealed that with increase in the ratio of n/v, the clearance angle (d) increased proportionately. The increase of clearance angle (d) with the increasing the ratio n/v when put in the equation proves the validity of the equation for the clearance angle (d).

Field test results

Study on weeding operation for first set was done with the tool for clearance angle (d) computation theoretically and in the field, there was significant difference in the weed population. The ratio above of n/v 12:1 not much variation /increase of weed elimination was observed. The result for z=3 showed that reduction in weed population was 87 to 90 per cent when n/v was kept in the ratio from 8:1 to 12:1.

Optimization of the clearance angle (d) as design parameter

The data for optimization of clearance angle (d) in the equation provide value of clearance angle (d) which can draw the curves for number of tools (z = 3) on the flange when clearance angle (d) is plotted against n/v. Weeding efficiency increased with the increase in the ratio of n/v which leads to increase in clearance angle (d) as per the equation and practice.

The optimization of clearance angle (d) for rotary tool was different with the length of tools on the flange with ratio of forward speed and rotation of the tool. But it is important to mention that the clearance angle (d) with R=28 cm for n/v at lower ranges is negative or very low which causes difficulty in penetration of tool in the soil and subsequently weed elimination percentage is reduced. This causes excessive consumption of power and energy besides the tool walking out of the field.

As the clearance angle (d) increased the tool eliminated more weeds and also helped to slash the weed plant and shook away the soil from the weed plant root. The clearance angle (d) with the R=30 cm and z=3 was found to be optimum as the ratio of n/v ranging from 8:1 to 12:1 was sufficient to uproot slash and shake away around than 87 to 90 per cent of the weed plants from the soil. Thus z=3 and the range of ratios of n/v 8:1 to 12:1 (Fig. 2) was considered to be optimum for the design parameter of clearance angle (d).

Ratio of n/v of 8:1 to 12:1 was optimum for clearance angle in the range of 5.25 degree to 5.84 degree. (d). At this range maximum weeding efficiency was the highest.

ट्रैक्टर पीटीओ चलित रोटरी निंदाई मशीन द्वारा चलित टूल का क्लियरेंस कोण डिजाइन पैरामीटर के रूप मे अध्ययन किया गया। क्ल्यरेंस कोण (δ) को रोटरी टूल के चक्कर प्रतिमिनिट व आगे कि गति के मुकाबले परीक्षत किया गया n/v के निचले अनुपात के अनुसार चलने पर क्लियरेंस कोण ऋणात्मक होने की वजह से रोटरी टूल निदाई करने पर असमर्थ हो जाता हैं अतः n/v का अध्ययन 2:1 से 14:1 के बीज किया गया क्लियरेंस कोण को डिजाइन पैरामीटर के रूप में अनुकूलित करने हेतु मूल्यांकन किया गया । रोटरी उपकरण के क्लियरेंस कोण प्राप्त करने हेतु विकसित सभीकरण का प्रयोग कर अनुकूलिन रेंज प्राप्त किया गया। n/v 8:1 से 12:1 अनुपात रखने पर क्लियरेंस कोण 5.25 डिग्री से 5.84 डिग्री इष्टतम प्राप्त हुआ। इस अनुपात में निदाई का प्रतिशत 87-90% प्राप्त हुआ।

अध्ययन के अनुसार यह पता चलता हे कि इष्टतम कार्य हेतु n/v को 8:1 से 12 के बीच चलाना समुचित होगा ।

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Agricultural resources mapping in GIS of Kymore Plateau and Satpura Hills agro-climatic zone, Madhya Pradesh

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Abstract

Agricultural production system needs characterizing its resources. Most of the agricultural resources are found varying with space and time. Geographical Information System (GIS) can store, analyze and retrieve information that pertains to various locations therefore an attempt have been made to characterize agricultural resources for Kymore Plateau and Satpura Hills agro – climatic zone of Madhya Pradesh. Resources data were tabulated in MS Access software, which was directly used by GIS software. Database generated includes attributes regarding area under different land use, grain crops, pulses, cash crops, oilseeds, medicinal crops, animals, farm implements and machines, rainfall and irrigation sources. Maps on various themes have been prepared which can be useful in characterizing agricultural resources of the zone and developing decision support system. To demonstrate the utility of thematic maps quarries were developed for identification of blocks requiring improved practices of water management in irrigated area by wells and identification of blocks for promotion of land use activities like intensive cropping, horticulture and agro-forestry. It was found that 18 blocks were identified which needs attention for improving water management practices. Fifteen blocks were found where intensive cropping should be promoted.

Keywords: Resource mapping, geographical information system

Land Cover is the physical state of the land surface with the combination of vegetation, soil, rock, water and human made structures. The term land use relates to the human activities associated with specific piece of land. Wise land-use planning involves making knowledgeable decisions about land use and the environment. Holistic planning involves input from multiple, interrelated data sources and types. In order to accomplish this feat a great deal of information must be considered simultaneously. Traditional land-use planning involved many different sources of printed information such as soil survey manuals, topographic maps, aerial photographs, vegetation surveys, flood maps, hydrology maps, and property surveys to name a few. Each source contributed an important characteristic to the final decision. Human decision-makers were challenged to keep track of all this information at once, to understand the interrelationships, and to correlate multiple data sources at single locations.

Advances have been made towards extraordinary digital systems for utilization in land-use planning. Computer programs including decision support systems (models), Geographic Information Systems (GIS), spreadsheets, databases, and color desktop publishing programs contribute to the speed and efficiency of the overall planning process. In recent years water and agricultural resources mapping on GIS platform is getting attention of research and development personals (Kar 2000; Singh and Prakash 2001; Natarajan 2001; Kumar and Prasad 2001; Dubey 2002; Bhattacharyya 2003; Gupta and Gupta 2004).

There is a need to have a diversified land use system for better utilization of natural resources in general and agricultural resources in particular. Therefore a study has been taken up with the specific objective of mapping of agricultural resources of the Kymore Plateau and Satpura Hills for agricultural

Fig.1. Location of Agro-climatic Zone –IV of Madhya Pradesh

resources using GIS technique and demonstrating its application.

Material and methods

The agro-climatic zone–IV of Madhya Pradesh is known as Kymore Plateau and Satpura Hills, comprises of Seoni, Jabalpur, Katni, Panna, Rewa, Satna and Sidhi districts (Fig.1). The total geographical area of the zone is 46.81 lakh ha, accounting for 11.3 per cent of the total area of the State.

Data required for preparation of relational database for agricultural resources were obtained from District Statistical Book of concerned districts. All data used in the study are related to year 2003-04 for Katni, Rewa, Seoni, Panna; 2004-05 for Sidhi and 2005-06 for Satna and Jabalpur. Unit for generation of database of agricultural resources is considered as development block. Spatial information of soils in the zone used for digitization is obtained from soil report (Tomar et al. 1995).

Resources data obtained were tabulated in MS Access. ID number was given to each block having 6 digits. First four digits are the ID for the district as per standards for GIS in India (NAARM 2005). Last two digits indicate the block number of the district, which were assigned according to location of the block starting from south and moving towards north. The specifications for map generation on GIS are-

- Projection system: POLYCONIC
- Coordinate system: Latitude-Longitude (Lat-Lon)
- Datum: India 1975 geodetic datum
- Digitize reference point (TICS) browsed on Lat-Lon (Table 1)

Table 1. Longitude and Latitude of TICS

Reference Point	Longitude	Latitude
Barghat	79:43:54.584	22:01:39.724
Singrauli	82:39:08.946	24:04:08.116
Teonthar	81:38:21.491	24:58:56.266
Ajaygarh	80:15:20.268	24:54:24.052

The registered raster image (Kymore Plateau and Satpura Hills) was digitized by tracing over the boundaries on the screen to turn into vector data for zone boundary, district boundary, block boundary, rain gauge station (point feature class) and town name (point feature class).

Connecting external database

Digitized block boundary map was connected to external database (MS Access) having the common Block-ID in block boundary vector map and external database. To establish a relationship between the feature classes, “join” was created. It facilitates to perform multi-field joins on feature classes and queries.

Preparation of thematic maps

A thematic display symbolized geographic feature according to non-graphic attribute data through the use of colour and other defined display properties. A thematic display was created from feature class in any open warehouse connection, or from query in the active Geo workspace and the attribute was classified as density/ intensity, count or range representing useful information.

Application of thematic maps on GIS platform

The main advantage of GIS software is that it enables mathematical and logical operations on spatial and attribute data. To demonstrate the practical utility of thematic maps two quarries were build up.

Identification of blocks requiring improved water management practices

Training campaign for farmers is to be launched. Let there be a query - what are the blocks where water application efficiency is poor for well irrigation? So that training and demonstration module can be planned in those blocks. To answer the question, a query in GIS platform was generated with thematic maps and database generated. Following assumptions were made to work out existing water application status in well command.

- Annual draft of water for open well is 1.0-1.5 ha-m/ year/well and for tubes well it is 2.0-3.0 ha-m/year/ well (CGWB, 2003). Average value of draft was considered as 1.25 ha-m/year/well for open well and 2.50 ha-m/year/well for tube well.
- In any block, out of the total number of wells available, 70% of the wells are open wells and remaining 30% are tube wells/ bore wells.
- Water requirement for rabi crops is 40 cm.
- Overall efficiency of irrigation from well is 65 percent.

With above assumptions, on an average a well should irrigate 2.65 ha. A function attribute command area of

100 wells (WELLCOM) was calculated as

WELLCOM = Well irrigated area x 100/ Number of wells.

Blocks where well irrigated area by 100 wells is in the range of 215 to 315 ha (average 265) is considered standard or medium. A thematic prepared for attribute WELLCOM with three classes (Table 2) was prepared. Blocks which are rated as Poor, require measures for improved practices of water management.

Table 2. Classification of well irrigated area

Irrigated area (ha) per 100 wells	Well irrigation status
0 – 215	Poor
215 – 315	Medium
315 or more	Good

Identification of blocks for promotion of crop diversification activities

There can be many requirements for developing action plan for crop diversification use. Looking to the database generated and simplicity in modeling following five criteria were considered for developing land use plan. The criteria are based on recommendation of IMSD technical guideline (IMSD 1995) with some modification.

- Percentage irrigated area: The important requirement for intensive agriculture is availability of irrigation facility from all sources of irrigation. Blocks where ratio of irrigated area and net sown area is less than 0.20 are considered as rain-fed areas (WARSA 1996). A thematic map has been prepared based on a functional attribute (IRA = Total irrigated area x 100/ net sown area) as described Table 3.

Table 3. Classification of irrigated area

IRSclass	Irrigation status	Percent irrigated area
1	Poor	<20
2	Medium	20-39
3	Good	40 or more

- Present agricultural land use: The existing land use is always important in deciding action plan for land utilization. In this report land use for agriculture has been classified on the basis of a new attribute (LU), calculated as percentage of net sown area to geographical area.
- Tractor Density: Tractor density is an indicator of mechanization in agricultural sectors. On an average one tractor for 20 ha land is required for mechanized farming. In the zone-IV, no block full fills this requirement. Hence it was considered that the blocks, which have one tractor for 50 ha, land (tractor density more than 20) can be enhanced to desired density of 50 by promoting activities for agricultural mechanization and financial arrangements.
- Soil Texture: Soil indicator makes it little easier to indicate the area for promoting various agricultural activities. For intensive agriculture medium black soil and light black soil is required. Soil texture is grouped in medium black soil (MBS), light black soil (LBS) and medium red and black soil (MRBS).
- Soil Depth: Soil depth can be used as an indicator of slope. To get the idea of land slope, soil depth is the criteria used which is grouped into deep, shallow and moderate. For intensive agriculture deep and moderate soil depth are required.

On the basis of these five criteria's a query has been made and land use has been suggested (Table 4).

Table 4. Guidelines for promotion of land use activity

Irrigated status (IRA)	Land use use (LU)	Tractor density	Soil texture (ST)	Soil depth (SD)	Promotion of activity
Good	Good	> 20	MBS LBS	Deep, Moderate	Intensive Cropping Horticulture
Medium, Good	Poor Medium	≤ 20	LBS, MRBS	Moderate Shallow	
Poor	Poor, Medium	≤ 20	LBS, MRBS	Shallow	Agro-forestry Cropping with other entrepreneurship
		Rest of all			

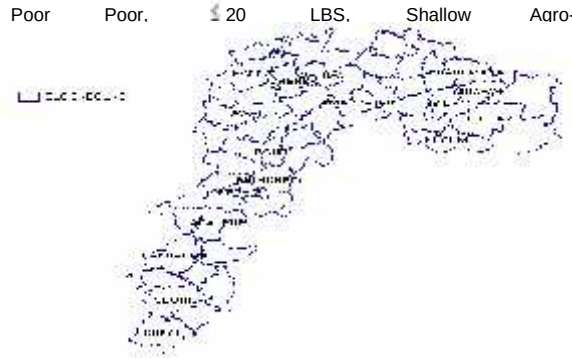

Fig.2. Digital map of block boundaries

Results and discussion

A scanned map in TIFF format has been imported in geo workspace for on screen registration and digitization. The digitized maps of zone, district boundary and block boundary have been prepared. Digital map in vector format of block boundary is depicted in Fig.2.

Resource mapping

Soils

Three types of soil namely viz., medium black and red soil, medium black soil and light black soil are found in the study area. A maximum area of 27.23 lakh ha in 28 development blocks, is covered by medium black soil (Fig. 3). The light black soil (LBS) is distributed in 8 blocks; where as mixed red and black soil (MRBS) is distributed in 15 blocks. Medium black soils are mostly found in Panna, Satna, Rewa and Sidhi districts. Depth of Soil in the zone varies from shallow to deep with maximum area of 27.21 lakh ha covered under deep soils (Fig.4).

Thematic maps

Database for other agricultural attributes (Table 5) have been prepared and thematic map can be prepared instantaneously in the GIS platform. Some of the thematic maps prepared are presented.

Crops

Rice is the major kharif crop of the zone. Block wise area under paddy crop is depicted in Fig.5. It can be seen that depicted from the map that 21 blocks have area in the range 3500 to 11375 ha , 22 blocks have the range 11376 to 19250 ha, 4 blocks each in the range 19251 to 27125 ha and 27126 to 35000 ha. A map of area under wheat crops in various blocks of the zone

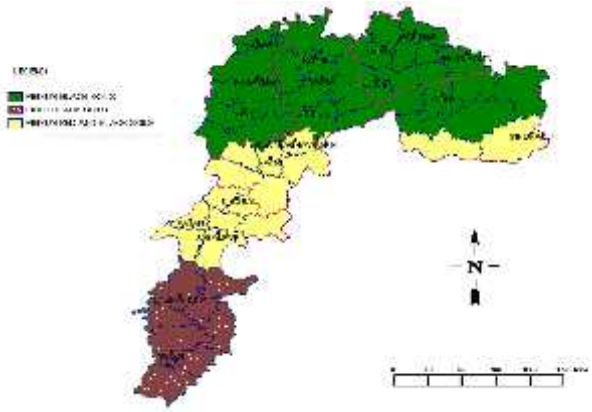

Fig. 3 Soils in Kymore Plateau & Satpura Hills

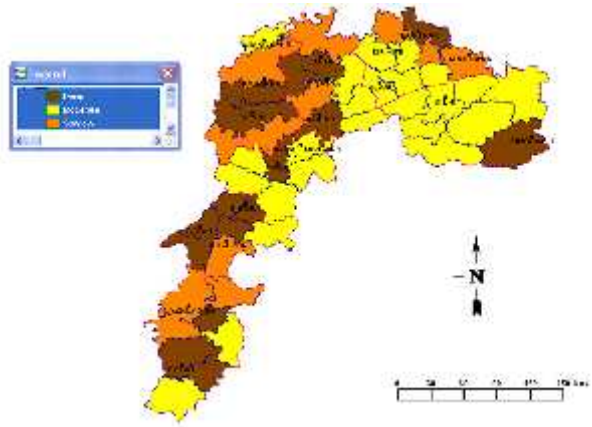

Fig. 4. Variation in soil depth in Kymore Plateau & Satpura Hills

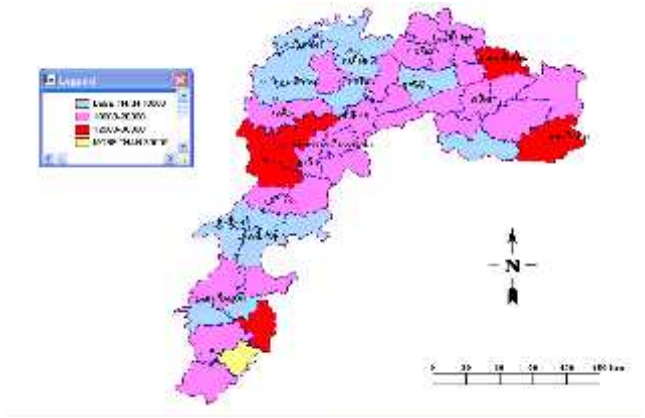

Fig. 5. Area under paddy crop in blocks of Kymore Plateau & Satpura Hills

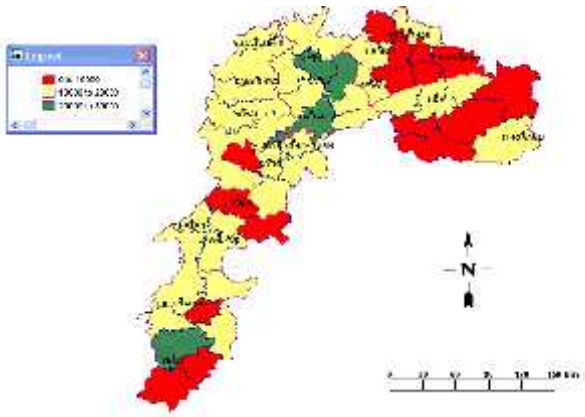

Fig. 6. Area under wheat crop in blocks of Kymore Plateau & Satpura Hills

Table 5. Attributes of resources database prepared for Kymore Plateau & Satpura Hills agroclimatic zone – 4

Database	Attribute
Grain	Wheat, Sorghum, Maize, Other grain crops, Total grain crops
Pulses	Chickpea, Pigeon pea, Black gram, Green gram, Lentil, Other pulses, Total pulses
Cash crops	Sugarcane, Total fruits, Total vegetables, Total spices, Cotton, Other fiber, Total fiber
Oil seeds	Sesame, Linseed, Groundnut, Mustard, Soybean, Other oilseeds, Total oilseeds
Season wise Crops	Kharif food crops, Kharif non food crops, Rabi food crops, Kharif non food crops, Total of Kharif and rabi crops
Irrigation	Number of canals, Canal irrigated area, Number of hand pump, Hand pump irrigated area, Number of wells, Well irrigated area, Number of ponds, Pond irrigated area ,Other source irrigated area, Total source irrigated area, More than one irrigated area, Total irrigated area, Percent of pure irrigated area to pure sown area
Land use	Geographical area, Forest area, Land not available for agriculture, Non agricultural land, Agricultural land, Fallow land, Pure sown area, Double crop area, Total of pure sown area and double crop
Medicinal	Tobacco, Other medicinal and aromatic plants, Total medicinal and aromatic, plants, Chari, Various non food crops, Total non food crops, Total of food and non-food crops
Animal and Bird	Number of bullocks, Number of cows, Calf cows, Total cow, Number of He- buffalo, She buffalo, Calf buffalo, Total buffalo, Sheep, Goat, Horse, Ass, Donkey, Camel, Pig, Total animals, Total hen, Duck, Total Poultry
Machinery	Wood plough, Iron plough, Bullock cart, Oil for pump, Electricity for pump, Number of tractors, Dhaani, Power operated cane crusher, Animal operated cane crusher
Rainfall	Year wise rainfall in mm

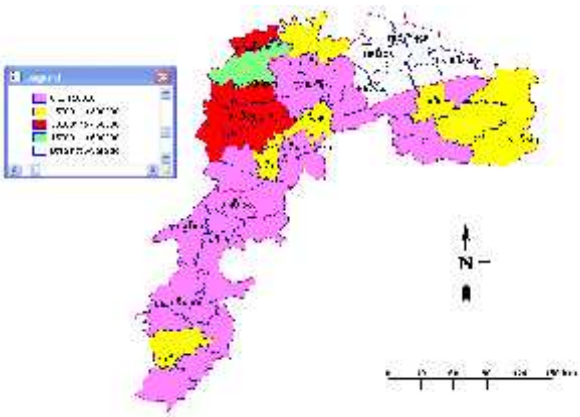

Fig. 7. Number of animals in blocks of Kymore Plateau & Satpura Hills

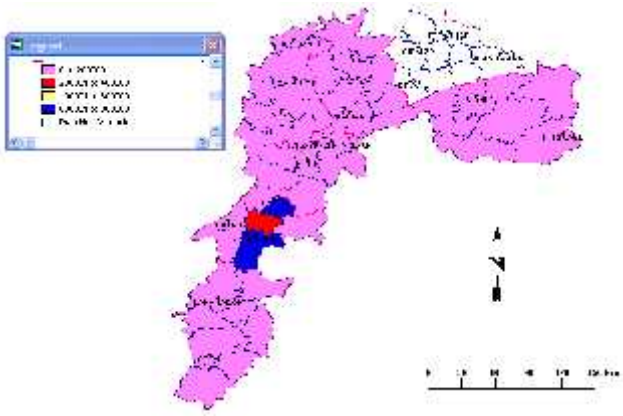

Fig. 8. Number of poultry bird in blocks of Kymore Plateau & Satpura Hills

has been prepared (Fig.6). It can be visualized form the map that 16 blocks have area under wheat in the range 2500 to 9375 ha, 24 blocks have the area under wheat in the range 9376 to 16250 ha, 8 blocks have the range of 16251 to 23125 ha, and 3 blocks have area under wheat in the range of 23126 to 30000 ha.

Animals

Thematic maps on animals were prepared including total number of cow, total buffalo, poultry birds, total animal etc. From the thematic map of total animals it can be observed that maximum number of animals is in Panna block of Panna district (Fig. 7). A map prepared for total number of poultry birds (Fig. 8) it is recoded that 39 blocks have number of poultry in the range 2000 to 201500, two blocks have in the range 600501 to 800000, two blocks have in the range 201501 to 401000. The maximum number of poultry birds in the zone is in Jabalpur block of Jabalpur district.

Irrigation

A map on number of wells used for irrigation has been prepared (Fig. 9). There are 32 blocks having number of wells less than 1700, fifteen blocks having number of wells in the range 1701 to 3400, three blocks having number of wells in the range 3401 to 5100, one block (Seoni) is having highest number of wells. Number of

Wells used for irrigation in a block is an indicator of the water table of the area, geological formation.

Agricultural machinery

The maximum numbers of tractors (more than 2000) are in Nagod block of Satna district (Fig. 10) with tractor density of 40, whereas minimum numbers of tractors are in Shahanagar block of Panna districts. This indicates the poor mechanization in Shahnagar block. There are 39 blocks having number of tractors less than 700, ten blocks having tractors in the range 701 to 1400 and one each in the range 1401 to 2100 and 2101 to 2800, respectively. The mode of working in the field in these blocks is iron & wooden plough.

Application of GIS

Identification of blocks requiring improved practices of water management

The result obtained from the query for the identification of well irrigated area is generated in a thematic map. In 18 blocks well status is poor shows that training and demonstration can be organized for improved water

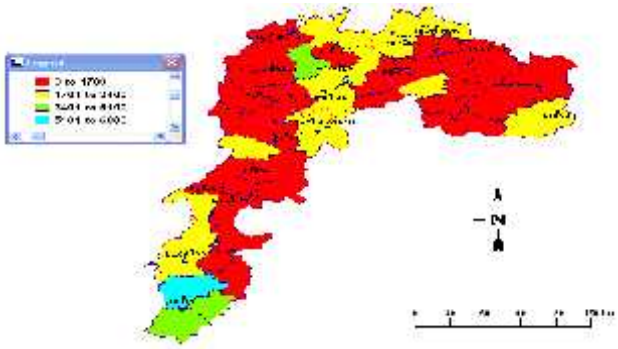

Fig. 9. Number of wells in blocks of Kymore Plateau & Satpura Hills

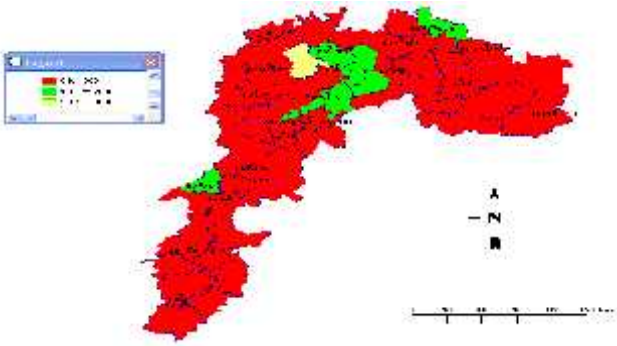

Fig.10. Number of tractors in blocks of Kymore Plateau & Satpura Hills

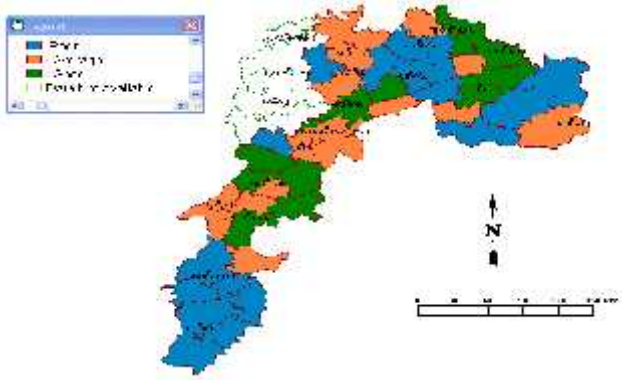

Fig.11. Well irrigation status in blocks of Kymore Plateau & Satpura Hills

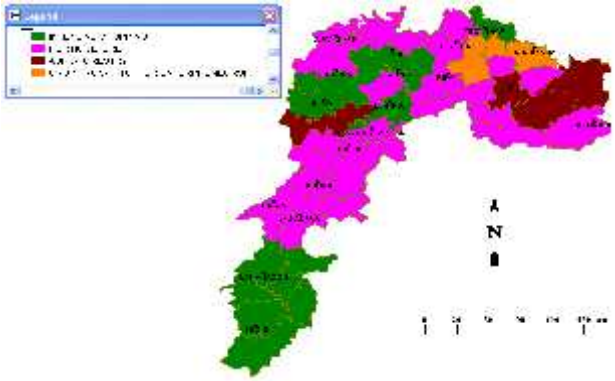

Fig.12. Suitability map for the promotion of land use activity

management (Fig.11).

Identification of blocks for promotion of land use activity

The result obtained from the query for suitable land use activities in blocks is generated in thematic map (Fig.12). From the thematic map of promotion of land use activity it can be depicted that intensive agriculture can be promoted 15 blocks, horticulture in 28 blocks, agro-forestry in 4 blocks and agriculture with other entrepreneurship in 4 blocks.

Geographical information system is an important tool for mapping resources and characterization of a region. Spatial and attribute data clubbed together in GIS platform makes development of models and decision support system faster and easier.

कृषि उत्पादन प्रणाली की जरूरत है अपने संसाधनों के लक्षण वर्णन की । कृषि संसाधन अधिकांशतः स्थान और समय के साथ बदलते हुए पाए जाते है। भौगोलिक सूचना प्रणाली (जी.आई.एस) विभिन्न स्थानों से

संबंधित जानकारी का भण्डारण, विश्लेषण एवं पुनः प्रदर्शन कर सकती है । इसलिए मध्यप्रदेश के कैमोर पठार एवं सतपुडा हिल्स कृषि जलवायु क्षेत्र के कृषि संसाधनों के मानचित्रीकरण का एक प्रयास किया गया है। संसाधन संबंधित आकडों को एम.एस. एक्सेस साफ्टवेयर में सारिणीबद्ध किया गया जिन्हें जी.आई.एस साफ्टवेयर ने सीधे उपयोग में लाया । तैयार डेटाबेस में भूमि उपयोग क्षेत्र, अनाज, फसलों, दालों, नकदी फसलों, तिलहनों, औषधीय फसलों, पशुओं, कृषि औजार और मशीनों, वर्षा तथा सिंचाई स्त्रोंत शामिल है। विभिन्न विषयों पर आध ारित मानचित्र तैयार किये गए जो कृषि संसाधनों के लक्षण वर्णन और निर्णय समर्थन प्रणाली के विकास में उपयोगी है । विषय आधारित मानचित्रों की उपयोगिता प्रदर्शित करने के लिए उन विकास खण्डों को चिन्हित करने के लिए क्वेरी की गई जहां कुओं से सिंचित क्षेत्र में जल प्रबंधन को बढावा देने की आवश्यकता है तथा जहां गहन-फसल, बागवानी एवं कृषि वानिकी की गतिविधियों को बढ़ावा देने की आवश्यकता है । जल प्रबंधन में सुधार के लिए १८ विकास खण्डों को चिन्हित किया गया है । पंद्रह विकास खण्डों में गहन फसल को प्रोत्साहित करने के लिए चिन्हित किया गया ।

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Seed coverer- a tool to enhance field emergence and productivity of soybean

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Abstract

An effective device to cover soybean seed after seeding with seed drill was developed at Directorate of Soybean Research, Indore. Attaching the developed device on shanks of seed drill effectively improves field emergence of soybean *cv* 'JS 335' as judged by the increase in resultant plant population to the extent of 42 %. As compared to traditional seed covering by attaching angle iron bar behind seed drill also, the field emergence was 19 % higher than non-use of seed coverer. The increased field emergence resulted in a yield increase of 28 and 24 % with the use of seed coverer and angle iron bar, respectively over control.

Keywords: Seed coverer, seed drills and plant population

. . . . . *Glycine max* (L.) Merrill] cultivation has established well in the Central India and other upcoming regions during past three and half decades. The area and productivity of crop in initial stages of commercial exploitation in 1970 was merely 30,000 ha and 426 kg/ha which is now more than 7 million ha with productivity of about 1000 kg/ha. Looking to the potential of newly developed varieties (about 3500 kg/ha) and realizable potential at farmers field as 1846 kg/ha (Billore et al. 2009), it appears feasible to enhance the yield levels in the country. Of late, there has been emphasis on the "Precision Agriculture", which envisages lying attention on the finer management of crop so that cumulative effect on productivity enhancement can be achieved.Soybean seed being a 'poor storer' loses viability very rapidly under warm and humid conditions of storage, hence, the major constraints in soybean cultivation is the non-availability of high vigour seed at the time of sowing (Singh and Dadlani 2003; Babu and Hunje 2008) for better field emergence. Further, it is influenced by the quality of the seed planted and by the seedbed environment, with soil moisture, pathogens, temperature and impedance being the most important components (Ramteke et al. 2009, Gummerson 1986, Helms et al. 1996, Ferriss et al. 1987, Wheeler and Ellis 1992, Hamman et al. 2002). Considering the above fact, uniform placing of seeds in the soil and properly covering of soil is necessary for epigeal germination and better plant population of soybean. Therefore, attention was drawn to overcome this problem. Poor plant population is considered to be one of the constraints in obtaining optimum yield. Hence, an attempt has been made to develop an effective seed covering mechanism, which turns out to be capable of instant covering of seed in planted rows with sowing operation with seed drills. The seed-covering device developed at Directorate of Soybean Research was evaluated for consecutive three years and the results obtained are presented in this paper.

Material and methods

Development of seed coverer

A simple seed coverer device was developed at Directorate of Soybean Research to facilitate covering of row planted seed using a seed drill. The developed device (Plate 1) is made of mild steel with dimensions of 16 cm (width) and 22.5 cm (height) and is attachable with shank of the seed drill using metallic fitment. The total weight with the fitment works out to 1.4 kg. In operation, the inverted V notch with base of 10 cm with height of 8 cm pushes the soil covering the seed completely. Weight of the Seed covering device was of 2.5 Kg/unit which include support system which is attached to the tine of the seed drill. Any quality manufacturer with a mere cost of Rs 180 per piece can fabricate this simple device with fitment.

The afore mentioned developed seed coverer . . . . . *kharif*

season for soybean crop and the performance was compared with traditional seed covering (running an angle iron bar behind the tractor) and without the use of above two. It was ensured that the seed depth in all the three treatments was uniform as recommended in package of practices (Bhatnagar and Tiwari 1995). For the purpose, the planting of soybean was carried out in 1.8 m x 50 m plots utilizing all the three treatments randomly in 10 replicates. The plant population was recorded after 15 days of planting in one square meter area at 10 places in a treatment and average population was worked out. The soybean variety (JS 335) was planted between 15th and 20th July during the three years. As per recommended practice, on account of late sowing, the seed rate was enhanced by 25 % and row-to-row distance was kept at 30 cm. The crop was harvested at harvest maturity and seed yield was reported as kg/ha.

The data were analyzed following Singh and Chaudhary (1985).The experiments were conducted on deep black cotton soils with pH 7.6 to 8.1 (Typic Chromusterts and Lithic Vertic Ustochrepts) in a Randomized Block Design at experimental farm of the Directorate of Soybean Research, Indore (MP) that is situated at 22º 4'37''N latitude, 75º 52'7''E longitude and altitude of 540 meter above the mean sea level.

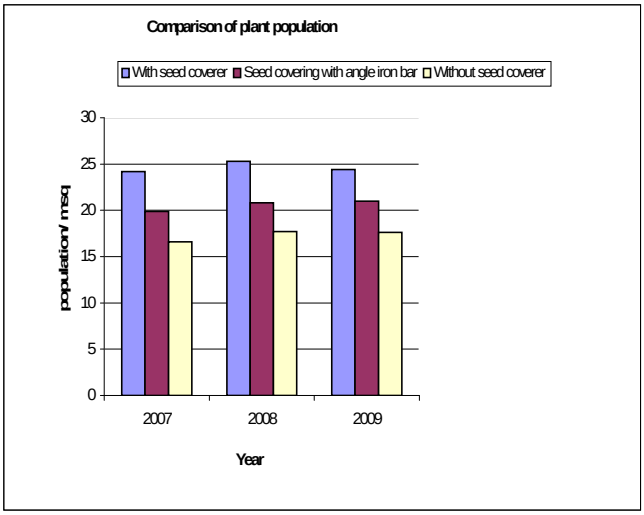
Results and discussion

Effect on plant population

Highly significant differences in plant population have been noted among the three treatments during each year and in the pooled analysis (Table 1). Planting soybean without any arrangement for covering of seed in rows with soil led to the lowest plant population (Fig 1). On the pooled basis, the improvement in plant population by attaching an angle iron rod behind seed drill improved the population by 19 %the use of developed covering device resulted in increased plant population of 42 % over treatment without seed covering. This indicates that resorting to seed covering either by angle iron rod and more effectively by NRC for Soybean developed seed coverer, not only improves germination but also subsequent emergence of seed. It also suggests that this finding may be of more of practical utility for bold seeded varieties like JS 71 05, Ahilya 3, PK 472 etc,

Table 1. Utility of seed coverer in improving the performance of soybean (JS 335)

Treatments	Plant population (plants/m^2)					Seed yield (kg/ha)				
	2007	2008	2009	Mean	% over control	2007	2008	2009	Mean	% over control
With seed coverer	24.2	25.3	24.4	24.6	42.19	1142	1123	1334	1166	28.1
Seed covering with angle iron bar	19.9	20.8	21.0	20.6	10.40	1052	1057	1268	1126	23.7
Without seed coverer	16.6	17.7	17.6	17.3	0.00	841	851	1040	910	0.00
CD (p = 0.05)	1.04	0.65	0.94	0.493		25.54	8.29	18.46	10.36	
CD (p = 0.01)	1.42	0.88	1.29	0.656		35.0	11.35	25.3	13.81	



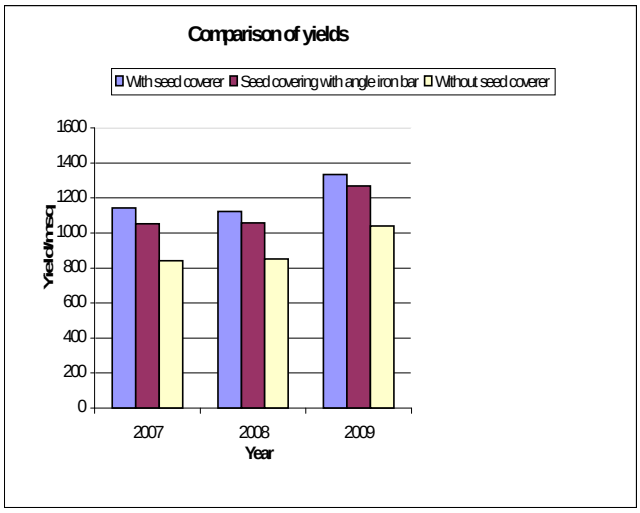
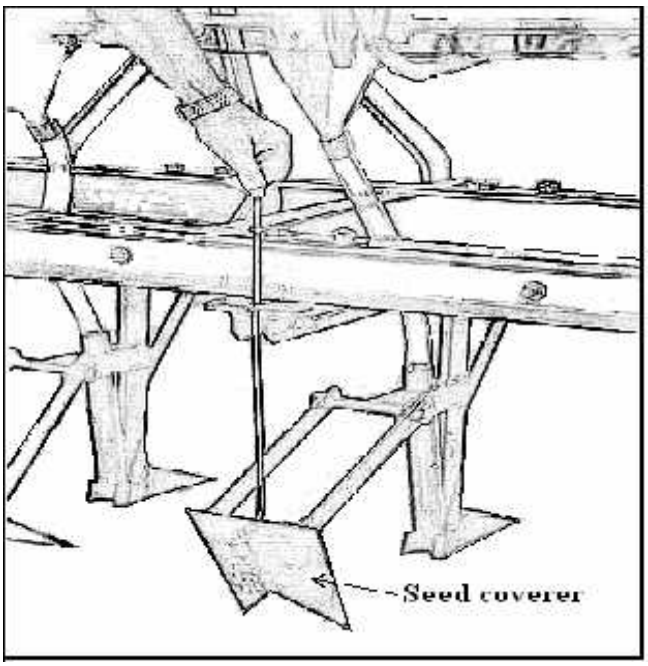


Fig 1 Effect of seed coverer on plant population and seed yield of soybean



which are shy in germination and field emergence. The use of this device will curb the practice among the farmers to use 1.5 to two times the recommended seed rate on account of fear of low germinability and field emergence of seed ultimately reducing the cost of cultivation. Seed and sowing is the costly input in cultivation of soybean after intercultural operations and weed management (Jain 1986).

Effect on seed yield

The data recorded in seed yield of soybean also revealed that like plant population, the productivity of soybean is also significantly influenced by the treatments during all the years of experimentation as well as in pooled analysis (Table 1). The increase in seed yield by merely running an angle iron bar behind the seed drill to cover the seeds in rows revealed an increase of 22 to 24 % during the three years of experimentation with an average increase of 24 %. Use of seed coverer over its non-use resulted in 28 % increase in soybean seed yield (Fig 1). The yield increase with optimum plant population (Bhatnagar and Tiwari 1995) appears to be logical. The study (Zhou et al. 2010) in China also indicated that enhanced productivity and water use efficiency (WUE) of rainfed summer soybean could be achieved via row spacing reduction and plant spacing widening under uniform planting density. The year-to-year variation in the yield has been noticed as the performance of rain fed soybean is directly related to the quantity and distribution of rains.

The study suggests that attaching the seed coverer device along with seed drill for planting soybean developed by Directorate of Soybean Research Indore facilitates better emergence and field establishment enhancing the seed yield. This also helps farmers to use recommended seed rate thereby avoiding the problems associated with over and under seeding economizing the cost of cultivation.

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Design parameters of border irrigation for clay loam soil

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Abstract

In surface irrigation the border strip method is the most practiced one. Proper designing of borders is essential to get its maximum advantage. In present paper, the hydraulic resistance, manning's roughness coefficient and application efficiency are reported for the clay loam soil of main campus of JNKVV.

Keywords: Border irrigation, hydraulic resistance, application efficiency

The purpose of irrigations is to provide moisture, which is essential for plant growth. Border irrigation is one of the methods of surface irrigation. Border method of irrigation makes the use of parallel ridges to guide a sheet of flowing water as it moves down the slope. The irrigation stream must be large enough to spread over the entire width between the border ridges and should be turned off when the advancing water front either reaches the lower end or a few minutes before or after that. The water temporarily stored in the border moves down the strip and infiltrates, thus completing the irrigation.

Variables which are involved in the hydraulics and design of surface irrigation system are:-

Size of stream, rate of Advance of water over the land surface, surface roughness, length of run and time required, depth of flow over the land surface, slope of the land surface, rate of movement of water into the soil (i.e. intake rate), depth of water applied.

Materials and methods

The present study for estimation of the design parameters per strip method was under taken. Different variables were evolved for clay loam of JNKVV Jabalpur. Experiment was conducted for various design parameters of border lengths 1x22m and 1.5 x 22m.

Size of stream was taken as 1.0 liters per second per meter width of the border. A plot of rate of advance and recession is presented in Fig 1. The recession started just after cutting the stream at 20 minutes and prolonged for 93 minutes. However, during meantime the advance was continuing till it reaches to the tail at 32 minutes. The difference between the water front reaches a particular point along the border and the time at which the tail water recesses from the same point is the infiltration opportunity time (IOT). The opportunity time varies from 21 minutes at the head to 43 minutes at the tail end. The IOT may be used in deciding depth of irrigation to this soil. The infiltration characteristics of the soil were determined by conducting concentric ring infiltrometer test. In Fig 2 the infiltration characteristics of the soil are given. Figure indicates the two curves i.e.

Fig. 1 Advance and recession of water front

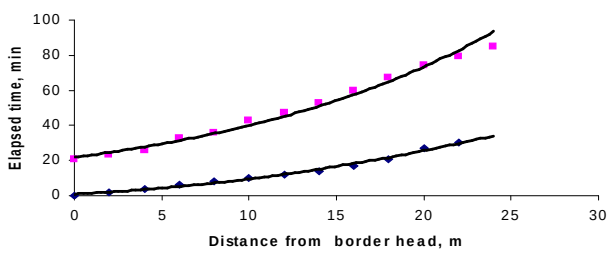
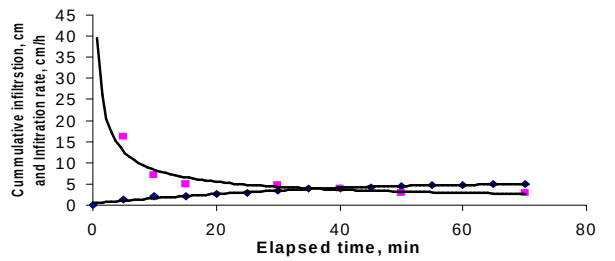


Fig 2 Infiltration characteristics of study area



average infiltration rate and accumulated infiltration depth as a function of time. The characteristics equation is

$$y = 0.59\ t^{0.49} + 0.28$$

Where, y is accumulated depth of infiltration in cm per hour with respect to elapsed time t in minutes.

Results and Discussion

Hydraulic Resistance

The Darcy - Weisbach resistance co-efficient for the non-vegetated border strips was calculated from the modified Blasius formula(1908) applicable to border strips which is expressed as follows:

$$f = (0.316)/4q/v)^{1/4}$$

Where,

f= Darcy-Weisbacn resistance co-efficient

q= Discharge (liter/sec.)

v= Kinematic viscosity of water (cm^2/sec.)

The Darcy - weishbach resistance co-efficient(1857) found out as 0.032 for size of 1 m x22 m and 0.422 for border size 1.5 m x 22 m.

Manning's Roughness Co-efficient-

In non-vegetated borders, when the hydraulic resistance is expressed by the Darcy-Weisbach friction factor f, the equivalent value of manning n is calculated using the following relationship:

$$n = (R^{2/3}\ \sqrt{f}\ )\ \sqrt{8g}$$

in which

R=hydraulic radius in meters

g=Acceleration due to gravity in m/sec^2

f= Darcy-Weisbach friction factor

The Manning's roughness co-efficient was found out to be 0.0155 for 1mx22mts border size and 0.0145 for 1.5 x 22 m border.

Application Efficiency

The application efficiency was determined by conducting the experiments in the field. Soil moisture samples were taken at distances from the head of the border just before the water application and 48 hour after the application. Five soil sampling stations were at 0, 5, 11,16.5 and 22 m from the border head. Samples were collected at four incremental depths of 15 cm. the moisture constants were determined by oven dry method. After computing available water perm depth the application efficiency was calculated using following relationship.

Application efficiency= Water stored in the root zone / Water applied to the field

The application efficiency were computed as 60.35% for 1 m x 22 m border and 55.25% for 1.5 m x 22 m

Conclusion

The derived parameters viz. Darcy - weishbach resistance co-efficient found out as 0.032 and 0.422, the Manning's roughness co-efficient was found out to be 0.0155 and 0.0145 and the application efficiency were computed as 60.35% and 55.25% for 1 m x 22 m border and for 1.5 m x 22 m respectively. These parameters are useful in border irrigation design for clay loam soil of JNKVV farm specifically soils behind College of Agricultural Engineering. Jabalpur

सतही सिंचाई विधियों में बार्डर पद्धति अग्रणी है। बार्डर पद्धति से समुचित लाभ लेने के लिये इसकी उचित डिजाइन होना आवश्यक है। प्रस्तुत शोध पत्र में जवाहरलाल नेहरू कृषि विश्वविद्यालय के मुख्यालय में पाई जाने वाले क्ले लोम मृदा के लिये बार्डर विधि के प्रमुख तत्व यथा हाइड्रालिक अवरोध, मेंनिंग्स घर्षण गुणांक एवं सिंचाई दक्षता का आकलन किया गया है।

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Planning and design of drainage system in Gopagwari village in the foot hills of Bargi dam

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Abstract

In the present work design aspects of sub-surface drainage is considered for planning in Gopagwari village of Bargi block of Jabalpur district. A reconnaissance survey for the assessment of the ground water and drain ability of the proposed area is done to plan the system. The study area is situated on the foothills of the Bargi dam near the Right Bank Canal (R.B.C.) To find the extent of water logging in the area, observation wells were laid out. Almost an area of 50 ha is affected by water logging in the vicinity of the dam in R.B.C. command. There are 36 laterals are proposed of length 624 m in West to East direction and inside diameter of each is 10 cm the mains of the length 924 m from north to south and diameter of 30 cm is proposed. The total design discharge from 36 lateral is 0.9109 cumec and from the main it is 0.918 cumec. Two motors of 40 HP were suited for the purpose.

Keywords: Drainage design, Pore volume percentage, Isobar- isobath

Drainage is a tool to manage ground water level, plays an important role in maintaining and improving crop yields. Sub-surface drainage is the removal or control of ground water and the removal or control of salts, using water as the vehicle(Agrawal and Malik 1985). The source of water may be percolation from precipitation or irrigation; leakage from canals, drains or surface water bodies at higher elevation or from artesian aquifer. In the present work design aspects of sub-surface drainage is considered. The system aims at controlling the water table that can be achieved by tube well drainage, open drains or subsurface drains (pipe drains or mole drains) A reconnaissance survey for the assessment of the ground water and drain ability of the proposed area is done to plan the system.

Material and methods

Description of the area

The study area is situated on the foothills of the Bargi dam near the Right Bank Canal (RBC), which is about 43 km from Jabalpur. The R.B.C. takes off from the right flank of Bargi dam. The area lies in between the latitude 22°52'30" and 23°26'30" and longitude 78°45'E and 79°54'E covers 950x650m. The major crop of this region is wheat. The area has considerable variations in rainfall, temperature and humidity. The rainy season extends from June to October under the influence of the south west monsoon. It also receives rainfall during the month of January. The average annual rainfall is about 1345mm. The temperature during the summer season ranges from about 35 to 45°C and during the winters it is between 30°C and 5°C. The maximum relative humidity ranges between 17 to 90% in August.

Topography

The elevation above the mean sea level varies from 403.03 to 407.43 m. The topography of the area is undulating and rolling due to hilly area. The surface texture of the area is clay loam. Permeability is slow to moderate in upper layers while moderate to rapid in the lower layers. The pH was calculated to be about 6.9.To design the subsurface drainage system the following method was adopted:

Demarcation of the area of water logging above 1.8m

A series of observation wells were laid out in the region. The P.V.C. pipe of 3m length and diameter of 0.1m were laid out. The pipe was perforate to 1.82 m from the

bottom. The perforated region is wound over by Nercule coir to avoid choking of the perforations which were about 12mm in India. Regular readings from these observation wells were taken into account. With the help of topographical survey of the area a contour map was prepared using linear interpolation. The readings of the groundwater levels that were taken from the observation well were then plotted graphically. The isobar map was drawn with the elevation of water table and the isobath map was drawn with depth to water table.

Design of subsurface drainage system

Keeping in view the characteristics of the area it was decided to plan out a sub-surface drainage system as the soil is very fertile and surface drainage will cause a loss of cultivable land as well as the movement of the implements on the field will be hampered. For design purpose (Luthin 1966)the tile drainage system was considered. It was accomplished by means of a series of tiles laid in a continuous line at a specified depth and grade. So that the free water entering the system will flow out by gravity. A tile drainage system consists of a drainage outlet, tile main, sub mains and laterals. The laterals remove the free water from the soil and the sub mains and main carry the water to the drainage outlet.

Results and Discussion

To find the extent of water logging in the area, observation wells were laid out. In this region there is not much fluctuation in the water level but depth to water table is very low. Almost an area of 50 ha is affected by water logging in the vicinity of the dam in R.B.C. command.

From the observations taken the isobar, isobaths and the topographic maps are drawn, (pre-monsoon)Fig 1 and (post-monsoon) Fig 2. The maps indicate the route or the movement of the groundwater and the source of augmentation in the ground water. By proper lining of the canal some of the seepage can be controlled but it is not possible to prevent water logging in the area. Hence the design of subsurface drainage system was required.

Table 1. Values of drainable pore volume at different capillary pressures

Suction head (cm)	Pore-volume percentage
91.4	22.0
60.0	17.4
44.1	11.3
34.2	5.2

Pore volume (22%) of soil at 91.4 cm capillary pressure was recorded (Table 1). According to the climatic conditions and the requirement of cropping pattern the depths of the lines have been assumed as 2.7m for keeping the water table at 1.8m below the land surface. The sub-surface drainage system is designed to lower down the water table from 0 m to 1.8m from the land surface within 3 days.

Drainage co-efficient = Rate of Removal of water x drainable pore volume-

$q - \frac{1.8-0}{3}$ x 0.22 = 0.132m/day

Determination of spacing of lateral tile lines

q/k = ratio = 0.132/3 = 0.437, and m = 0.9m

Spacing is evaluated from the graphical solution of modified ellipse equation, (drainage of agricultural land, U.S.D.A., 1972)

S = 26 m

Pattern for laying laterals

Length of field	=	950m
Spacing	=	26 m
No. of laterals	=	950/26 = 36.53 $\cong$ 36

Thirty six laterals tile lines having a length of 624 m along with a main tile line of 950 m length were laid below the ground surface.

Determination of diameter of lateral tile line and main tile line

Determination of diameter of lateral tile line

Catchments area of one lateral tile line

= 624x26 = 16224m² = 1.6224 ha

Diameter of one lateral for full flow

Using empirical formula

$$d = 0.892\ (dcxA)^{0.375} / S^{0.1875}$$

d =Dia of tile for full flow (inch), dc=drainage co-efficient (inch/day), A=Area in acres, S =Slope

$d = 0.892\ (0.132x4.02351)^{0.375} / (0.001)^{0.1875}$

= 2.56 inches $\cong$ 3 inches

Diameter for ¾ flow

Cross section area of lateral = Π $(4/3)^2$ 7.068 inch²

4/3 cross section area of lateral = 9.42 inch²

Dia for ¾ th flow = $\sqrt{}$(9.42 x 4) /Π

= 3.46 inch

Design dia. of lateral $\cong$ 4 inch $\simeq 10\ cm$

Determination of diameter of main tile line

Catchment area of main tile line

= 650 x 950 = 617500 m² = 61.75.ha

= Diameter for full flow

d = 0.892 $(0.132x\ 153.14)^{0.375}$ / $(0.001)^{0.1875}$

= 10 inch

Cross section area of main tile line = π/4 $(10)^2$

= 79.44 inch² = 198.6cm²

Cross section area of main tile line for ¾ th flow

= 4/3 x 79.44 = 105.92 inch² = 264.8 cm²

Design diameter of main lateral

= $\sqrt{}$ (105.92 x 4) / Π= 11.6 inch

$\cong$ 30 cm.

Determination of the discharge of tile lines

Discharge for one lateral

Formula used

Qr = A X q / 86400

Qr = relief drain discharge in m³/sec. (cumec.)

q = drainage co-efficient (m/day)

A = catchment area of one lateral in m²

Qr = (26 x 637)0.132 / 86400 = 0.025 cumec.

= 25 lps

Total discharge for 36 lateral = 25 x 36 = 910.9 lps

Qr = A X q / 86400

= (13 x 937) 132 / 86400 = 0.01860

= 18.6 lps

Total discharge for main tile line

= 910.9 + 18.6 = 918.6 lps = 0.918 cumec.

Design of outlet (outlet design consists of sump design, motor design, motor and centrifugal pump design)

Determination of sump depth and diameter

The depth of main lateral = 6m

Taking the depth of sump = 4.5 m

In which 1/3m is kept for silt deposition.

Discharge for 2 minutes = 918.6 x 2 x 60 = 110232 lt

= 110.232 m³ for two minutes

Diameter of sump = $\sqrt{}$(110.232 x 4) / 4.5 x Π = 4.6 $\cong$ 5 m

Diameter of sump chosen = 5m

Design of pump

Let us consider that pump is placed 0.5m higher than ground surface.

Total water head = 4 + 0.5 = 4.5m

Water horse power = W.H.Q./75

W = wt. of 1 cubic metre of water

H = head of water in metre

Q = discharge of pump in m³/ sec.

W.H.P. = 1000 x 4.5 x 0.9185 / 75 = 55.06

Efficiency of pump = 70 percent

Actual horse power of pump = (55.06 x 1000)/70 = 78.68 $\cong$ 80hp

Choose the water pump = 80 H.P.

Thus 2 pumps of 40 H.P. is best suited for the selected water logged area

Selection of envelop material

The base material of the soil has been taken at the depth; the drain is to be laid. Sample has been taken and mechanical analysis was made (Gupta 1986). The graph between the size of the particles and percent of smaller particles that size has been plotted. Two filter materials have been determined. It was observed that the filter material should be filter 1 or filter 2 was the best suited. The first and second filters are selected according to design criteria based on the research by U.S. Bureau of reclamation and the corps of Engineers U.S. Army. The ordinary bedding condition has been selected for laying out the tile lines over the filter material. Following conditions were taken into consideration for this purpose.

a. The gradation curve of the filter material should be generally parallel to that of the base martial.

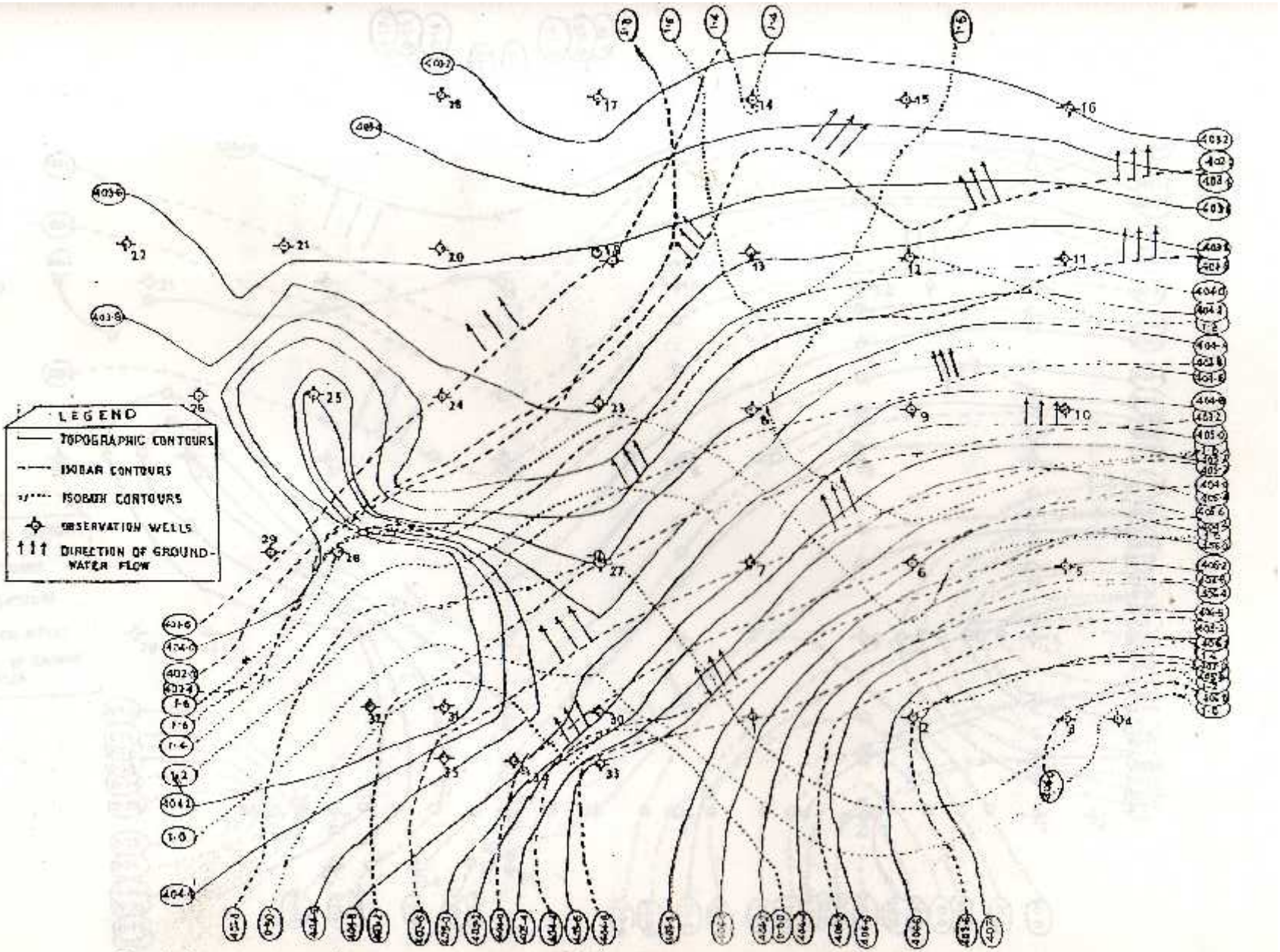

FIG. 6. TOPOGRAPHIC ISOBAR AND ISOBATH CONTOUR (PRE MONSOON)

Table 2. Mechanical analysis for filters

Sieve No.	Sieve size (mm)	Wt. retained (gms)	Accu. Retained wt. (gms)	Accu. Percent retained	Percent finer than
1	4.76	247.5	247.5	5.39	94.61
2	2.83	264.5	512.0	11.16	88.84
3	1.41	524.5	1036.5	22.6	77.4
4	1.0	442.5	1479	32.2	67.8
5	0.707	305.9	1784.9	38.9	61.1
6	0.595	382.8	2167.7	47.24	52.76
7	0.063	297.5	2465.2	53.7	46.3
8	0.015	1587.2	4052.4	88.32	11.68
9	0.009	281.8	4334.2	94.46	5.54

b. 50 percent size of filter / 50 percent size of base = 12 to 58

c. 15 percent size of filter / 15 percent size of base =12 to 40

d. 15 percent size of filter / 85 percent size of base = less than 5

Observations have been taken for mechanical analysis and presented in Table 2.

To find the filter size following calculations were done:

1. 50% size of filter = 12 x 50% of base
   = 12 x 0.48 = 5.76 mm
2. 15% size of filter = 12 x 15% of base
   = 12 x 0.058 = 1.02 mm
3. 50% of size filter = 58 x 50% of base
   = 58 x 0.48 = 27.84 mm
4. 15% size of filter = 40 x 15% of base
   = 40 x 0.085 = 3.4 mm
5. 15% of tiller < 5 x 85% of base
   < 5 x 2.3

Conclusion

There are 36 laterals are proposed of length 624 m in West to East direction and inside diameter of each is 10 cm the mains of the length 924 m from north to south and diameter of 30 cm is proposed. The total design discharge from 36 lateral is 0.9109 cumec and from the main it is 0.918 cumec. Two motors of 40 HP were suited for the purpose.

जबलपुर जिले के बरगी ब्लाक में गोपाग्वारी गांव की जललग्नता का निराकरण क्षेत्र के लिये अधो सतही जल निकास संरचना की डिजाइन की गई संबंधित क्षेत्र जबलपुर से 43 किलोमीटर दूर बरगी डेम के ठीक बाजू मे दायाी तट नहर के बाजू में स्थित है, जिसका क्षेंत्रफल 50 है. है। जल लग्नता के निराकरण हेतु कुल 36 लेटरल लाइन जिसमे से प्रत्येक 624 मी. लंबाई की डिजाइन किया गया 1 कंक्रीट की लेटरल जिसकी व्यास 30 सेंमी है, के द्वारा 0.9109 क्यूसेक का जल प्रवाह निकाला जा सकता है, इस हेतु 40 एचपी की दो मोटर प्रस्तावित की गई।

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Development of artificial neural network based model for prediction of stream flow in Wainganga catchment, Balaghat (Madhya Pradesh)

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Abstract

Runoff prediction is important in fields of engineering and resource management. Wainganga catchment at Kumhari gauging station near Balaghat has been chosen for developing multiple linear regression analysis model and artificial neural network model. Daily stream flow at Kumhari and daily rainfall of Balaghat, Seoni and Keolari for nineteen years was used for developing the models. It was found that multiple linear regression model with thirteen input variables performed better. An ANN model with 14 input variables with 7 neurons, single hidden layer and one output and learned with Levenberg-Marquardt (LM) algorithm performed best.

Keywords: Artificial neural network, multiple linear regression, rainfall-runoff modeling, Levenberg-Marquardt algorithm

The runoff is critical to many water resources activities, for example, design of flood protection works, protection of agricultural lands, planning of water storage and release, etc. Rainfall-runoff is the most complex hydrological phenomenon to comprehend due to tremendous spatial variability of watershed characteristics and precipitation patterns, making the physical modeling quite complex. The physically based classical models require wide range of parameters related to land uses, soil characteristics, soil horizon, watershed treatment, manmade activities, conservation practices, soil moisture variation, topographic data, surface roughness, etc. These parameters vary significantly over a space and time, and are difficult to monitor. Under these circumstances, classical models require assumption of the parameters. Therefore a model with one or two parameters is desired for estimation of runoff.

An artificial neural network (ANN), usually called neural network, is a mathematical model or computational model that tries to simulate the structure and/or functional aspects of biological neural networks. It consists of an interconnected group of artificial neurons and processes information using a connectionist approach to computation. Many reserchers (Sudheer and Jain 2003; Cigizoglu 2003; Kisi 2004; Sarangi et al. 2005; Cigizoglu and Kisi 2005; Deka and Chandramouli 2005; Kisi 2008) developed ANN based runoff model and found that ANN based model performed better than classical models.

Present investigation was conducted at Kumhari (Balaghat) gauging station on Wainganga river. To establish the true merit of ANNs relative to simpler statistical techniques, comparisons are also made between the forecasting skill of the two ANNs and a stepwise multiple linear regression models. A study has been carried out to analyze runoff at Kumhari station of Wainganga River and develop model for its estimation, with the specific objectives of developing a multiple linear regression model and an Artificial Neural Network model for prediction of stream flow.

Material and methods

The study was carried out for the catchment of Wainganga river in Godavari basin. The Wainganga is a river on Madhya Pradesh, which originates about 12 km from Mundara village of Seoni district in the southern slopes of the Satpura Range of Madhya Pradesh. The river flows in south direction through Madhya Pradesh and Maharashtra. After joining the Wardha, the united stream, known as the Pranahita, ultimately falls into the River Godavari. The stream flow model has been developed based on the stream flow data recorded at Kumhari gauging station near Balaghat, Madhya

Pradesh. Kumhari is located at Latitude of N 21°52'58"and Longitude of E 80°10'41" on Balaght-Kumhari road. The total catchment area at Kumhari is 8070 sq km.

Daily stream flow data (from 1st June 1999 to 31st May 2008) of Kumhari gauging station (code AGH40R6) were collected from Central Water Commission, Nagpur. The daily rainfall data of Balaghat, Seoni and Keolari for the same period were obtained from the Office, Sub Divisional Officer, Left Bank Dhooti Canal, Subdivision no.6, Balaghat, Block Development Office Seoni and Block Development Office, Keolari, respectively.

Development of Multiple Linear Regression Model

Rainfall is the important input variable for runoff modeling, which varies with time and space over a catchment. Therefore, rainfall for prediction of runoff on t^{th} day (Q_t), rainfall recorded on t^{th} day at the Balaghat (PB_t), Seoni (PS_t) and Keolari (PK_t) has been considered as input variable. Since the catchment area is large, watershed storage shall affect the streamflow. To incorporate the effect of watershed storage, previous day's rainfall (P_{t-1}), two days earlier rainfall (P_{t-2}); and previous 3rd day rainfall (P_{t-3}) of all the three stations have been also included as input variables. During non-rainy periods, some quantity of stream flow also has been recorded at the gauging station. This flow is base flow and is assumed to be affected by previous day's stream flow. Stream flow on previous day (Q_{t-1}), two days earlier (Q_{t-2}) and three days earlier (Q_{t-3}) has been also considered as input variable to develop the model. Multiple linear regression models developed with input variables are listed (Table 1). In order to optimize the number of input variables, stepwise regression analysis was also performed. Critical p values (p=0.05) was used to control entry and removal of effects from the model in stepwise regression. Various models (M-I to M-XV) were calibrated using 60 percent of the total data set and validated with remaining 40 percent of data.

Artificial Neural Network (ANN)

An ANN is a massively parallel-distributed information processing system that has certain performance characteristics resembling biological neural networks of the human brain (Haykin 1994). ANN is a network of large number of processing elements (also called as nodes or artificial neurons) connected by unidirectional communication channels (connections), each with its own small sphere of knowledge and access to data in its local memory. Typically, a neural network is characterised by its architecture that represents the pattern of connection between neurons, its method of determining the connection weights and the activation function (Fausett 1994).

The structure of an artificial neuron is shown in Fig. 1. There are weighted input connections to the artificial neuron, analogous to the dendrites. These input signals get added up, and are fed into an activation function, which determines if the neuron should at all react like soma in biological neuron. The reaction signals of the neuron would then pass through a transfer function, which decides the strength of the output signal

$$y_j = f(X \cdot W_j - b_j)$$

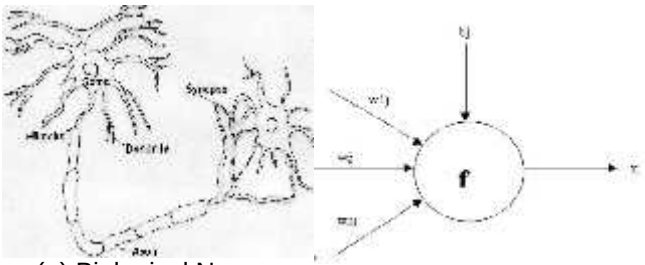
Table 1. Multiple linear regression models with varying input variables

Model	Output Variable	Input Variable
M-I	Q_t	PB_t
M-II	Q_t	PB_t, PS_t
M-III	Q_t	PB_t, PS_t, PK_t
M-IV	Q_t	PB_t, PS_t, PK_t, Q_{t-1}
M-V	Q_t	PB_t, PS_t, PK_t, Q_{t-1}, Q_{t-2}
M-VI	Q_t	PB_t, PS_t, PK_t, Q_{t-1}, Q_{t-2}, Q_{t-3}
M-VII	Q_t	PB_t, PS_t, PK_t, Q_{t-1}, Q_{t-2}, Q_{t-3}, PB_{t-1}
M-VIII	Q_t	PB_t, PS_t, PK_t, Q_{t-1}, Q_{t-2}, Q_{t-3}, PB_{t-1},PB_{t-2}
M-IX	Q_t	PB_t, PS_t, PK_t, Q_{t-1}, Q_{t-2}, Q_{t-3}, PB_{t-1},PB_{t-2}, PB_{t-3}
M-X	Q_t	PB_t, PS_t, PK_t, Q_{t-1}, Q_{t-2}, Q_{t-3}, PB_{t-1},PB_{t-2}, PB_{t-3}, PS_{t-1}
M-XI	Q_t	PB_t, PS_t, PK_t, Q_{t-1}, Q_{t-2}, Q_{t-3}, PB_{t-1},PB_{t-2}, PB_{t-3}, PS_{t-1}, PS_{t-2}
M-XII	Q_t	PB_t, PS_t, PK_t, Q_{t-1}, Q_{t-2}, Q_{t-3}, PB_{t-1},PB_{t-2}, PB_{t-3}, PS_{t-1}, PS_{t-2}, PS_{t-3}
M-XIII	Q_t	PB_t, PS_t, PK_t, Q_{t-1}, Q_{t-2}, Q_{t-3}, PB_{t-1},PB_{t-2}, PB_{t-3}, PS_{t-1}, PS_{t-2}, PS_{t-3}, PK_{t-1}
M-XIV	Q_t	PB_t, PS_t, PK_t, Q_{t-1}, Q_{t-2}, Q_{t-3}, PB_{t-1},PB_{t-2}, PB_{t-3}, PS_{t-1}, PS_{t-2}, PS_{t-3}, PK_{t-1}, PK_{t-2}
M-XV	Q_t	PB_t, PS_t, PK_t, Q_{t-1}, Q_{t-2}, Q_{t-3}, PB_{t-1},PB_{t-2}, PB_{t-3}, PS_{t-1}, PS_{t-2}, PS_{t-3}, PK_{t-1}, PK_{t-2}, PK_{t-3}

similar to hillock. Finally, the output signal is send through all the output connections to other neurons as through synapses in case of biological neuron.

Mathematically, the inputs to a neuron may come

$$f(x) = \frac{1}{1+\exp^{-x}}$$



(a) Biological Neuron (b) Artificial Neuron

Fig. 1. An artificial neuron and biological neuron showing its components

from an input vector X = (x_1, x_2 ,….., x_n). The sequence of weights leading to a neuron from a weight vector W_j = (w_{1j}, w_{2j}….w_{nj}) where wij represents the connection weight from the ith neuron in the preceding layer to the jth neuron. The output of the neuron j, yj is obtained by computing the value of function ¦ with respect to the inner product of the vector X and Wj minus bj, where bj is the threshold value also called as bias associated with the neuron. In neural netwrok parlance, the bias bj must be exceeded before it can be activated. The following equation defines the operation:

The function ¦ is called as an activation function. The activation function enables a network to map any non-linear process. The most commonly used activation function is the sigmoidal function expressed as:

Learning of ANN

Levenberg-Marquardt (LM) algorithm was used for learning of ANN. The second order non-linear optimisation techniques used in the training is expressed as:

$$\Delta W = (H + \mu I)^{-1} J^T e$$

where H = J^T * J, is the Hessian matrix of error vector and is equal to (Ñ^{2}E @ 2 J^T J), J=ÑE is the Jacobian matrix of derivatives of each error to each weight, m is a small scalar which controls the learning process, e is an error vector, DW is the change in weights of the synaptic connections between the layers, JT is the transpose of the Jacobian matrix and I is the identity matrix. Therefore, in LM algorithm, the value of m decreases after each successful step and increases only when a step increases the error. In practice LM is much faster and better for a variety of the problems (Coulibaly et al. 2000).

Normalization of data

Due to nature of the algorithm, large values slow training because the gradient of the sigmoid function at extreme values approximate zero. Also, because of the nature of the logistic activation function used in the output layer, outputs from the network are constrained to the range [0, 1]. In addition, because each predictor can cover a different range of values, it is prudent to rescale each input to common range so that one predictor does not dominate all other. Mean and Standard Deviation (mapstd), an approach for scaling network inputs and targets was used to normalize the mean and standard deviation of the training set. The function mapstd normalizes the inputs and targets so that they will have zero mean and unity standard deviation. They effectively become a part of the network, just like the network weights and biases. After that these outputs converted back into the same units. A program was written in MATLAB 6.5; Neural Network Toolbox to design the ANN architecture and for defining training algorithm, error goal etc.

Selection of input vector

The selection of an appropriate input vector that may allow an ANN to map the desired output is an important prerequisite for successful application of artificial neural networks. Selection of key input parameters help in avoiding loss of information, whereas inclusion of spurious variable tends to confuse the training process. Fifteen ANN models M1-1 to M-15 were developed with number of input variables 1 to 15 as listed in Table 1-Column 3. All ANNs were trained using supervised training algorithms that tried to minimize a performance measure (often termed objective function from the point of view of validation). The Mean Squared Error (MSE) was considered as objective function of ANN. The ANN model architecture is single layer feed forward network, which is the most commonly used neural network for the prediction of the non-linear process like rainfall-runoff relationship. Initially 15 number of Neurons was considered in the development of ANN model. The

number of the hidden layer is one. The transfer function from input to hidden layer is Tan-Sigmoid Transfer Function (Tansig) and from hidden layer to output layer is Linear Transfer function (Purelin).

Selection of Number of Neurons

Number of neurons (N) selected for developing ANN model is important. Lower N, results in poor training of the model and by increasing N, training performance is improved. With Higher values of number of neurons, generalization of the model is poor and reflected in model performance during model validation. Number of neurons was varied from 5 to 20 for the ANN model optimized with number of input variables and final model was selected with optimum number of neurons. All the ANN models tested were trained with 60 percent of total data length and validated with remaining 40 percent data.

Performance Indicators

Mean squared error (MSE), Root mean squared error (RMSE), Mean Absolute error (MAE), and Coefficient of determination (R^2), were used to evaluate the performance of the developed models.

Results and Discussion

Multiple Linear Regression model

Using 60 percent of data for calibration of model and 40 percent data for validation of developed model, regression models with varying number of input variables have been developed. Constant and coefficients of various models are given (Table 2). Graphical relation between predicted and observed runoff during calibration and validation of model M-I is depicted in Fig.2., and for model M-XV in Fig.3. In general, by increasing the input variables in the model, value of R^2 has increased and value of RMSE and MAE has decreased; showing the improvement in the model efficiency.

Stepwise Regression Analysis

Increasing input variable from Model M-I to Model M-XV, indicate that inclusion of each input variable has increased the correlation coefficient. In some cases the

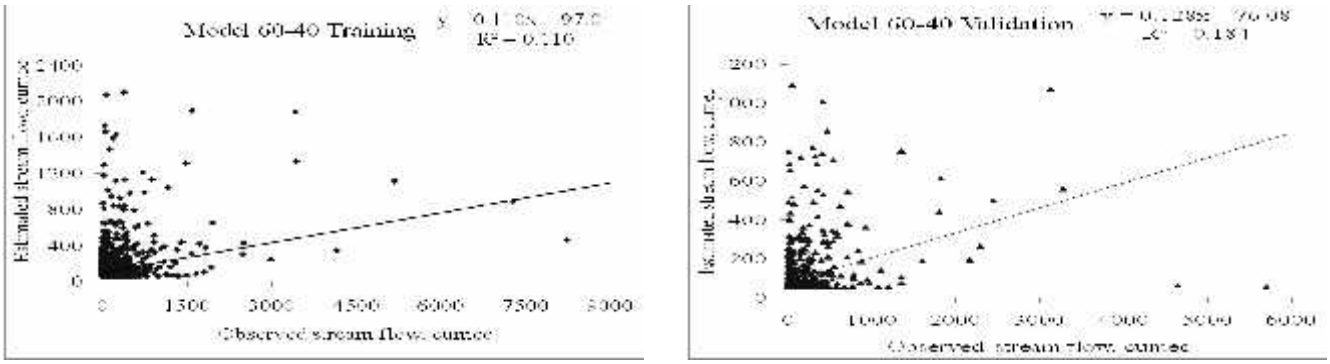


Fig.2 Relationship between observed and estimated stream flow during calibration and validation of the model M-I

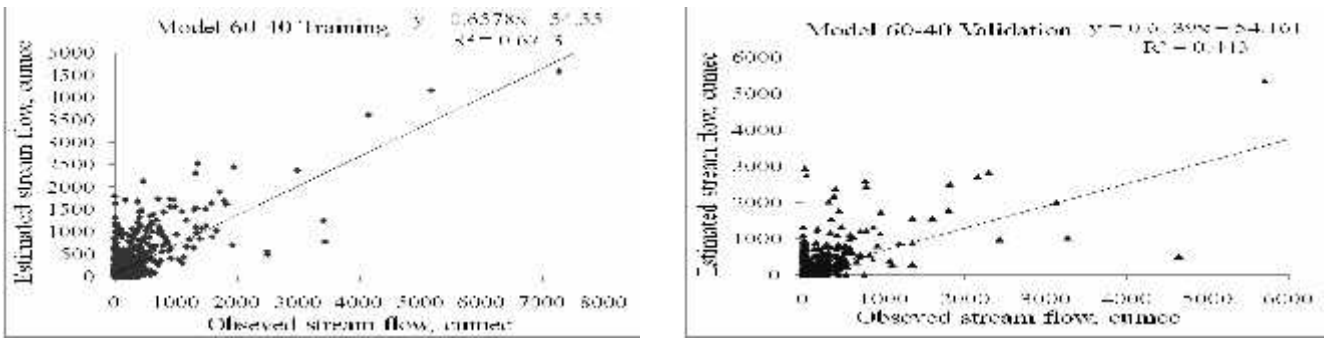


Fig 3 Relationship between observed and estimated stream flow during calibration and validation of the model M-XV

Multiple regression model M-XV over estimates the stream flow especially during the period of high flow (Fig.3).

Table 2. Constant, coefficient and performance of regression models

Model	Constant	Coefficient	R^2	RMSE	MAE	R^2-Validation
M-I	55.604	10.535	0.111	452	122	0.184
M-II	16.483	2.799, 23.116	0.281	419	114	0.280
M-III	5.276	-0.221, 10.942, 21.111	0.413	391	114	0.287
M-IV	-21.699	-1.099, 6.231, 19.974, 0.468	0.614	321	96	0.452
M-V	-17.441	-1.046, 6.080, 19.942, 0.522, -0.090	0.620	319	97	0.455
M-VI	-22.871	-1.266, 6.181, 29.921, 0.537, -0.173, 0.126	0.630	316	96	0.460
M-VII	-16.912	-0.76, 6.712, 20.553, 0.557, -0.174, 0.127, -2.666	0.635	319	97	0.432
M-VIII	-23.412	-1.241, 6.946, 19.635, 0.554, -0.199, 10.128, -3.139, 3.026	0.642	317	90	0.430
M-IX	-22.960	-1.216, 6.29, 19.646, 0.555, -0.199, 0.130, -3.121, 3.063, -0.234	0.642	317	89	0.431
M-X	-22.536	-1.229, 7.002, 19.744, 0.561, -0.201, 0.131, -3.008, 3.117, -0.249, -0.633	0.643	317	89	0.429
M-XI	-24.433	1.289, 6.734, 19.380, 0.555, -0.227, 0.136, -2.924, 2.478, -0.560, -1.067, 3.603	0.645	317	90	0.430
M-XII	-22.445	-1.103, 6.722, 19.436, 0.563, -0.225, 0.159, -2.964, 2.457, -0.017, 0.896, 3.957, -2.910	0.647	317	89	0.421
M-XIII	-21.807	-1.052, 6.236, 18.282, 0.476, -0.173, 0.153, -3.578, 2.088, -0.186, -2.693, 3.162, -3.335, 7.688	0.659	310	89	0.435
M-IV	-21.509	-0.994, 6.295, 18.246, 0.491, -0.140, 0.134, -3.579, 2.415, -0.052, -2.596, 3.998, -2.976, 7.919, -3.465	0.661	309	89	0.442
M-XV	-21.785	-0.984, 6.495, 18.230, 0.483, -0.123, 0.148, -3.564, 2.393, -0.210, -2.544, 4.021, -2.268, 8.002, -3.248, -2.470	0.663	309	89	0.443

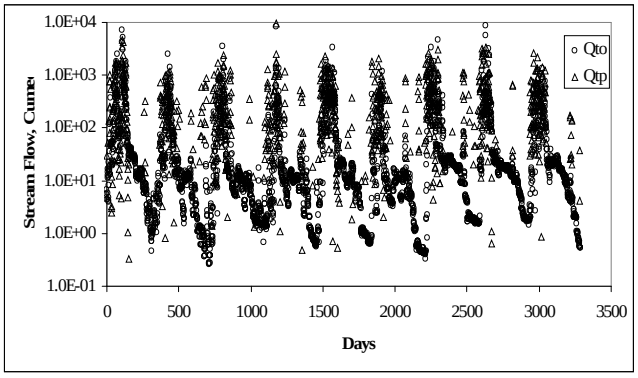


Fig.4. Hydrograph sowing observed (Q_{to}) and predicted (Q_{tp}) streamflow by MLR model with 13 input variables

increase in coefficient of determination (R^2) is very small or insignificant. To find out that which input variables makes significant change in coefficient of determination (R^2) and should remain in the model and to discard those variables having insignificant influence on correlation coefficient, stepwise regression analysis was carried out. In stepwise regression analysis, thirteen input variables remained in the model and two variables (PB_t and PB_{t-3}) were removed. Performance parameter with stepwise regression analysis are- R^2=0.662, RMSE=308, MAE=81.The R^2 for the Model M-XV during training is 0.671 where as with stepwise regression the R^2= 0.662. It indicates that stepwise regression model with thirteen input variables is at par with fifteen variables. The model can be written as-

$$Qt = -21.301+5.795PS_t + 14.251PK_t + 0.423Q_{t-1} - 0.810Q_{t-2} + 0.114Q_{t-3} - 0.821PB_{t-1} + 2.025PB_{t-2} - 0.170PS_{t-1} + 2.093PS_{t-2} - 0.548PS_{t-3} + 6.897PK_{t-1} - 3.425PK_{t-2} - 1.825PK_{t-3}$$

ANN based model

ANN models have been developed with varying input variables, and evaluated in terms of performance indicators. The ANN model M1 with one input variable achieved the error (MSE) of 0.895 and R=0.4626 and 0.36998 during model training and validation respectively (Fig.5). Performance parameters of ANN models with various input variables have been listed in the Table 3. As number of input variables increased from one to fifteen in ANN model, training performance indicator, MSE of scaled output and target has reduced from 0.895 to 0.125 (Table 3). Mean absolute error between estimate and target during training has reduced from 119 to 48; and during validation from 94 to 56.

Table 3 clearly indicates that amongst fifteen ANN models with varying input variables developed, model

M14 performed best in terms of R^2, RMSE and MAE during training as well as validation with independent data set. MSE during training process, relationship between observed and predicted stream flow with Model M14 is depicted in Fig.6. Hydrogaph of observed stream flow and predicted stream flow with model M14 having 15 neurons is depicted in Fig.7. Hence model M14 has been considered for further improvement in terms of number of neurons.

ANN models with different numbers of neurons

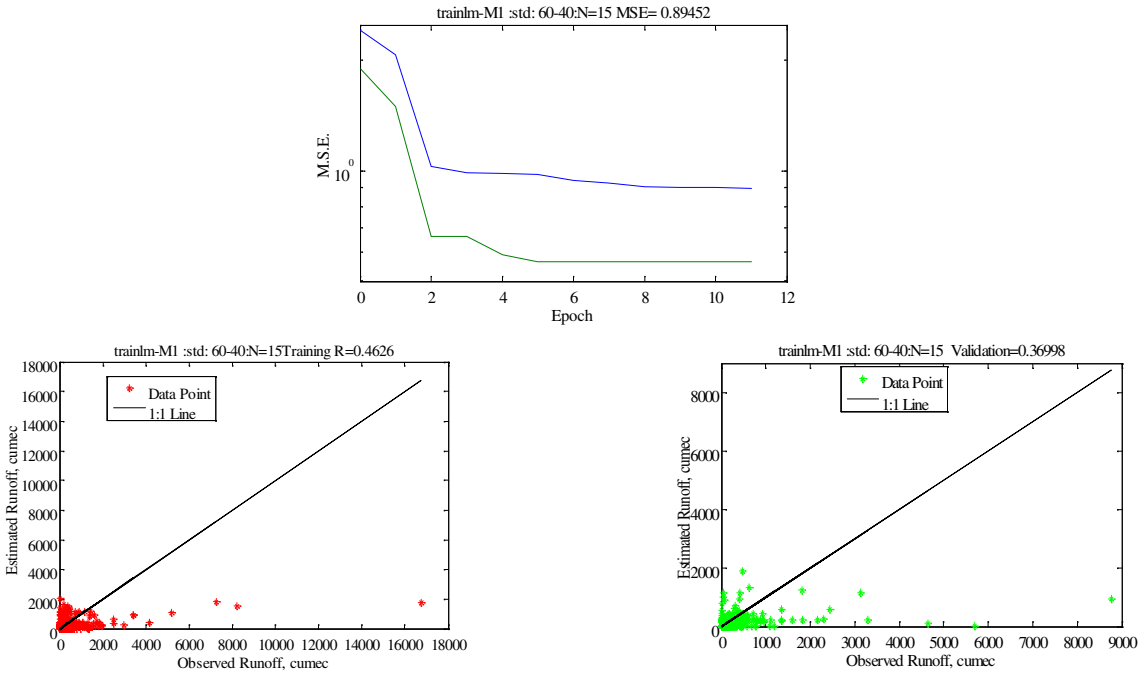


Fig 4. Performance of Model M1 with N=15

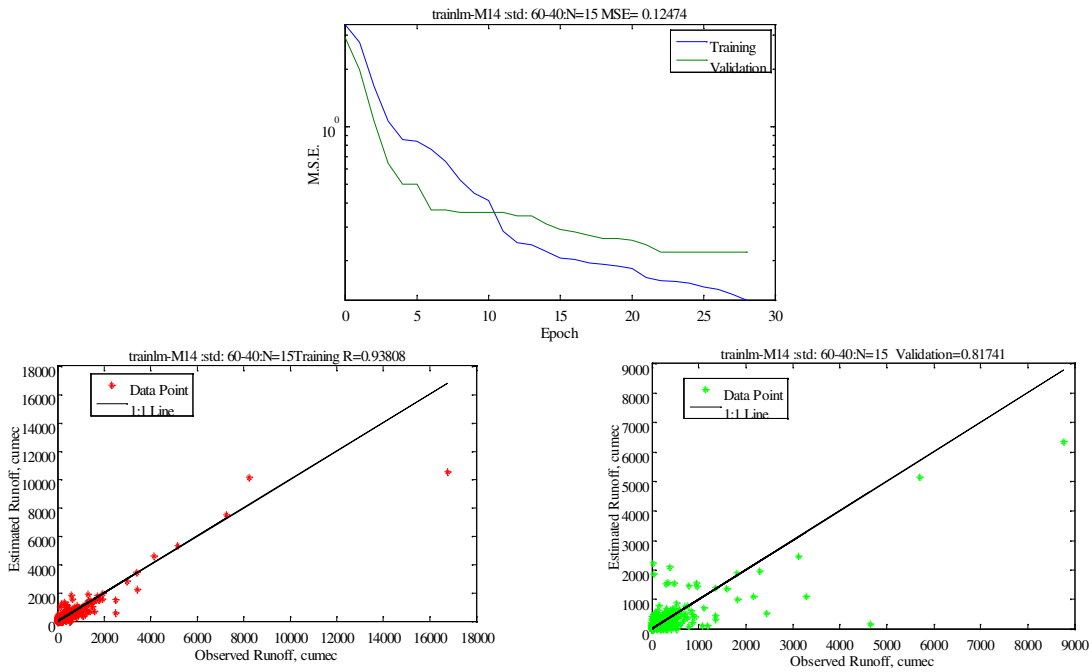


Fig. 5. Performance of Model M14 with N=15

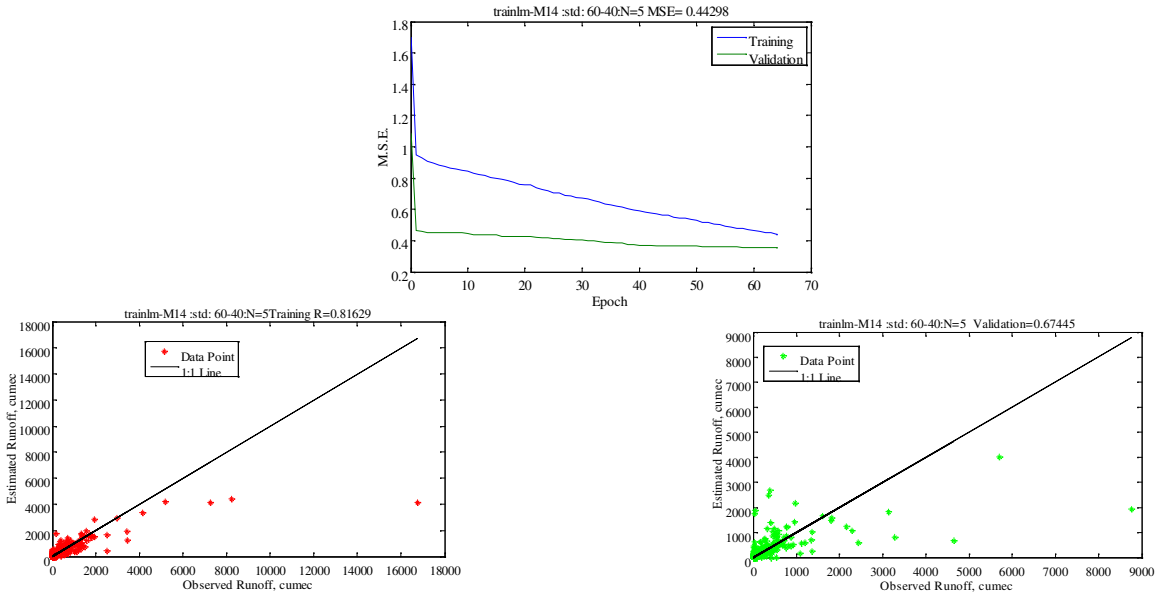


Fig.8 Performance of Model M14 with N=6

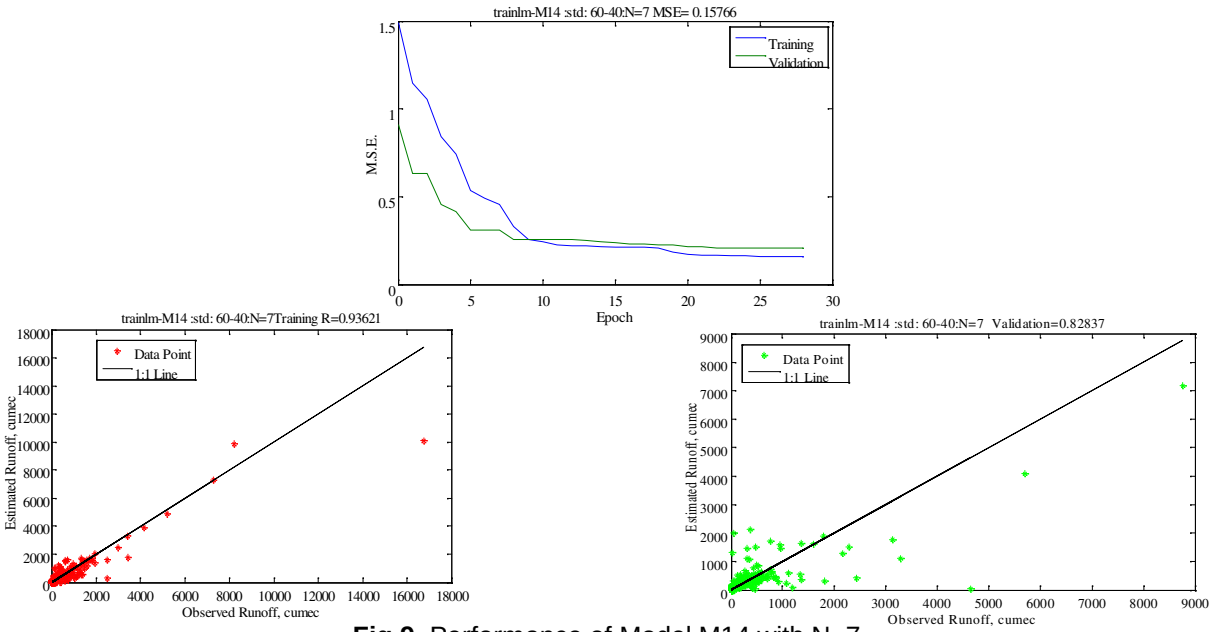


Fig.9. Performance of Model M14 with N=7

An optimum number of neurons in the hidden layer of ANN model can be determined by trial and error, at which a model perform better. ANN Models with 14 input variables were further was tested with varying number of neurons (5 to 20).

MSE of scaled output and target is obtained as 0.443 and 0.358 during training and validation, respectively; coefficient of correlation between estimated runoff and observed runoff is 0.816 and 0.674 during training and validation, respectively (Fig8) when 5 neurons were

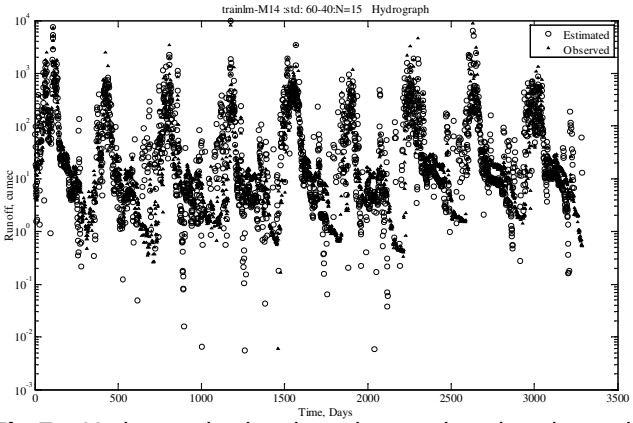


Fig.7. Hydrograph showing observed and estimated stream flow with model M-14 (training with 60% data)

considered in the ANN. MSE during training has been reduced as compared to the earlier ANN model with N=15. Performance of ANN models with various number

Table 3. Performance of Neural Network models with different input variables

Model	R^2		MSE		RMSE		MAE	
	Trg	Val	Trg	Val	Trg	Val	Trg	Val
M1	0.214	0.144	0.895	0.566	478	395	119	94
M2	0.243	0.292	0.825	0.465	468	357	119	97
M3	0.333	0.257	0.688	0.489	446	363	114	99
M4	0.596	0.503	0.370	0.339	348	300	60	57
M5	0.792	0.584	0.279	0.277	261	269	48	52
M6	0.789	0.566	0.136	0.287	270	275	53	58
M7	0.759	0.594	0.196	0.267	283	269	65	58
M8	0.726	0.516	0.216	0.327	293	295	53	61
M9	0.843	0.545	0.163	0.321	238	282	50	60
M10	0.639	0.320	0.274	0.488	357	339	70	65
M11	0.604	0.376	0.418	0.433	350	342	75	71
M12	0.533	0.428	0.461	0.381	375	315	61	63
M13	0.642	0.469	0.372	0.370	333	306	70	77
M14	0.880	0.667	0.125	0.222	189	234	48	56
M15	0.599	0.517	0.490	0.342	355	290	69	69

(Trg = Training, Val = Validation)

Table 4. Performance of Neural Network with different number of Neurons

No. of Neurons	R^2		MSE		RMSE		MAE	
	Trg	Val	Trg	Val	Trg	Val	Trg	Val
N5	0.666	0.454	0.443	0.358	334	301	57	60
N6	0.518	0.466	0.518	0.363	374	303	76	72
N7	0.876	0.687	0.158	0.207	196	230	43	49
N8	0.691	0.501	0.412	0.327	319	290	58	60
N10	0.691	0.483	0.354	0.343	305	296	59	64
N13	0.539	0.382	0.332	0.431	366	341	66	69
N15	0.880	0.667	0.125	0.222	189	234	48	56
N20	0.762	0.545	0.263	0.313	278	280	54	64

(Trg=Training Val=Validation)

of neurons is presented (Table 4).

Comparing the performance parameters for ANN model with 14 input variables with various number of neuron (Table 4), it can be stated that model performed better with N=7 and N=15 then all others. Performance of ANN model with 7 neurons is depicted in Fig.9. However, the overall performance in terms of R, MSE, RMSE and MAE (cumulative for training and validation) of model with N=7 is best, model M14 with N=7 is found suitable for prediction of stream flow. Fig. 10 presents the hydrograph of observed and estimated by M14 with N=7 model. A close agreement can be observed between estimated and target runoff.

Based on the above findings following conclusions are drawn.

- Regression model with thirteen input variable is found most suitable for stream flow forecasting.
- The ANN model with Levenberg-Marquardt, 7 Numbers of neurons is found best model for runoff estimation.
- ANN based model is superior to multiple linear regression models for runoff forecasting.

नदी के जल प्रवाह का पूर्वानुमान, इंजीनियरिंग और संसाधन प्रबंध के क्षेत्र में महत्वपूर्ण हैं । बैनगंगा जलगृहण क्षेत्र बालाघाट के नजदीक कुम्हारी मापन स्टेशन पर, नदी के जल प्रवाह के पूर्वानुमान के लिए एकाधिक रेखीय प्रतीपगमन विश्लेशण मॉडल तथा कृत्रिम तंत्रिका नेटवर्क मॉडल विकास के लिए चुना गया है । उन्नीस वर्षो के कुम्हारी के दैनिक जल प्रवाह तथा बालाघाट, सिवनी एवं केवलारी के दैनिक वर्षा का उपयोग जल प्रवाह मॉडल विकसित करने के लिये किया गया । यह पाया गया तेरह इनपुट चर के साथ एकाधिक रेखीय प्रतीपगमन मॉडल का प्रदर्शन बेहतर है । चौदह इनपुट चर, सात न्यरान्स, एक छिपी परत,

एक आउटपुट परत के साथ और लेवेनबर्ग–मार्कड्ट एलगोरिथ्म के साथ कृत्रिम तंत्रिका नेटवर्क मॉडल का प्रदर्शन सर्वोत्तम है ।

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A multiple regression approach to predict production of paddy and wheat crops in Madhya Pradesh

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Abstract

During the last few decades, the statisticians, economists & other scientists have given due consideration to see the performance of the production of paddy and wheat. crops based on area and fertilizer consumed. Multiple regression models have been fitted using least square technique. Independence of serial (auto) correlation in error terms of the model and consistency for variation in observed and predicted production have also been considered.

Keywords: Multiple regression, auto correlation, Durbin Watson 'd' statistics, partial regression coefficients.

Rice and wheat are the most important staple food crop grown in all parts of India. India occupies largest area (43 million ha.) under rice with production of (81 million tones). The average productivity in India is 1.33 tones/ hectare.

In this study, the status of area, production and productivity of Rice and wheat and projected levels of the crops in the years to come in M.P. state have been considered.

Test of independence of autocorrelation in error terms accruing in approach of multiple regression theory has been reported by (Durbin Watson 1951). An advantageous metrit of 'd' statistic is that it is based on estimated residuals obtained from regression study. The multiple regression models have been fitted for the data of 25 years on rise and wheat. Kulhare (2003), Rajput (2003), Shrivastava et al. (2003), Raghuwanshi et al. (2003), Sharma and Jain (1997), Sharma and Joshi (1995) have made an attempt to study in the area through various experiments conducted.

Material and methods

Secondary data were collected from Agricultural Statistics of M.P. State available in the Department of Agricultural Economics & Farm Management in JNKVV, Jabalpur for 1981-82 to 2005-06.

To perform the multiple regression analyses for the data available, we have denoed yield by(x_1) as response variable, and area by (x_2), fertilizer consumed by (x_3) as two covariates. Now, multiple regression model is postulated as

$$X_1 = \beta_0 + \beta_{12.3} X_2 + \beta_{13.2} X_3 + e \qquad \text{... (1)}$$

Where b_0, b_{123} and $b_{13.2}$ are unknown parameters to be estimated from available data itself and e is the random error term involved in the model and distributed as e ~ N (o, s_e^2). Using least square technique, the fitted regression line is obtained as –

$$X_1 = bo + b_{12.3} X_2 + b_{13.2} X_3 \qquad \text{...(2)}$$

where bo= X_1 is the sample mean, and $b_{12.3}$, $b_{13.2}$ are the sample partial regression coefficients of X_1 on X_2 and X_3 respectively.

The multiple correlation coefficient $R_{1.23}$ between X_1, and joint effect of X_2 and X_3 on X_1, is reported as

$$R_{123} = \frac{Cov(X_1, \hat{X}_1)}{\sqrt{V(X_1)V(\hat{X}_1)}} \qquad \text{.... (3)}$$

The test of significance of R_{123}, the test statistic (F statistic) is carried out as

$$R^2_{1.23} \qquad (n-k-1)$$

$$F_{(K,\ n-k-1)} = \frac{\quad}{(1-R^2_{1.23})} \quad \frac{\quad}{K} \qquad \ldots(4)$$

where K=2

A test for independence of serial correlation in error terms based on residual ei. = $(x_1 - X_1)$, (I =1,2,3, ….., n) will be carried out using Durbin Watson 'd' statistic defined as

$$d = \frac{\sum_{i=2}^{n} (e_i - e_{i-1})^2}{\sum_{i=1}^{n} e_i^2} \qquad \ldots(5)$$

with statistical hypothesis stated as –

Ho : The error terms e_i's in regression equation are serially independent i.e. (uncorrelated).

H1 : The error terms ei,s in regression equation are serially dependent i.e. (correlated)

Consistency of variability in observed yield data have been worked out using coefficient of variation (C.V.) defined as

$$C.V.\ (X) = \frac{\sigma_x}{\overline{X}} \times 100 \qquad \ldots(6)$$

The $R_{1.23}$ for paddy crop is computed as

$$R^2_{1.23} = (r^2_{12} + r^2_{13} - 2\, r_{12}\, r_{23}\, r_{31}) / (1-r^2_{23})$$

$$= 0.3644$$

To test the significance of $R_{1.23}$ i.e. Ho : $R_{1.23} = 0$ the test statistic F is computed as

$$F\ (K, n-k-1) = \frac{R^2}{(1-R^2)}, \frac{(n-k-1)}{K} = 6.3065$$

for k = 2, i.e. $F_{(2,\ 22)} = 6.3065 > F_{0.05}\ (2, 22)$

Hence, Ho is significant and conclude that the multiple regression equation of production (X_1) obtained on the basis of area (X_2) and fertilize (X_3) is the best fitted equation for the rice crop.

Results and Discussion

Rice

Table 1. Estimate of yield and its residue for 'd' statistic

Year	Production (Y)	Area (X_1)	Fertilizer (X_2)	$\hat{Y}$	ei = (Y - $\hat{Y}$)	(e_1 - e)	e_1^2
1981-82	1026	1553	1233	1052.932	-26.9317		725.3165
1982-83	1021	1544	1542	1067.734	-46.7337	-19.802	2184.039
1983-84	1308	1587	1515	1125.569	182.4311	229.1648	33281.11
1984-85	761	1565	1751	1115.687	-354.687	-537.118	125802.7
1985-86	1396	1604	1969	1189.651	206.3494	561.0361	42580.07
1986-87	976	1591	1962	1170.821	-194.821	-401.17	37955.07
1987-88	974	1418	1689	904.2844	69.7156	264.5362	4860.265
1988-89	1292	1525	2335	1111.46	180.5405	110.8249	32594.87
1989-90	1036	1500	2398	1082.03	-46.0301	-226.571	2118.77
1990-91	1435	1556	2468	1166.678	268.3217	314.3518	71996.53
1991-92	978	1559	2877	1207.159	-229.159	-497.48	52513.71
1992-93	1185	1573	2959	1234.042	-49.0419	180.1168	2405.108
1993-94	1346	1566	3064	1300.644	158.3563	45.9068	25076.72
1994-95	1459	1612	3094	1300.644	-172.242	45.9068	25076.72
1995-96	1212	1672	3089	1384.242	-0.8853	-330.599	29667.38
1996-97	1346	1644	3110	1346.885	-135.669	171.3569	0.783756
1997-98	1229	1656	3121	1364.669	36.5646	134.784	18406.19
1998-99	1424	1672	3125	1387.435	265.1882	172.234	1336.97
1999-00	1750	1740	3149	1484.812	-459.675	228.6236	70324.78
2000-01	982	1708	3168	1441.675	155.989	-724.863	211300.8
2001-02	1693	1776	3169	1537.011	-375.759	615.6637	24332.57
2002-03	1032	1681	3212	1407.759	288.3939	-531.748	141194.5
2003-04	1750	1719	3219	1461.606	-107.181	664.1525	83171.04
2004-05	1309	1686	3228	1416.181	274.5146	-395.575	11487.83
2005-06	1656	1658	3279	1381.485	-0.0005	381.6959	75358.27
Sum	31576	10365	65725			301.4463	1113320

For estimating the value of production of paddy crop, the following regression line has been obtained

$$X_{lp} = -1231.7225 + 1.4007\ X_2 + 0.0887\ X_3$$

$R_{1.23}$ for wheat crop is computed and is obtained as

$R^2_{1.23} = 0.9504$

and for testing of significance of $R_{1.23}$ i.e. Ho: $R_{1.23}$ =0, the value of F statstic is obtained as earlier and we have

$$F_{(2,22)} = 210.7742$$

Which is > tabulated $F_{0.05}$ (2,22).

Thus, it is concluded that the multiple regression equation of production (X_1) obtained on the basis of area (X_2) and fertilizer (X_3) is the best fitted equation for rice crop.

Wheat

For estimating the production of wheat crop, the following regression line –was obtained

$$X_{1w} = -5596.68 + 2.6252\ X_2 + 0.4608\ X_3$$

Durbin – Watson d statistic for production of wheat

Here K=2 , n =25, and from the statistical table of drapper and smith (1966), we have the values of dl and di at 5% level of significance for two tail test given as

dl = 1.18, (4-dl) = 2.82

du = 1.34, (4-du) = 2.66

The computed value of durbin –watson 'd' statistic from table 2, is obtained as : d=0.019937

Thus, the computed value of 'd' statistic is equal to 0.019937 which is smaller than dl (1.18), Hence, the null hypothesis Ho is declared significant i.e. it is rejected and we finally conclude that the errors involved in the estimation of production of wheat crop for different years (1981-82 to 2005-06) are serially dependent.

पिछले दस सालो में साख्यिकीविद, अर्थशास्त्रीय एवं अन्य बैज्ञानिकों ने धान एवं गेहूँ के क्षेत्रफल एवं उपयोग में लाई गयी खाद के आधार पर उनके पैदावार के परिणामों पर विशेष ध्यान दिया है । न्यूनतम वर्ग

Table 2. Estimate of yield and its residuals for 'd' statistic

Year	Production (Y)	Area (X_1)	Fertilizer (X_2)	$\hat{Y}$	ei = (Y - $\hat{Y}$)	(e_1 - e)	e_1^2
1981-82	3234	3204	1515	3512.573	-278.5728		77602.805
1982-83	3731	3446	943	3884.294	-153.2936	125.2792	23498.928
1983-84	4606	3675	1445	4716.786	-110.786	42.5076	12273.538
1984-85	3856	3499	1598	4325.253	-469.2532	-358.467	220198.57
1985-86	4136	3592	1827	4674.92	-538.92	-69.6668	290434.77
1986-87	4161	3381	1700	4062.481	98.5188	637.4388	9705.954
1987-88	4546	3532	1719	4467.642	78.3584	-20.1064	6140.0989
1988-89	4724	3568	1928	4658.456	65.544	-12.8144	4296.0159
1989-90	4049	3196	1860	3650.547	398.4528	332.9088	158764.63
1990-91	5742	3738	1969	5123.633	618.3672	219.9144	382377.99
1991-92	5066	3458	2368	4572.436	493.564	-124.803	243605.42
1992-93	5172	3589	2485	4970.251	201.7492	-291.815	40702.74
1993-94	6675	4053	3970	6872.632	-197.6316	-399.381	39058.249
1994-95	7269	4096	3987	6993.349	275.6512	473.2828	75983.584
1995-96	6571	3925	3994	6547.665	23.3348	-252.316	544.51289
1996-97	7701	4235	3980	7355.026	345.974	322.6392	119698.01
1997-98	7154	4502	3990	8060.562	-906.5624	-1252.54	821855.39
1998-99	8257	4575	3997	8255.428	1.5724	908.138	2.4724418
1999-00	8687	4670	4013	8512.194	174.8056	173.2332	30556.998
2000-01	4869	3311	4019	4947.312	-78.3124	-253.118	6132.832
2001-02	6001	3704	4020	5979.477	21.5232	99.8356	463.21814
2002-03	4623	3382	4035	5141.074	-518.0744	-539.598	268401.08
2003-04	7365	4046	4062	6894.024	470.9764	989.0508	221818.77
2004-05	7327	4200	4087	7312.45	14.5504	-456.426	211.71414
2005-06	5958	3693	4105	5989.768	-31.7676	-46.318	1009.1804
Total	141480	94269	73616		-0.2316	246.8052	3055337.4

Table 3. Consistency for variation in observed production : CV (Xp) and CV (Xw) in paddy and wheat crops during the periods (1981-82 to 2005-06) are given below

	Paddy production	Wheat production
Mean	1263.04	5659.2
SEm±	50.0309	311.4414
R2	03644	0.9504
CV (X1)	3.96%	5.50

प्रक्रिया का उपयोग करते हुए बहुउददेशीय प्रसरण फलनों का प्रतिपादन किया गया है । फलन में लिये गये त्रुटि के मूल्यों में आने वाले स्वतः सहसम्बधों की सवतन्त्रता एवं अवलोकित और अनुमानित उपज में आने वाले अन्तर के सामन्जस्य को भी ध्यान में रखा गया है।

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Jack- knife technique and almost unbiased class of ratio type estimators in circular systematic sampling scheme

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Abstract

A general class of almost unbiased ratio type estimators T_{RU} to estimate the population mean of response variatey in (C.S.S.) scheme is hereby proposed based upon Jack-knife technique. The explicit expression for the sampling variance of the class is derived to the terms of order $0(n^{-1})$. Minimum variance unbiased estimator (M.V.U.E.) in the class is investigated. An empirical illustration is provided to examine the utility of the results derived.

Key words: Ratio estimator, jack-knife technique, circular systematic sampling, M.V.U.E. (estimator).

The classical ratio estimator under Linear Systematic Sampling (LSS) was proposed by Swan (1964) and its properties were studied. In general, the ratio estimator is biased, A weighted class of ratio type of estimators was proposed and made almost unbiased by Kushwaha and Singh (1989) using Jack-Knife technique in LSS scheme.

A serious demerit of LSS scheme is that it is not possible to estimate the sampling variance of the estimator under study but using the technique of interpenetrating systematic sampling with independent random start, it can be estimated unbiasedly. A simple modification of LSS scheme makes it possible to ensure a fixed sample of size n and to make the sample mean' y unbiased for population mean' y_N even in case of $N^1K.n$ where K is a positive integer. This sampling scheme is known as 'Circular Systematic Sampling' (CSS) scheme.

Murthy (1977) and Sukhatme and Sukhatme (1970) have suggested to use CSS scheme in situation when N^1Kn.

The main steps involved in selecting a sample using CSS scheme are as follows.

i. Select a random number 'r' from (1 to N) and name it as 'random start'.

ii. Choose some integer value of K = (N/n) or number nearest to (N/n) and name it as skip.

iii. Select all the units in the sample with serial numbers

$$r + jk \quad \text{if } (r+jk) \leq N, \{j = 0,1,2\ldots\ldots, (n-1)\}, \; 1 \leq r \leq N$$

$$r + jk-N \quad \text{if } (r+jk) > N, \{j = 0,1,2\ldots\ldots, (n-1)\}, \; 1 \leq r \leq N$$

Sudhakar (1978) pointed out that the use of skip or span of sampling as an integer nearest to (N/n) in CSS does not always provides a sample of desired size n. Sudhakar (1978) has also mentioned that if the span of sampling 'K' is the nearest integer £ N/n, then we do not encounter the above cited difficulty although this choice depends upon n.

J ack-knife technique has been profitably employed in several estimation and testing problems. In this study we have utilized jack-knife technique to get rid off bias in usual ratio estimator proposed in CSS scheme and have derived a general class of almost unbiased ratio type estimators say $T_{RU.}$

An expression for sampling variance (T_{RU}) along with an empirical illustration is provided to see the performance of the derived estimators (T_{RU}) with respect to efficiency point of views over other estimators existing in literature.

Class of Almost Unbiased Ratio Type Estimators

Let the population be consists of N units.U=(U1, U2,

……..U_N) labeled from (1 to N) in circular order. let N¹Kn where k is an positive integer nearest to (N/n). We select one sample at random and observe both the variates (y,x) for each and every unit included in the sample.

Let (y_{r+jk} x_{r+jk} j = 0, 1, ….., (n -1) and r = 1, 2, …….., N) be the sample units.

Circular systematic sample means $(\bar{y}, \bar{x})$ are defined as

$$\bar{y} = \frac{1}{n}\sum_{j=0}^{n-1} y_{r+jk}$$

$$\bar{x} = \frac{1}{n}\sum_{j=0}^{n-1} x_{r+jk} \qquad j = 0,1,2,\ldots\ldots\ldots, (n-1)$$

$$r = 1,2,3,\ldots\ldots\ldots, N \qquad (2.1)$$

K = Sampling span

The sample means $(\bar{y}, \bar{x})$ are respectively unbiased estimators of the population means $(\bar{Y}, \bar{X})$. The population means'X of covariate x is assumed to be known in prior.

The classical ratio estimator 'y_R of'Y based on a sample in CSS [$\bar{y}_{r+jk}$, J= 0,1,…..... (n-1)] of size n is defined as

$$\bar{y}_R = \frac{\bar{y}}{\bar{x}}\bar{X} \qquad (2.2)$$

Jack-knife technique is employed to reduce the bias ('y_R). Let N¹Kn and split the selected sample in CSS in to g sub samples each of size m units in a systematic manner as this avoids the need for selecting the samples in the form of sub samples of smaller size (m < n), thereby retaining the efficiency generally obtained by a large circular systematic sample. Let ('y_t , 'x_t, t=1,2…, g) be unbiased estimators of ('Y,'X) based on circular systematic sub samples each of size m. Let us define complimentary sub sample means. ('y_t', 'x_t', t = 1,2,…....g) written as

$$\bar{y}_t' = (n\bar{y} - m\bar{y}_t)/m', \quad t' = 1,2,3 \ldots g$$

$$\bar{x}_t' = (n\bar{x} - m\bar{x}_t)/m' \qquad (2.3)$$

which are the sample means based on subsamples. each of size m'= (n-m) units obtained by omitting t^{th} (t = 1,2,…,g) subsamples from complete circular systematic sample of size n.

The estimators ('y_t', 'x_t') are unbiased for ('Y, 'X) respectively. With this background, we define another ratio type estimator along with its Jack-knife version written as

$$\bar{y}_{Rt}' = \frac{\bar{y}_t'}{\bar{x}_t'}\bar{X} \quad \text{and}$$

$$\bar{y}_R' = \frac{1}{g}\sum_{t=1}^{g} \bar{y}_{Rt}' \qquad (2.4)$$

The expression for bias of (.) to the terms of order 0(n^{-1}), are respectively given as

$$B_1(\bar{y}_R) = \frac{\bar{Y}}{n}\left\{1 + (n-1)\rho_w\right\}(1-k^*)C_x^2$$

and $B_1(\bar{y}_{R'}) = \frac{\bar{Y}}{n}\left\{g + (n-g)\rho_w\right\}(1-k^*)C_x^2 \qquad (2.5)$

where,

$$B_1(\bar{y}_R) = \frac{\bar{Y}}{n}\left\{\frac{v(\bar{x})}{\bar{X}^2} - \frac{cov(\bar{y},\bar{x})}{\bar{Y},\bar{X}}\right\}$$

$$V(\bar{y}) = \frac{1}{N}\sum_{r=1}^{N}(\bar{y},\bar{Y})^2$$

$$= \frac{1}{N}\sum_{r=1}^{N}\left(\frac{1}{n}\sum_{j=0}^{n-1} y_{r+Jk} - \bar{Y}\right)^2$$

$$= \frac{1}{Nn^2}\left(\sum_{j=0}^{n-1} y_{r+Jk} - n\bar{Y}\right)^2$$

$$= \frac{1}{Nn^2}\left[\sum_{r=1}^{N}\sum_{j=0}^{n-1}\left(y_{r+Jk} - n\bar{Y}\right)^2 + \sum_{j=0}^{N}\sum_{j>J}\left(y_{r+Jk} - n\bar{Y}\right)\left(y_{r+J'k} - n\bar{Y}\right)\right]$$

$$= \frac{1}{Nn^2}\left[\sum_{r=1}^{N}\sum_{j=0}^{n-1}\left(y_{r+Jk} - n\bar{Y}\right)^2 + \sum_{r=1}^{N}\sum_{j=0}^{N}\sum_{j>J}\left(y_{r+Jk} - n\bar{y}\right)\left(y_{r+J'k} - n\bar{y}\right)\right]$$

$$= \frac{1}{Nn^2}\left[Nn\sigma_y^2 + Nn(n-1)\rho_{yw}\sigma_y^2\right]$$

$$= \frac{\sigma_y^2}{n}\left\{1 + (n+1)\rho_{yw}\right\}$$

Similarly

$$v(\bar{x}) = \frac{\sigma_x^2}{n}\left\{1 + (n-1)\rho_{yw}\right\}$$

By definition, the intraclass correlation coefficient r_{yw} wihtin the sample of the same variate (say y) is defined as -

$$\rho_{yw} = \frac{E(y_{r+Jk} - \bar{Y})(y_{r+J'k} - \bar{Y})}{E(y_{r+Jk} - \bar{Y})^2}$$

$$= \frac{\sum_{r=1}^{N}\sum_{j=0}^{n-1}\sum_{j<J'}^{n-1}(y_{r+jk} - \bar{Y})(y_{r+J'k} - \bar{Y})}{Nn(n-1)\sigma_y^2}$$

$$\rho_{yx} = \frac{E(y_{r+Jk} - \bar{Y})(x_{r+Jk} - \bar{X})}{\sqrt{E(y_{r+Jk} - \bar{Y})^2 E(x_{k+Jk} - \bar{X})^2}}$$

$$Cov(\bar{y}, \bar{x}) = \frac{E(y_{r+Jk} - \bar{Y})(x_{r+Jk} - \bar{X})}{\sqrt{E(y_{r+Jk} - \bar{Y})^2 E(x_{r+Jk} - \bar{X})^2}}$$

$$C_z = \frac{S_z}{\bar{Z}}, (z = x, y), k^* = \rho_{yx}\frac{C_y}{C_x}$$

Here ρ_{yx} is the population correlation coefficient and $\rho_{yx} = \rho_{xw} = \rho_w$ is the intraclass correlation coefficient for the variates (y, x) and has been assumed to be same (Murthy 1977), (Cx,Cy) are the C.V's for (x,y) respectively.

Now taking the linear combination of $(\bar{y}, \bar{y}_R, \bar{y}_R')$, we propose a weighted class of estimator T_R as

$$T_R = \alpha_1\bar{y} + \alpha_2\bar{y}_R' + \alpha_3\bar{y}_R, \sum_{i=1}^{3}\alpha_i = 1, \qquad ...(2.6)$$

where $\alpha_i's, (i = 1,2,3)$ are suitably chosen weights attached to different estimators . Now we have the following theorem

Theorem (2.1): The weighted class T_R of estimators defined in (2.6) would be unbiased if-

$$h\alpha_2 + \alpha_3 = 0$$

$$\text{for } h = \frac{[g + (n-g)\rho_w]}{[1 + (n-1)\rho_w]} \qquad (2.7)$$

which can be proved easily. If we take $\alpha_1 = \alpha, \alpha_2 = \alpha$ and $\alpha_3 = (1 - \alpha - \alpha)$, the unbiasedness condition (2.7) reduces to-

$$\beta = -(1-\alpha)/(h-1)$$

where a, b are the suitably chosen constants . Thus, we obtain a general class T_{RU} of almost unbiased ratio type estimators in CSS scheme defined as

$$T_{RU} = \alpha\bar{y} - \left(\frac{1-\alpha}{h-1}\right)\bar{y}_{R_0}' + \left(\frac{1-\alpha}{h-1}\right)h\bar{y}_R \qquad (2.8)$$

3. Properties of Class T_R

The expression for sampling variance of the proposed class T_R in (2.6) can be written as

$$V(T_R) = \alpha_1^2 v(\bar{y}) + \alpha_2^2 v(\bar{y}_{r0}') + \alpha_3^2 v(\bar{y}_R) + 2\alpha_1\alpha_2$$

$$Cov(\bar{y}, \bar{y}_{R0}') + 2\alpha_3\alpha_1 \operatorname{cov}(\bar{y}_r, \bar{y}) \qquad ...(3.1)$$

To the terms of order $O(n^{-1})$the variances and covariances for various estimators in (3.1) are cited in the lemma (3.1) given as-

$$V(y) = \frac{\bar{Y}^2}{n}\{1 + (n-1)\rho_w\}C_y^2$$

$$V(\bar{y}_{R0}') = v(\bar{y}_R) = \operatorname{cov}(\bar{y}_{R0}', \bar{y}_R)$$

$$= \frac{\bar{Y}^2}{n}\{1 + (n-1)\rho_w\}(C_y^2 - (1-2k^*)C_x^2)$$

$$Cov(\bar{y}, \bar{y}_{R0}') = \operatorname{cov}(\bar{y}, \bar{y}_R)$$

$$= \frac{\bar{Y}^2}{n}\{1 + (n-1)\rho_w\}(C_y^2 - k^* C_x^2)$$

The results reported in lemma (3.1) can be proved easily by following the standard technique reported by Sukhatme and Sukhatme (1970) under the large sample approximation to the terms of order $o(n^{-1})$ under CSS scheme.

Substituting the results (3.2) and $\alpha_1 = \alpha$, $\alpha_2 = \alpha$ and $\alpha_3 = (1-\alpha-\alpha)$, in (3.1) and simplifying, we get the expression v(T_{RU}) given as

$$V(T_{RU}) = \frac{\bar{Y}^2}{n}\{1+(n-1)\rho_w\}\left[C_y^2 + (1-\alpha)\{(1-\alpha)-2k^*\}C_x^2\right] \quad ...(3.3)$$

The v (T_{RU}) in (3.3) will be minimum for

$$\alpha = (1 - k^*) = \alpha_0 \text{ (say)} \quad ...(3.4)$$

Thus, the resulting minimum V(T_{RU}) is

$$MinV(T_{RU}) = \frac{\bar{Y}^2}{n}\{1+(n-1)\rho_w\}\left(C_y^2 - k^{*2}C_x^2\right) \quad ...(3.5)$$

which is equivalent to the approximate variance of usual biased linear regression estimator $(\bar{y}_{lrc})$ in circular systematic sampling scheme written as

$$\bar{y}_{lrc} = \bar{y} = B_{yx}(\bar{X} - \bar{x}) \quad ...(3.6)$$

where b_{yx} is the sample regression coefficient of (y on x) under CSS scheme. Substituting $\alpha_1 = \alpha_0 = (1-k^*)$, $\alpha_2 = \alpha = -k^*/(h-1)$ and $\alpha_3 = (1-\alpha_0-\alpha_0) = k^*h/(h-1)$ in (3.1), we obtain an optimum estimator T_{RU0} in the class written as

$$T_{RU0} = (1-K^*)\bar{y} - \left(\frac{k^*}{h-1}\right)\bar{y}_{R0}' + \left(\frac{k^*h}{h-1}\right)\bar{y}_R \quad ...(3.7)$$

with V (T_{RU0}) given in (3.5).

Here, it is pointed out that the class T_{RU} in (2.8) would be more efficient than the usual sample estimator $\bar{y}$ and ratio estimator $\bar{y}_R$ defined under ESS scheme according if

either $0 < \alpha < (1 - 2k^*)$

or $(1 - 2k^*) < \alpha < 0$ ...(3.8)

and either $0 < \alpha < 2(1 - k^*)$

or $2(1 - k^*) < \alpha < 0$ ...(3.9)

Remark 3.1

The variance of any estimator derived from the class T_{RU} (2.8) can be obtained by substituting the corresponding values of constant á in V(T_{RU}) cited in (3.3).

Numerical Illustration

To see the performance of the class T_{RU}, we consider the data on y : the timber value and x: the strip length in strip wise complete enumeration.The 25 values are considered from Murthy (1977) and treated as a population of size N= 25.The summarized data are complied as follows.

N=25	C_y^2 =0.4	ρ_{yx} =0.08072
$\bar{Y}$ =459.84	C_x^2 =0.0153	K*=1.306
$\bar{X}$ =10.44	S_{xy} =104.19	ρ_w =0.0135

The interclass correlation coefficient has been worked out as $\rho_w = 1 - \frac{n}{(n-1)}\frac{\sigma_x^2}{\sigma^2}$

Table 1. Values of V1 (.) and percent relative efficiency (. $\bar{y}$,)

Values of a	Estimators	V1(.)	PRE (., $\bar{y}$)
-	$\bar{y}$	29.9x10^{-3}	100.00
a0 = -0.306	T_{RU0}	8.6 x10^{-3}	347.67
(1-2k*)<a<1 or -1.612<a<1	T_{RU}	<V1(y)	>100.00
-1.40	T_{RU}	47.99 x10^{-3}	62.31
-1.900	T_{RU}	41.74 x10^{-3}	71.83
-	$\bar{y}_R$ or $\bar{y}_{R0}$'	78.3 x10^{-3}	38.18
2(1-k*)<<0 or -0.612< <0	T_{RU}	<V1((y)	>71.63
-0.500	T_{RU}	12.6 x10^{-3}	237.31
-0.950	T_{RU}	24.8 x10^{-3}	120.56

where and are the population and within sample variance respectively defined under CSS scheme as

$$\sigma^2 = \frac{1}{N}\sum_{r=1}^{N}\sum_{J=0}^{n-1}(y_{r+Jk} - \bar{Y})^2$$

$$\sigma_w^2 = \frac{1}{N}\sum_{r=1}^{N}\sigma_{rw}^2 = \frac{1}{N}\sum_{r=1}^{N}\frac{1}{n}\sum_{J=0}^{n-1}(y_{r+jk} - \bar{Y}_r)^2$$

We have worked out the values of

$$V_1(.) = \frac{V(T_{RU})}{\frac{\bar{Y}^2}{n}\{1+(n-1)\rho_w\}} = [C_y^2 + (1-\rho)\{(1-\rho)+2k^*\}C_x^2]$$

and P.R.E. (. $\bar{y}$,) = $V(\bar{y})/V(T_{RU})$ x 100, the percent relative efficiency of proposed class with respect to $\bar{y}$ for different values of a and are complied in the Table 1.

The relative efficiency of the estimator T_{RU} is maximum among estimators considered here which shows that T_{RU0} (Table 1) is the most efficient (optimum) estimator in the class T_{RU0} In practice, one may substitute the estimated values of variances and covariance in order to obtain a "near optimum" values ofFor the choice of in an interval (-1.612<<1.0), the class T_{RU0} is always more efficient than the sample mean . It is also evident that the values of in the subinterval (-0.612<<0), the class T_{RU} is more efficient than $\bar{y}$ but is more efficient than the ratio estimator $\bar{y}_x$.

अनुक्रिया चर के जनसंख्या माध्य को आकलित करने के लिये अनुपातित प्रकार के लगभग पूर्ण रूप से अनभिनत आकलकों के बृहत समूह को जैक–नाइफ प्रक्रिया के आधार पर प्रस्तावित किया गया है। समूह के प्रतिचयन प्रसरण के निश्चित सूत्र को $O(n^{-1})$ के पद तक प्राप्त किया गया है। समूह मे कम से कम प्रसरण वाले अनभिनत आकलन का पता लगाया गया है। प्राप्त किये गये सूत्रों (फलनों) के उपयोगिता की जॉच करने के लिये एक अनुभविक उदाहरण को प्रस्तुत किया गया है।

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Analysis and estimation of soybean yield using ANCOVA technique

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Abstract

Analysis of Covariance (ANCOVA) technique has been used to sort out the covariance effects assignable to different sources under investigation of soybean crop. Analysis reveals that the yield attributing characters of soybean viz. seed weight plant^{-1}, number of branch plant^{-1} and number of pods plant^{-1} have been found significant cofactors (covariates) in increasing the yield of soybean crop.

Keywords: Analysis of covariance techniques, Analysis of Variance techniques, Regression estimates

Globally, India ranked 5th in area and production of soybean. At present, the crop occupies an area of 6.5 million hectares with an annual production of 7.5 million tones in India. Cultivation of soybean crop is concentrated in central India which is predominantly in Madhya Pradesh, Maharastra and Rajasthan. Madhya Pradesh contributes to the extent of 70% to area and 65% to its production in country and is often referred as "Soybean State" (Kumar et al. 2008)

As in ANCOVA techniques, we sort out the variance components attributable to different sources of variation like blocks, treatments, errors etc. ANCOVA technique is the combination of two important techniques known as "Analysis of Variance" and "Regression Analysis". The regression analysis is used to analyze data obtained from "served data or observational data" but ANCOVA technique is utilized to analyze data obtained from an experimental design. An ANCOVA technique keeps statistical control of variability whereas an experiment can not control it effectively. This technique reduces the experimental error by taking advantage of covariates which are highly correlated with the response variable. ANCOVA makes use of regression analysis under the role of linear prediction theory.

Keeping these facts in view, the present investigation was carried out to (1) Evaluate the effect of important characters which actually act as covariates in soybean yield and (2) to estimate the soybean yield under "unadjusted and adjusted effects of covariates" and test of significant difference among treatments mean (i.e. different date of sowing) effects on yield parameters.

Methodology for Statistical Analysis

Experimental data recorded on yield attributing characteristics on soybean crop viz. seed weight plant^{-1}, number of pods plant^{-1}, number of seed plant^{-1} and number of branch plant^{-1} etc. have been noted from the field experiment conducted during the year 2006-07, Department of Physics and Agrometeorology, College of Agricultural Engineering, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur.

Following Steel and Torrie (1980), the linear statistical model in 'Randomized Complete Block Design (RCBD) for ANCOVA, is written as

$$y_{ij} = \mu + t_i + \beta_j + \gamma(x_{ij} - \bar{x}) \qquad \text{...(i)}$$

where (i = 1, 2, 3……..t, j = 1, 2, 3……..r)
(y_{ij},x_{ij}):are the values (yield) on ith treatments of soybean and jth value of ith character of covariate, respectively

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

(ti,α): Effect of ith treatment and j^{th} block, respectively

(b,e^{i}_{ij}): Regression coefficient of y on x and error terms distributed as $e_{ij} \sim N(0, \sigma^2_e)$

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

$$\hat{\alpha}_i = \bar{y}_{.j} - \bar{y}.. - b(\bar{x}_j - \bar{x}..)$$

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

$$\sigma^2_{x.y} = s^2_{y.x} = E_{yy} - E_{yy} / E_{xx} \quad ...(ii)$$

Here, E_{xx}, E_{xy} and E_{yy} and are adjusted SS and SP for error, respectively and fe is the error d.f. The deviation of any treatment mean from general mean must be adjusted by the quantity b $(\bar{x}_{i.} - \bar{x}..)$. This adjustment removes any attributable effect of covariate X on response variate Y. It is the adjusted treatment means that are comparable effectively.

Pair wise correlation coefficient was worked out for combination of all characteristics under study using the expression.

$$r_{xy} = \frac{\sum_i^n x_i y_i - \sum^n x_i \sum^n y_i / n}{\sqrt{\left(\sum^n x_i^2 - \left(\sum^n x_i\right)^2 / n\right)\left(\sum^n y_i^2 - \left(\sum^n y_i\right)^2 / n\right)}} \quad ...(iii)$$

Results and Discussion

The Response variate Y (yield) is not correlated significantly with covariate i.e. x_1 (number of branches plant^{-1}), x_2 (number of pods plant^{-1}), x_3 (number of seed plant^{-1}), x_4 (seed weight plant^{-1}) and x_5 (number of seeds pod^{-1}), respectively. But all the five covariates (x_1, x_2, x_3, x_4, x_5) are correlated significantly among themselves but pair wise (Table 1.).

Table 1. The correlation matrix of various covariates with response variate (yield)

	Y	X_1	X_2	X_3	X_4	X_5
Y	1.000					
X_1	0.562	1.000				
X_2	0.472	0.992**	1.000			
X_3	0.428	0.984*	0.999**	1.000		
X_4	0.446	0.988*	1.000**	1.000*		
X_5	0.300	0.965*	0.982*	0.898*	0.897*	1.000

The block effects for seed weight plant^{-1} and number of pods plant^{-1} are non significant whereas the number of branch plant^{-1} is found to be any how significant at 5% level of significance. The data in table also shows that four treatments (i.e. four dates of sowing for soybean crop, JS-335) are found highly significant at 5% level of significance for all the yield attributing characters (Table 2).

Seed weight plant^{-1} shows that on comparison of adjusted mean yield, with critical difference values, it is clear that the timely date of sowing (i.e. treatment T_2) is effective to give highest seed weight (yield) among the treatments followed by treatment T_3 and significantly different from other treatments i.e. dates of sowing (Table 3).

The branches plant^{-1} revels that comparison of adjusted mean yield, with critical difference values, the timely date of sowing (T_2) is effective to give highest seed weight (yield) among treatments followed by treatment T_1 and is significantly different from other date of sowing. The dates (3rd and 4th) are pair wise significantly at par (Table 3). The number of pods plant^{-1} also shows that comparison of adjusted mean yield, with critical difference value, the timely dates of sowing is effective to give highest seed weight (yield) among other dates of sowing followed by T_1 and is significantly different from other date of sowing.

It was concluded that the timely date of sowing i.e. 3rd date of sowing i.e. 3rd July, 2007 is more effective among all date of sowing for kharif season crop to increase the yield.

सोयाबीन पर किये गये परीक्षण के दौरान ANCOVA तकनीकी के द्वारा covariance के विभिन्न घटको का अध्यन किया गया। सोयाबीन के विभिन्न लक्षणों के विश्लेशण के पश्चात बीज भार प्रति पौधा, शाखा संख्या प्रति पौधा एवं फली संख्या प्रति पौधा सोयाबीन की उपज में वृद्धि करने वाले सार्थक एवं प्रभावी संघटक (covariate) पाऐ गये।

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Table 2. Analysis of variance for unadjusted yield of soybean with different covariance separately

Response covariates	Source of variation	d.f.	Sum of Square	Mean Sum of square	Fcal.	Ftab.
Seed weight/plant	Replication	2	435.526	467.760	0.878	5.14
	Treatment	3	676520.600	225506.90	80.26*	4.76
	Error	6	16858.920	2809.819		
	Total	11	698315.046			
Number of branches/plant	Replication	2	1.1267	0.5633	6.035	5.14
	Treatment	3	45.2625	15.0875	161.65*	4.76
	Error	6	0.5600	0.0933		
	Total	11	46.9492			
Number of pods/plant	Replication	2	6.660	3.330	3.85	5.14
	Treatment	3	597.109	199.036	229.95*	4.76
	Error	6	5.193	0.866		
	Total	11	608.963			

Table 3. ANCOVA for adjusted and unadjusted yield of soybean with different covariance separately

Covariance	Treatments	Average yield unadjusted	Average yield adjusted
Seed weight/plant	T_1 (0.03)	744.152	745.87
	T_2 (3.34)	1003.66	1006.53**
	T_3 (3.01)	679.824	881.43
	T_4 (0.91)	337.72	331.54
Number of branches/plant	T_1 (14.24)	744.152	828.88
	T_2 (15.64)	1003.66	1292.88**
	T_3 (14.34)	679.824	779.16
	T_4 (10.44)	337.72	132.63
Number of pods/plant	T_1 (20.1)	744.152	726.237
	T_2 (22.9)	1003.66	969.426*
	T_3 (20.13)	679.824	661.734
	T_4 (4.97)	337.72	467.953

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Impact of integrated application of organic manure and chemical fertilizers on productivity of soybean, wheat and chickpea grown on vertisols of Madhya Pradesh

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Abstract

It has been observed that the productivity of cereal and pulse crops specially in black soils of Madhya Pradesh was found to declined continuously could be because of non adoption of adequate technology by the farmers. Looking to the problem an experiment was frame out at farmers field to compare conventional system over farmers practice. In this connection front line demonstration were conducted during 2001 to 2005 at farmers field. The result data indicated that use of proper cultivation technologies increased yield of soybean by 53, 40, 45 & 32 %, wheat 38, 40, 46 & 39 % and chickpea 42, 43, 46 & 42 % with application of GRD + FYM in comparison to farmers practice. The data also clearly indicated that the production levels was more than 50% higher when the integrated nutrients applications was used (GRD + FYM treatments). In terms of improvement in quality of produce as well as high net monitor returns.

Keywords: Front Line Demonstrations, Vertisols, Adoption of integrated nutrient management.

Black clay soils of Madhya Pradesh characterized with relatively flat to sloppy topography required proper soil and water management practices. Therefore, adoption of improved technology to conserve soil & water using high yielding varieties which are resistant to biotic and abiotic stresses is only option to improve productivity potentials of crops. Keeping this in view farmers field trials were carried under the M.S. Swaminathan Research Foundation Jawaharlal Nehru Krishi Vishwa Vidyalaya Collaborative project on cereal and pulse crops (Soybean, Wheat and Chickpea) during *rabi* and *Kharif* seasons during the year 2001 to 2005 with the following objectives: i.e.

1. To evaluate the improved land and water management practices for achieving high agricultural production in black soils of central India through participatory approach and
2. To evaluate the impact of integrated nutrient management practices for improving productivity of soybean-wheat and soybean-chickpea cropping system in black soil region of Madhya Pradesh.

Material and methods

Front line demonstrations on selected farmers was under taken by department of Soil Science & Agricultural Chemistry, Jabalpur. Soybean, Wheat and Chickpea crops were grown at farmers field of Dhangidhana and Murlipodi villages of district Narsinghpur, Madhya

Table 1. Performance of recommended varieties of crops

Crop & Season	No. of FLDs	Area (ha)	Yield (q/ha)			% Increase
		CD at 5%	In FLD	Far. Practice		
Soybean *Kharif* 2001-02	8	3.20	26.96	12.44	53	2.16
Soybean *Kharif* 2002-03	15	6.00	27.93	16.87	40	2.16
Soybean *Kharif* 2003-04	7	2.80	31.88	17.50	45	1.30
Soybean *Kharif* 2004-05	10	4.00	24.17	16.42	32	2.45
Cost Benefit Ratio (2001-05)		2.23:1	0.83:1			
Grain Straw Ratio		1.925	2.100			
Wheat *Rabi* 2001-02	8	3.20	30.69	19.13	38	1.10
Wheat *Rabi* 2002-03	15	6.00	34.73	20.86	40	0.58
Wheat *Rabi* 2003-04	4	1.60	35.88	19.25	46	1.25
Wheat *Rabi* 2004-05	11	4.40	33.73	20.55	39	1.14
Cost Benefit Ratio (2001-05)		2.64	1.15:1			
Grain Straw Ratio		1.70	1.91:1			
Chickpea *Rabi* 2001-02	8	3.20	22.21	12.79	42	0.52
Chickpea *Rabi* 2002-03	7	2.80	22.41	12.84	43	0.73
Chickpea *Rabi* 2003-04	5	2.00	22.60	12.20	46	1.45
Chickpea*Rabi* 2004-05	9	3.60	21.83	12.56	42	0.85
Cost Benefit Ratio (2001-05)		4.02:1	1.75:1			
Grain Straw Ratio		1.959	2.151			

Pradesh. These experiments were monitored regularly by the scientists to guide the farmers and feed back information were also collected for further improvement in research and extension programs. Field days and group meetings were also organized at the demonstration sites to provide the opportunities to other farmers to witnessed the benefits of the recent technologies. The demonstrations were conducted on area consisting of approximate one acre each. Recommended seed rates were used. The variety of soybean crop (JS335), wheat crop (GW273) and Chickpea crop (JG322) were selected. Integrated plant nutrient practice was used in farmers field demonstration. Integrated application of organic manures was applied and rest of the nutrient requirement is compensated with chemical fertilizers. The nutrient supplied through organic inputs was adjusted. Data were collected from the demo farmers and analysed with the suitable statistical tools to compare the yield whereas each farmers treated as a separate replication and soil samples were analysed as per recommendations outlined by the Puri et al. (2000).

Table 2. Seed Replacement in Villages (Q) Soybean, Wheat and Chickpea

Crop	Seed Replacement in quintals			
	2001-02	2002-03	2003-04	2004-05
Soybean	4.0	72.00	215.40	310.25
Wheat	4.0	409.34	556.80	670.70
Gram	3.5	245.92	284.90	390.10

Results and discussion

Front line demonstration on *kharif* (soybean)

Field trails of Soybean crop were successfully conducted at eight sites in 2001-02, at fifteen sites in 2002-03, seven sites in 2003-04, ten sites in 2004-05 in Dangidhana & Murlipodi villages of Narsinghpur district during *Kharif*

Table 3. Training, field days and farmers sangosthi during 2001 to 2005

Activity	No. of Programs				No. of Trainees			
	2001-02	2002-03	2003-04	2004-05	2001-02	2002-03	2003-04	2004-05
Training Program	2	20	6	-	125	550	179	-
Farmers sangoshti	2	4	4	4	450	595	595	980
Field days	4	2	2	2	385	55	70	439
Total	8	26	12	6	950	1175	844	1419

Table 4. Distribution of respondents of Soybean, Wheat and Gram Crop

Statement		Fully adopted	Partially adopted	Non adopted
Did you grow high yielding variety		25(100)	00(00)	00(00)
Did you follow Seed treatment		12(48)	01(04)	12(48)
Do you grow high yielding varieties according to their sowing time		23(92)	01(04)	01(04)
Do you use bio fertilizers		13(52)	05(20)	07(28)
Do you use Chemical Fertilizers	N	24(96)	01(04)	00(00)
	P	24(96)	01(04)	00(00)
	K	14(96)	08(32)	03(12)
Did you follow plant protection measures		09(36)	10(40)	06(24)

season, respectively. The data in Table-1 revealed that during 2001-02, eight trials of Soybean (JS335) were demonstrated. An average yields of 26.96 q/ha was obtained as compare to 12.44 q/ha. During *Kharif* season 2002-03, fifteen trails were demonstrated with an average yield of 27.93 q/ha as compared to 16.87 q/ha. Season 2003-04 and 2004-05, seven and 10 trails of Soybean (JS335) were demonstrated with an average of 31.88 q/ha & 24.17 q/ha as compared to 17.50 q/ha & 16.42 q/ha, respectively. The average cost benefit ratio of soybean crop was 2.23:1 as compare to farmers practice 0.83:1 with grain straw ratio i.e 1.925 as compared to farmer's practice. The results were in conformity with Rajput and Verma (1993) and Saxena et al. 1990.

Front line demonstration on *Rabi* (wheat and chickpea)

The performance of front line demonstrations on cereal and pulses during *Rabi* season of 2001-02, 2002-03, 2003-04 and 2004-05 exhibited the performance of crop production by innovated scientific method as compared to farmers practice on wheat (GW273) and Chickpea (JG322) in Table-1. The data revealed that during *Rabi* 2001-02 season, eight demonstrations of wheat and Chickpea covering 3.2 ha of land in two villages, resulted in yield of 30.69 q/ha and 22.21 q/ha as compared to 19.13 q/ha and 12.79 q/ha of farmers practice. Wheat yield on average was 34.73, 35.88 and 33.73 q/ha in *Rabi* season 2002-03, 2003-04 and 2004-05, as compared to 20.86 q/ha, 19.25 q/ha and 20.55 q/ha due to farmers practice respectively. Seven, five and nine demonstrations of chickpea were laid out in the year 2002-03, 2003-04 and 2004-05 covering an area of 2.8, 2.0 and 3.6 ha of land, respectively. An average yield of 22.41, 22.60 and 21.83 q/ha as compared to farmers practice i.e. 12.84, 12.20 and 12.56 q/ha, in the year 2002-03, 2003-04 and 2004-05, respectively were recorded. The average cost benefit ratio calculated for wheat and Chickpea crop was 2.64:1 and 4.02:1 as compare to farmers practice 1.15:1 and 1.75:1, respectively (Anonymous 2005).

Impact

In black soils (Vertisols) of Madhya Pradesh, water stagnation during *Kharif* season is a common problem, due to low infiltration rate of the soils and fairly high rainfall as a result planted crops suffer for water and oxygen in the root zone. Many farmers kept the land fallow in *Kharif* season (This process is called as "Haveli" Cultivation) and cultivate crops in post rainy season with the stored soil moisture. This might be leads to loss of water and soil due to erosion cropping system followed by farmers of the region (Anonymous 2002).

Land management treatments were also demonstrated and tested with respect to farmers practice. The treatments provided adequate drainage, minimizing water lodging and erosion thus conserving rainwater in the soil, integrated plant nutrient supply needs to be superimposed to study the effect of improved management practice on rainfed crops. The breeder seed of Soybean, Wheat and Gram crop was introduced in both the villages initially. As a result the FLD resulted in much higher productivity than farmers practice. Proper trainings of different aspect of appropriate agricultural practices were given from time to time (Table-3). The seed of all three crops were also replaced in both villages over the years. Which depicted clear impact of seed replacement on yield (Kalyani 2004 and Yadav et al.2007).

Adoption of improved practices

A report (Table 4) specify the impact of training which revealed that farmers adopted the used high yielding varieties of Soybean, Wheat and Gram crop with recommended dose of fertilizers (96%), according to their sowing time (92%), seed treatment (48%) and bio fertilizers (52%). Partially adopted practices by majority of trainees which included use of plant protection

measures (40%) followed by potash application (32%), whereas 48% farmers did not adopt recommended practices and seed treatment, biofertilizers (28%), plant protection measures (24%) (Anonymous 2004).

मध्यप्रदेश की काली मृदाओं में उन्नत तकनीकी के अभाव में धान्य एवं दाल फसलों की उत्पादकता एवं उत्पादन में निरंतर कमी आ रही है परंतु कृषकों के खेतों पर उन्नत तकनीकी के प्रक्षेत्र प्रदर्शन कर किसानों में तकनीकी की जागरुकता लाई जा सकती है। उपरोक्त पहलुओं को ध्यान में रखकर एम. एस. स्वामीनाथन रिसर्च फाउन्डेशन एवं जवाहरलाल नेहरु कृषि विश्वविद्यालय, जबलपुर द्वारा की गई संयुक्त परियोजना में जिला नरसिंहपुर में किसानों के यहॉ वर्ष 2001-02 से 2004-05 तक अनेको प्रक्षेत्र प्रदर्शन डाले गये जिनके परिणाम स्वरुप पारम्परिक खेती की तुलना में सोयाबीन फसल में क्रमशः 53, 40, 45 एवं 32 प्रतिशत, गेहूँ में 38, 40, 46 एवं 39 प्रतिशत तथा चने में 42, 43, 46 एवं 42 प्रतिशत सार्थक वृद्धि आंकी गयी। साथ ही पाया गया कि समन्वित पौधा पोषण पद्धति के उपयोग से सभी फसलों में 50 प्रतिशत से ज्यादा उपज में सार्थक वृद्धि देखी गयी समन्वित पौध पोषण पद्धति अपनाने से न सिर्फ फसल की गुणवत्ता में सुधार होता है एवं प्राकृतिक संसाधनों के उपयोग से लागत में कमी भी आती है साथ ही अधिक सकल आय भी प्राप्त होती है।

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Efficient production and marketing of soybean in Central India: An initiative of ITC e-Soya Choupal

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Abstract

An introduction of corporate culture in the form of ITC e-soya Choupal creates a congenial soybean production and marketing environment in Madhya Pradesh. This resulted in enhanced benefits to soybean growers and developed users' friendly environment in the domain. The benefited soybean growers were earn more profit due to narrowed and efficient marketing channel, which reduces price spread on the one hand and it directly indirectly enhance the efficiency of soybean production and thus profitability on the other. These benefits are also associated with supply of quality seed and other associated inputs along with dissemination of information through electronic and other media on soybean production technology. Therefore, it is suggested that corporate environment should also be develop for marketing of other agricultural produce through PPP mode and some of the "A" grade regulated markets should be transform to corporate culture for efficient marketing of agriculture inputs and outputs.

Keywords: Production, Marketing, Soybean, ITC-e- soya choupal

The efficient agriculture marketing system is of a vital importance for development of agri-based economy. The entry of corporate sector creates healthy competitive environment which have both beneficial and detrimental effects. Some agricultural economists claimed that competition serve as a mechanism for determining the best suited group politically, economically and ecologically. On the negative side competition can have an adverse affects on the participant groups. This may also drain valuable resources and energy. In the present era of liberalization, the agricultural marketing is liberalized and gates are open for the alternative marketing channels for participation in marketing process (Kumar et al 2005). Private companies, co-operatives or any legal entity was establish and operate the agricultural marketing infrastructure and supporting services as competitive measures with the markets established by APMCs (Birthal et al. 2007). Direct purchase of agricultural produce from the farmers' field by individuals as well as companies, societies, co-operatives is encouraged to reduce the number of intermediaries thereby providing opportunity in increasing the share of farmer in consumer rupee. Contract farming is popularized for the assured sale at the predetermined price before sowing. Specialized market yards for special commodities were also developed to provide a commodity specific modern marketing infrastructure for the particular crops grown in a specified area. Public-Private Partnership (PPP) for establishment and management of markets for agricultural produce and to encourage the private investment and professionalism in agricultural marketing including post harvest handling of agricultural produce and encouraging value addition to share the burden and provide healthy competition with APMC's is encouraged in the recent past. E-market, e-marketing, and e-trading for speedy and distance transactions were also established (Balakrishnan 2010). ITC was emerged as a new marketing channel in the domain of agriculture marketing. The *e-choupal* initiative is enabling Indian agriculture significantly enhance it's competitiveness by empowering Indian farmers through the power of electronic media.

ITC's Agri Business Division, one of India's largest exporters of agricultural commodities, has conceived e-Choupal as a more efficient supply chain aimed at delivering value to its customers around the world on a sustainable basis. The e-Choupal model has been specifically designed to tackle the challenges posed by the unique features of Indian agriculture, characterized by fragmented farms, weak infrastructure and the involvement of numerous intermediaries. The e-soya Choupal' also unshackles the potential of Indian farmers who has been trapped in a vicious cycle of low risk taking

ability, low investment, low productivity, weak market orientation, low value addition, low margin and low risk taking ability. This made Indian agribusiness sector globally less competitive, despite rich and abundant natural resources and mega biodiversity. Such a market-led business model can enhance the competitiveness of Indian agriculture and trigger a virtuous cycle of higher productivity, higher incomes, and enhanced capacity for farmer risk management, larger investments and higher quality and productivity of the produce. How far this particular emerging marketing channel (EMC) benefited to the farmers as compared to the traditional marketing channel (TMC) i.e. regulated market in Madhya Pradesh for enhancing production and marketing efficiency of soybean is the matter of intend study.

Research Methodology

Amongst all the districts of the Madhya Pradesh, Sehore district was selected purposively due to its remarkable position in soybean production and introduction of first ITC e-soya choupal (2004) in the district. The Sehore block of Sehore district was also selected purposively for the study as maximum area under the cultivation of soybean was confined to this block along with presence of ITC e-soya choupal. A list of all the villages in the jurisdiction of the ITC e-soya choupal was prepared and 3 villages were selected on the basis of area under soybean. For the collection of primary data a list of all soybean growers of the selected villages was prepared and 50 soybean growers associated with ITC e-soya choupal were selected (Group as EMC) for the study. An equal number of soybean growers (50) who marketed their produce to regulated (Group as TMC) market were also selected for comparison between these two marketing channels. The primary data were collected by the survey method and were related to agricultural year 2009-10.

Results and Discussion

Enhance Profitability

The majority of the soybean growers were reported that they were using high yielding varieties, quality seeds, manures/fertilizer, insecticides and weedicides and engaged hired labour and machines power for cultivation of soybean. As regards to the total cost of soybean cultivation per hectare, it was higher (Rs18640.08) in EMC group as compared to TMC group (Rs15463.74). This may be due to higher investment on quality production inputs. The EMC group of soybean growers invested more on use of culture (576.77%), manure (61.25%), fertilizers (100.32%), micronutrients and growth regulators (256.12%), weedicides (208.42%), insecticides (114.33%) and machine power (118.37%) as compared to TMC group (Table-1). On the contrary they were found to invested lower on hired human labour (-28.74%), family labour (-40.19%) and bullock labour (-48.76%). Indirectly this has been substituted by machine power in EMC group of soybean growers. In both the groups the major share of the total cost is accounted for use of labour and power (>45%) followed by seed and seed treatment (>11%). The higher percentage expenditure on manures and fertilizers and plant protection chemicals by the soybean growers belong to EMC group reflect towards their awareness and access to improved production inputs.

The overall cost per hectare was higher in EMC group as compared to TMC group. It is higher by Rs. 3176.34 per hectare (20.54%). But the enhancement in productivity was only 12.12 per cent in EMC group over its counterpart. This revealed that the additional cost incurred (20.54%) by the EMC group of soybean growers was not transform in the output in a required rate and this may be due to managerial constraints. The gross income was higher in EMC group (Rs 4905.00 & 15.77%) but income at variable and total cost was only higher by 12.12 and 11.05 per cent respectively. This also reflects in input output ratio which was higher in TMC group as compared to EMC group despite of higher investment by the soybean growers of the EMC group. This lead to conclude that only investing more in the soybean production without proper time and other managerial skills will not transform input in to the output with the required efficiency and therefore rate of return may decline with higher investment in soybean production. Although EMC i.e. ITC e-soya choupal is supplying quality inputs to the soybean growers with required knowledge and skill of soybean production but this has not been transformed in the required rate at field level. This may be due to managerial and other constraints persist amongst soybean growers in the study area.

Efficient marketing

The 95 per cent of produced soybean was disposed off only in 4 months (October-January) after the harvesting of the product by the soybean growers of TMC group. But due to specified standards / norms of grading in the EMC, they do not purchase soybean just after harvesting

Table 1. Comparative cost and profitability of soybean cultivation in TMC and EMC groups

(Rs./ha)

Particulars	Cost		Cost & profit over TMC	Percentage difference
	TMC	EMC		
Labour & Power				
Hired Human labour	3673.35	2617.60	-1055.75	-28.74
Family labour	1126.48	673.77	-452.71	-40.19
Bullock Labour	518.38	265.61	-252.77	-48.76
Machine power	2190.40	4783.13	2592.73	118.37
Sub total	7508.61	8340.11	831.50	11.07
	(48.59)	(44.74)		
Seed and seed treatment				
Seed	2040.57	2080.35	39.78	1.95
Culture	10.89	73.70	62.81	576.77
Seed Treatment	7.62	7.73	0.11	1.44
Sub total	2059.08	2161.78	102.70	4.98
	(13.31)	(11.60)		
Manure & Fertilizers				
Manures	69.88	112.68	42.80	61.25
Fertilizer	400.94	803.15	402.21	100.32
Micro-nutrients & growth regulators	25.80	91.88	66.08	256.12
Sub total	496.62	1007.71	511.09	102.91
	(03.21)	(05.40)		
Protection chemicals				
Insecticides	161.32	345.75	184.43	114.33
Weedicides	352.61	1087.51	734.90	208.42
Sub total	513.93	1433.26	919.33	178.88
	(03.32)	(07.69)		
Indirect variable costs				
Depreciation	54.76	119.58	64.82	118.37
Interest on Working Capital	45.56	46.03	0.47	1.04
Sub total	100.32	165.93	65.61	65.40
	(0.65)	(0.89)		
Total variable cost	10678.56	13108.79	2430.23	22.76
	(69.058)	(70.32)		
Fixed Cost				
Interest on fixed capital	120.40	130.77	10.37	8.61
Rental value of owned land	4664.78	5400.52	735.74	15.77
Total Fixed Cost	4785.18	5531.29	746.11	15.59
	(30.95)	(29.68)		
Total Cost of Cultivation	15463.74	18640.08	3176.34	20.54
	(100)	(100)		
Profitability				
Yield (q/ha)	16.81	18.85	2.04	12.13
Gross Income	31098.50	36003.50	4905.00	15.77
Income at variable cost	20419.94	22894.71	2474.77	12.12
Input output ratio at VC	2.91	2.74	-	-
Income at total cost	15634.76	17363.42	1728.66	11.05
Input output ratio at TC	2.01	1.93	-	-

TMC: Traditional marketing channel (regulated market)

EMC: Emerging marketing channel (e-choupal)

(Figures in parentheses shows percentage to total cost of cultivation)

Table 2. Comparative marketing cost and price spread in TMC & EMC groups

(Rs/q)

Particulars	TMC	%	EMC	%
Quantity marketed (q)	14.28	-	15.97	-
Loading & Unloading Cost	3.99	13.02	0.00	0.00
Transport Cost	16.27	52.96	16.95	75.62
Storage Cost	2.95	9.60	2.36	10.63
Mandi Tax	0.09	0.30	0.00	0.00
Development Cess	1.00	3.25	0.00	0.00
Sampling of Produce	0.00	0.00	2.04	9.19
Wastage cost	5.39	17.55	0.00	0.00
Other Fees Paid	0.02	0.06	0.01	0.06
Marketing cost borne by farmers	30.73	100.00	22.21	100.00
Actual cost of the produce	1039.04	-	1011.06	-
Cost of Bags	29.96	15.39	28.26	33.19
Loading & Unloading Cost	13.12	6.74	9.08	10.66
Transport Cost	59.26	30.43	30.89	36.28
Administrative Charges	7.16	3.68	12.56	14.75
Storage Cost	1.86	0.96	1.85	2.17
Mandi Tax	44.26	22.73	0.00	0.00
Development Cess	22.13	11.37	0.00	0.00
Weighing Cost	4.95	2.54	1.77	2.08
Brokege Expenses	1.03	0.53	0.00	0.00
Wastage	10.16	5.22	0.00	0.00
Other Fees Paid	0.83	0.43	0.74	0.87
Marketing Cost borne by whole Seller	194.72	100.0	85.15	100.0
Price paid to farmers	1850.0	-	1910.00	-
Whole Seller's Margin	306.89	-	246.89	-
Price paid by the processor	2351.61		2242.04	
Price Spread	501.61	27.11	332.04	17.38
Marketing Efficiency (ratio)	2.69	-	4.75	-

TMC: Traditional marketing channel (regulated market)
EMC: Emerging marketing channel (e-choupal)

due to high moisture contain and therefore none of the soybean grower belong to EMC group sale his produce during the month of October. This is one of the major reasons for not preferring this channel (EMC) of marketing by soybean growers, who want to dispose off his produce just after harvesting for want of money. In TMC group 12.06 per cent of the produce was sell to the whole sellers just after harvesting (at regulated market) at lower rate with high moisture content.

Out of the total per hectare production of 16.81 and 18.85 in TMC and EMC groups of soybean growers respectively, the extent of marketed surplus was 14.26q (84.94%) and 15.97q (84.72%) per hectare. The marketing cost borne by the soybean producers in two groups was remarkably differs. It was Rs. 30.73 per q in TMC group and Rs 22.21 per q in EMC group. This revealed that the marketing cost borne by the soybean producers belong to EMC group was less as compared to the cost borne by the TMC group. The major component of marketing cost borne by the soybean producers were transportation, storage and sampling cost in EMC group, while it was transportation, wastage, loading and unloading costs in case of TMC group. And therefore actual cost of the produce was higher (Rs 1039.04/q) in case of TMC group as compared to EMC group (Rs 1011.06/q).

The marketing cost borne by the whole seller was Rs194.72 /q when the produced is sold through regulated market. The cost borne by the e-soy choupal kiosk was only Rs 85.15/q when the produce is sold through ITC e-soya choupal. The reasons for higher cost incurred by the whole seller operated in regulated market is that he has to bear higher transportation cost, high marketing taxes, development cess and wastage cost which was not a part of marketing cost except transportation cost when the produce is sold through ITC e-soya choupal.

The price realized by the farmers belonging to EMC group was higher (Rs1910.00/q) as compared to price (Rs 1850.00/q) realized by the soybean growers belong to TMC group. The margin of ITC e-soya choupal was less (Rs. 246.89) as compared to the whole sellers (Rs 306.89) operated in the regulated market. Processor also benefited through ease access to quality product (soybean) at remunerative prices (Rs 2242.04) from ITC e-soya choupal. The extent of price spread was only Rs 332.04q (17.38%) when the produce is sold through ITC-e-soya choupal, while it was Rs 501.61 (27.11%) when it was disposed off through traditional marketing channels (TMC-Regulated market).

The respondents related to the EMC group reported that they were sold their product to ITC e-choupal when it was convinced by the *Sanchalak* of ITC e-soya choupal, who have been facilitated with computer and internet at his home in the village. The Sanchalak of e-soya choupal disseminated information on prices according to different grades before the actual marketing process. The other reasons for selecting the EMC (e-soya choupal), as reported by the soybean growers were superior services (100%), superior infrastructure (100%), low cost of marketing (100%), higher price/ fair price of the product (100%), proximity (70.27%), no hidden charges or bribe (100%) and no waiting time (100%). Apart from these reasons the ITC-e-soya choupal also facilitate them through supply of quality input (62.16%). Besides this, the member also benefited through purchase of quality consumer goods from ITC Sagar Mall at reasonable prices. The majority of respondents related to the EMC reported that the facilities of storage, auction arrangement, sale supervision, loading, parking , telephone/ internet were more efficient. Where as, such facilities are not so effectively available to the soybean growers who sale their produce through TMC.

Conclusion

It is clear from the above discussion that ITC e-soya choupal is found to be technically viable, economical feasible and efficient channel for soybean marketing in the central part of India. Therefore, the efforts should be made to facilitate the producers, traders and regulated markets in the lines of the ITC e-choupal. Further, it is also observed during the course of investigation that the farmers who were related to the TMC were lacking in the technical knowledge, supply of quality inputs and ease access to information technology. These functions are either supervised or carried out by the public extension system with load of other responsibilities and lack of manpower on the other hand these functions are effectively carried out by the private extension agencies associated with soybean industry, since processor is the ultimate profit maker, because it is still not consume as food product in India and most of the produce is process for production of edible oil. Therefore, it is suggested that the other corporate sectors like ITC should also come forward for providing and strengthening knowledge of soybean growers on full package of practice, supported by the ease access to quality inputs at subsidized rate and guarantee of purchased at fair price. The Government should also provide special tax relief on such initiatives of the processors and corporate sectors. These efforts will definitely bridge the yield gap on the one hand and will help in enhancing production of soybean and hence farmers income on sustainable manner.

मध्यप्रदेश में आई.टी.सी. ई-सोया चौपाल के रूप में कोरपोरेट कल्चर के प्रारंभ होने से सोयाबीन उत्पादन एवं विपणन का सुदृढ़ वातावरण बना है। जिसके फलस्वरूप इससे सम्बन्धित क्षेत्रों में सोयाबीन उत्पादकों को अधिक लाभ प्राप्त हुआ है तथा मित्रवत् उपयोगी पर्यावरण निर्मित हुआ है। इससे हितग्राही सोयाबीन उत्पादक, जहॉं एक ओर दक्षतापूर्ण विपणन माध्यम मिलने से कम मूल्य-प्रसार का लाभ प्राप्त करते पाये गये हैं वही दूसरी ओर, उन्हे उन्नत बीज, गुणवत्तायुक्त आदानों की पूर्ति तथा सोयाबीन तकनीक के समुचित प्रसार का लाभ प्राप्त होने से प्रत्यक्ष तथा अप्रत्यक्ष रूप से उनके सोयाबीन उत्पादन में दक्षतापूर्ण वृद्धि पाई गयी है। अतएव, यह सुझाव दिया जा सकता है कि अन्य कृषि उत्पादों को भी लोक-निजी भागीदारी के माध्यम से कोरपोरेट कल्चर से जोड़ा जावे तथा कुछ 'अ' श्रेणी की कृषि उपज मण्डियों को इसके अनुरूप कृषि आदानों एवं उत्पादों के दक्षतापूर्ण विपणन के लिए परिवर्तित किया जावे।

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Web based information system of aromatic plants using IT tools for Agri-Rural development

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Abstract

India is having a vast treasure of aromatic plants grown in the forest areas as well as field crops. Presently the knowledge of aromatic plants grown at different level is limited to botanist, horticulturist, and industries engaged in the production. The knowledge of aromatic plants naturally grown in forest is also known to agri-rural & tribal as they use these products in the treatments of some diseases. This knowledge is slowly disappearing due to non availability of information at larger level. Now a day, there are many knowledge centers of aromatic plants by way of books, websites and annual reports of different organization working in this field. However, comprehensive database of each plant variety, its location, identification, productivity, marketing and industrial uses needed to be augmented. Almost all aromatic plants can be cultivated by the farmers provided knowledge of latest package of practices can be made readily available to them. The data base contain the information of importance of each aromatic species, their visualization in industry, productivity figures and shortage if any along with export potential of each species. It also highlight the recent technological development for the cultivation of aromatic plants as field crops. The most important aspect of the information to be collected and to be updated on day to day basis regarding availability and requirement aspects of these products in different market. Keeping this in view, authors have developed a web application which is useful to farmers, growers, agri-rural and tribal's, planners, industries etc. The web application is bilingual i.e. in Hindi and English & developed using PHP & MYSQL for aromatic plants grown in central India.

Keywords: Aromatic Plants, Data Base, Treasure, Therapatic, PHP, MYSQL

Aromatic plants are the source for the manufacturing of perfumes, flavors and cosmetics in the world [Farooqie and Sreeramu (2004). India possesses rich and diverse source of aromatic plants for fulfilling the demand of cosmetic industry based on these plants at national level and to some extent at globe level. Aromatic plants are grown in forest whereas some species can also be grown at farmer's field by cultivation. Cultivation in central India is possible because wide variation in soil and climate in the region.

Madhya Pradesh possesses a vast treasure of diverse aromatic plants, which occur as flora in natural forests distributed throughout the state Agrawal et al (2004). Some forest areas considered rich in natural genetic resources have been identified as Hot Spots of aromatic plants. The tremendous amount of diversity and floristic pattern is due to variations in climatic, edaphic and topographic features of the State. Madhya Pradesh is natural habitat for over 50% of the herbs used in the industry and is key source of raw material to the domestic herbal industry. The farmers and extension agencies are need to be trained on scientific way of cultivation and processing of aromatic plants. Cultivation and processing of aromatic plants are very labour intensive and have also tremendous potential for employment generation and poverty alleviation at rural level. More than one million people are engaged in gathering, processing, manufacturing and marketing in the country. There is a growing demand both in India and abroad. Therefore, the demand for raw material will also increase correspondingly. One of the ways to increase productivity is to adapt modern agronomical techniques in growing aromatic plant at farmer's fields.

Even though, the land mass of India occupies only 2 % of the globe, it occupies 11% of the total known world flora and one of the world's top 12 mega diversify nations. India having different soil types with varied climate conditions is ideally suited for the cultivation of these plants. The cost of production is considerably low since many of these can be grown and harvested round the year. It provides steady employment to agricultural labour and income to farmers. Most of the aromatic

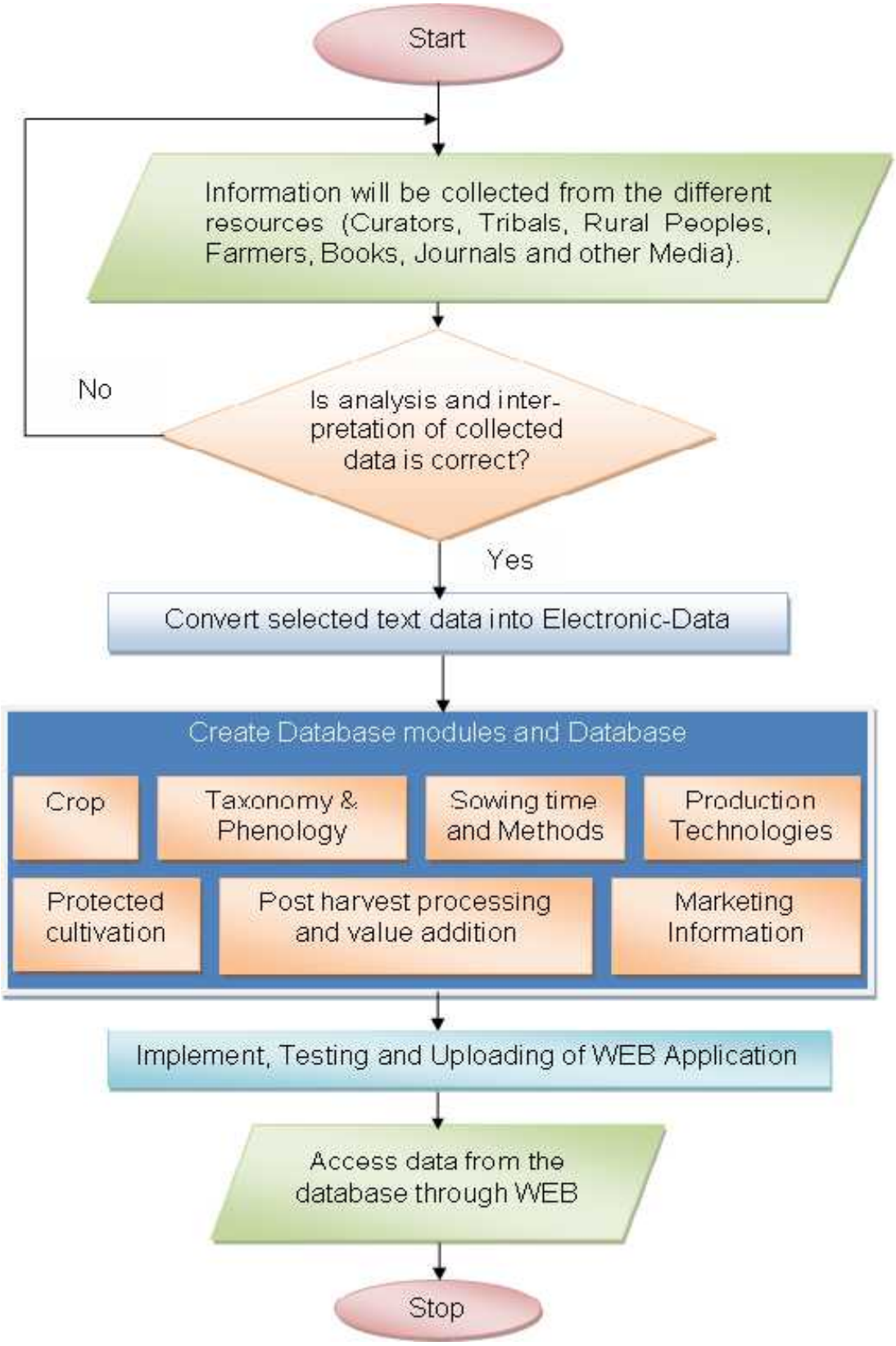

Fig 1: Flow Diagram Showing Aromatic Plants Species

plants can be grown as intercrops in the farmers' fields.

Presently the knowledge of aromatic plants grown at different level is limited to botanist, horticulturist, and some industries engaged in the production. The knowledge of aromatic plants naturally grown in forest is also known to agri-rural & tribal as they use these products in the treatments of some diseases. This knowledge is slowly disappearing due to non availability of information at larger level. Now a day, there are many knowledge centers of aromatic plants by way of books, websites and annual reports of different organization working in this field. However, comprehensive database covering most of the aspects of aromatic plants has not been prepared. A comprehensive database of each plant variety, its location, identification, productivity, marketing and industrial uses needed to be augmented. Agro climatic condition of central India is suitable to grow aromatic plants (www.dmap.org.in). Almost all aromatic plants can be cultivated by the farmers provided knowledge of latest package of practices can be made readily available to them.

The internet is to facilitate the dissipation of comprehensive knowledge of aromatic plants to growers and different level of user group. This also includes amateur who want to start small scale ventures based on Aromatic plants. The knowledge will be key based and bilingual in Hindi and English on web portal with digital photo gallery.

Methods

The web based data base generation, application module covering different aspects of crop production (with a separate sub-module) designed and developed using PHP (for dynamic web application). The database of farm management technologies can be stored and updated using MYSQL**.** These tools are completely *free ware*.

In the recent year interest in the aromatic plants has increase to an extent. Throughout the globe scientist are busy in finding the aromatic values of aromatic plants (www.ayurvedic_medicines.com). The demands for aromatic plants are increasing day by day. But for reference presently a complete website regarding cultivation practices of aromatic plants is no where available on the internet. Development of database of aromatic plants on internet will fulfill the requirement in all the aspects of availability of knowledge of the stated field. This field has generated the demand for plant and their products in the country. Efforts are being made to introduce many of these aromatic plants into the Indian agriculture (www.nmpb.nic.in).

The proposed database will be comprehensive. The agriculture extension workers and advanced farmers will be able to use the database for finding answers to their problems and also for growing better varieties of aromatic plants having very good marketing potential (Dwivedi et al. 2006). The database is bilingual i.e. in Hindi and English. Multimedia tools, audio video clips, sounds and text are supporting each module. The system developed in such a way that the user can interact with the database for obtaining information for a set of aromatic plants.

The title clearly indicates that the database will dynamically help in educating agriculturist, horticulturist, extension workers and others engaged in the field of aromatic plants. It consist of information in modular fashion, so that the user can choose a particular module depending upon requirement. It is interactive in such a way that simple scavy knowledge of computer operation will be enough to browse different modules. The primary aim is to utilize the IT tools for effective dissipation of available technological inputs through GUI. The database address mainly to different type of users. The first one is for importing knowledge for the cultivation of aromatic plants at the farmer's field. This modules have sub modules and each sub module consist of sub-sub module depending upon major activities perform for cultivation of particular plant species. All type of variations in technologies due to agro climatic regions is also incorporated wherever needed. The most suitable aromatic plants will be suggested. If someone is already growing aromatic plants then the operator will have an option for the recent package of practices for improving the quality and obtaining optimum yield. For the creation of above module and other sub modules huge database is created by gathering information on each species in terms of their genetic variability, cultivation practices, seed availability, harvest and post harvest technologies, chemical composition of these species for their use in therapies (Bhattachayi 2008; Sharma 2003). The database will be also incorporates taxonomical feature of the each species, their scientific nomenclature and local nomenclature in Hindi and English (Gangrade et al. 2003; Singh and Somadey 2005). The marketing information is also incorporated. So that maximum profit can be achieved by the cultivator (Anon 2008). The cost of cultivation in brief is incorporated. The flow diagram of the developed database is shown in Fig 1. Detailed list of aromatic plants is given in Table1 which includes trees, shrubs, herbs and climbers.

Expected Results

The system may work as an assist to farmers and experts in furnishing knowledge on various aspects of aromatic plants. The aromatic plants sector suffers from lack of availability of good quality planting materials, lack of uses of hybrid seeds and poor farm management. Hence the production technology needs improvement qualitatively and quantitatively, so that the standards of the aromatic plants after processing produce can be further improved to cater the acceptability of international market. At present whatever production technology is available that is through extension bulletins published by different extension agencies or through aromatic plants seed production farms. In the software the recent technologies available in the country is collected and incorporated in different modules so that user can easily access all the modules or module of his/her interest. Information technology will play a pivotal role in agriculture extension activities and the database of above nature will definitely help the extension workers as most of the village panchyat may have personal computer in near future. It can be easily converted in any other Indian languages as per need and requirement.

भारत वर्ष में संगध पौधों की बहुतायत संपदा है, जो कि वनों में पायी जाती है, तथा खेतों में भी उगायी जाती है । आज के समय में सगंध पौधों की खेती की जानकारी केवल वनस्पतियों, उद्यान विशेषज्ञों एवं उद्योगों जो इनका उत्पादन करते हैं उन्हें ही विशेष जानकारी है । वनों में प्राकृतिक रूप से पाई जाने वाली सगंध पौधों की जानकारी वहाँ पर रहने वाले ग्रामीणों एवं जनजातियों को ही पता है क्योंकि वे इनका उपयोग रोगों के उपचार के लिए करते है । यह ज्ञान धीरे-धीरे लुप्त होता जा रहा है । क्योंकि सगंध पौधों के उत्पादन विधि बड़े स्तर पर उपलब्ध नहीं है । कुछ जानकरी किताबों, बेबसाइटों एंव विभिन्न संस्थाओं की वार्षिक रिपोर्टो में है । प्रत्येक पौधों की विभिन्न किस्में, पहचान, उत्पादन, बाजार भाव, औधोगिक उपयोग इत्यादि की व्यापक जानकारी के लिए एक डेटाबेस बनाने की फिर भी आवश्यकता है । उपरोत्त विचारों को ध्यान में रखते हुये लेखकों ने एक ऐसा वेब आधारित सूचना तंत्र का विकास किया है जिसमें संगधीय पौधों की उन्नत खेती की सम्पूर्ण जानकारी उपलब्ध है । इस वेब आधारित सूचना तंत्र को हिन्दी एवं अग्रेंजी दोनों भाषाओं में विकसित किया गया है । इस साफ्टवेयर को पी.एच.पी. एवं माय एस.क्यू.एल. का उपयोग करते हुये विकसित किया गया है ।

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Accessing electronic resources at University Central Library in the digital eon: an appraisal

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Abstract

The article describes the availability of information resources amidst digital eon. Electronic access of library usage tend to bring the library in the forefront. This paper assists faculty, staff and students by providing information on suitable accessible resources for reading, learning, researching, referencing and for information gathering from available library collections in print and those available in digital format.

Keywords: Central library, digital, information, data documentation, information, access, journal

Physical space to house an ever growing collection has always been a problem for the library. As the prevalence and prominence of electronic resources continues to grow in academic libraries, it is not surprising that there is a large and increasing body of research in this area (Gottfried 2011). The scope of research, extension, teaching, education and training cannot be confined, learning essentially begins at the level of an individual and library is a place where learning is developed. Life is always lived forward but understood backwards, for faculty, staff and students' successful lifelong learning is a way of life and it's their inherent ability to effectively and efficiently utilize literature available in the library. Also science does not recognize geographical boundaries (Florence 2008) and for this reason the users must always be aware of global online resources available on the web. The coming age of the electronic journals has altered the way scholarly information is disseminated throughout the world (Gleeson 2001). They have not only affected the way information is spread, but the way information is acquired and how scientific researchers seek that needed information (Guruprasad et al. 2009).

Libraries have been significantly transformed with the advent of Internet and the ability to provide resources to people who may never visit a physical building, but use resources intensively in own homes or work places (Kumar 2009). Library is a place where knowledge and information is available in various forms. Today more emphasis is laid on soft information or more precisely on digitized form of information (Pandey et al. 2009). The searching of any required literature must be highly targeted, focused and rapid so also the result obtained should be authentic, accurate and viable to be feasible to support findings.

An agricultural library primarily renders service to the policy makers, specialists, scientists, teachers, students, researchers and farmers in agriculture and allied subject (Visakhi 2009). Central library is constantly striving for adoption of novel and innovative technologies so that all the users are benefitted from library services. Although huge volumes of printed holding are available in the library as stored data but still there is an enormous want of timely information which is available on the internet unexplored due to lack of information.

Central Library

The Central Library of Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV) was established in the year 1964 Central Library is currently linked with 60 national institutes and Universities under exchange programme, VSAT connectivity is available for internet browsing at ARIS lab (Pandey et al. 2009). Recently with NKN (National Knowledge Network) support high speed (10Gbps) connectivity is also made available. The Central library of Jawaharlal Nehru Krishi Vishwa Vidyalaya is well equipped with core i3 and Pentium IV computers supported by data capturing unit, bar code scanners, bar code printer, thermal power printer, flat bed scanner, laser printer and photocopier. Twelve computers are installed in the library for consultation.

Information Sources

Library is places where different sources of information are available to the users. Although information sources are classified as primary, secondary and tertiary, but they are also classified on account of the information availability in digital format. Three forms of electronic access are currently available are i.e. full text access, abstract access and bibliographic databases. Apart from this the information on net is available to the library users in the form of consortium, abstracting services and bibliographic databases.

Consortiums

A consortia is an association of two or more individuals, companies, organizations or governments (or any combination of these entities) with the objective of participating in a common activity or pooling the resources for achieving a common goal. Consortium is a Latin word, meaning 'partnership, association or society' and derives from consors 'partner', itself from con- 'together' and sors 'fate', meaning owner of means or comrade. Library consortia, providing for physical and electronic delivery of materials, and integrating the collection-development process are all distinct and crucial steps in moving toward the twenty-first century library. Consortia are tools, which aid in exploiting the features of the e-resources in effecting savings (Singh and Rao 2008).

Abstracting services

An abstract is an abbreviated summary of a research article, review, or any in-depth analysis of a particular subject or discipline, and is often used to help the reader quickly ascertain the paper's purpose. When used, an abstract always appears at the beginning of a manuscript, acting as the point-of-entry for any given scientific paper or patent application (http://www.websters-online-dictionary.org). Abstracting services normally constitute a database of available journal articles. Abstracting services helps us in locating a particular article in the ocean of published literature. A citation is always available with an abstracting service.

Bibliographic databases - A bibliographic database is a database of bibliographic records, or an organized digital collection of references to published literature, including journal and newspaper articles, conference proceedings, reports, government and legal publications, patents, books, etc (http://en.wikipedia.org/wiki/Bibliographic_database).

Below are the brief descriptions of available consortiums, abstracting services. bibliographic databases:

e-TOC

e-TOC stands for electronic table of contents, it is of utmost importance as it acts as a catalyst to bring the users to the library to access the full contents of the desired literature. The faculty, staff and students first normally register for e-TOC services and then the table of contents of required periodical is sent to them via email as soon as its new issue arrives in the library or is released by the publisher. E-TOC acts as an alert service for the user so that information is collected within the speculated time

CeRA

CeRA stands for Consortium for e-Resources in Agriculture. CeRA was launched successfully on 30 April 2008 at its headquarters at Indian Agricultural research Institute (IARI), New Delhi, India. The published materials form publishers of Agriculture, Veterinary Science, Fisheries, Crop Science, Computer Science, Soil Science, Animal Science fields are available for full as well as for partial access. At present the journals from the domain Elsevier, Springer Link, Annual Reviews, Indian Journals.com, Taylor and Francis, Oxford Journals, Wiley Online Library, CSIRO (Australia) and American Society of Agronomy are available to the users. In all, a total of 2747 journals are available for access. The CeRA facility is functional at the computer lab of Central Library and can be accessed by faculty, staff research scholars and students (http://www.cera.jccc.in/).

JCCC

JCCC stands for J-Gate Custom Content for Consortia, i.e. the gateway for accessing journals is one of the services provided by M/s Informatics India Limited, Bangalore. They are providing two types of services under J-Gate viz. J-Gate Custom Content i.e. JCC (for individual libraries, a service not subscribed) and J-Gate Custom Content for Consortia i.e. JCCC (for consortium of libraries), CSIR Consortium through its Indian National Science & Technology Information Resources Consortia (INSTIRC) has collaborated with Informatics India to offer

JCCC to all the CSIR laboratories and the same is known as JCCC-INSTIRC (http://www.instirc.jccc.in)

INDEST

This consortium is named as the Indian National Digital Library in Science and Technology (INDEST) Consortium. The Ministry of Human Resource Development (MHRD) has set-up a consortia-based Subscription to Electronic Resources for Technical Education System in India. The consortium is named as the Indian National Digital Library in Science and Technology (INDEST) Consortium. E-INDEST Consortium is the most ambitious initiative taken so far in the country The Ministry of Human Resource Development (MHRD) has set-up a Consortia-based Subscription to Electronic Resources for Technical Education System in India (http://indest.iiita.ac.in/ and http://paniit.iitd.ac.in/indest/)

UGC-Infonet Digital Library Consortium

The Consortium provides current as well as archival access to more than 7000+ core and peer-reviewed journals and 10 bibliographic databases from 26 publishers and aggregators in different disciplines. The programme is wholly funded by the UGC and executed by the INFLIBNET (Information and Library Network) Centre, Ahmedabad (http://www.inflibnet.ac.in/econ/index.php).

MCIT Libraries Consortium

It is a Resource Sharing and Networking of Libraries. Ministry of Communications and Information Technology, Government of India, comprises of three departments those are Department of Information Technology (DIT); Department of Telecommunication (DOT) and; Department of Post (DOP). Each department has a number of PSU/Organizations/Autonomous Bodies. These organizations have their own Libraries, Documentation Centres and Information Centres to meet the information needs of their officials. Sometimes it has been observed that these libraries purchase common/similar information resources separately. Thus there is a need of common purchasing and sharing of information resources among these organizations for the best utilization of their library budget as well as information resources. MCIT Libraries Consortium has the above areas in its purview (http://mcitconsortium.nic.in/).

UGC-DAE Consortium for Scientific Research

UGC-DAE Consortium for Scientific Research, DAE Library Consortia, Department of Atomic Energy. It was established to promote interaction amongst the scientists working in the research centres of the Department of Atomic Energy and the faculty from the universities and other institutions of higher learning and also acting by providing specialized training and advanced characterization facilities to University researchers; making facilities of DAE accessible to university researchers and to add a new concept of researchers in academic institutions working together. (http://www.csr.res.in/)

IIM's Library Consortia

This consortium is active at Indian Institute of Management (IIM) Library Consortium. The Indian Institute of Management (IIM) Library consortia is a e-content digital network system available at all the IIM over India. The resources related to IIM's curricula are available in this consortium (http://www.iimahd.ernet.in/library/vslib/consortia.htm).

DOAJ

DOAJ stands for the Directory of Open Access Journals. DOAJ essentially lists those journals which are available in open access to its access-or. It provides us with free, full text, quality controlled scientific and scholarly journals, covering all subjects and many languages and currently about 6568 journals are available in DOAJ out of which 2918 journals searchable at article level and contain 574391 articles. DOAJ is accessible. Currently DOAJ has 318 journals India. The agriculture section is having 340 open access from journals (http://www.doaj.org).

Open J-Gate

Open J-Gate is an electronic gateway to global journal literature in open access domain. It was launched in the year 2006. Open J-Gate is the contribution of Informatics (India) Ltd to promote open access initiative (OAI). Open J-Gate provides seamless access to millions of journal articles available online. Open J-Gate is also a database of journal literature, indexed from 8701 open access journals, with links to full text at publisher sites (http://www.openj-gate.com/).

World Bank eLibrary

The World Bank eLibrary is the World Bank's subscription-based collection of nearly 6,000 books, reports, journals, and working papers. eLibrary contains only the final, peer-reviewed versions of the bank's formal publications. eLibrary is designed to meet the needs of the library, academic and research community. Its value lies in the quality and convenience of its publications database. Each article, book, and working paper is enriched with semantic and bibliographic metadata, including topics, regions, countries, abstracts and keywords using a controlled vocabulary (http://elibrary.worldbank.org).

Cambridge University Press

The Cambridge University Press journals can be accessed at http://journals.cambridge.org/. The Cambridge University Press is currently publishing about 250 peer-reviewed academic journals which are easily accessed online. The dedication of Cambridge University Press is to advancing knowledge. Apart from all other subject field the press publishes journals from Agriculture, Science & Technology and physical sciences (http://journals.cambridge.org).

Emerald

Emerald is a leading independent publisher of global research with impact in business, management society, public policy and education. Emerald publishes about 200 journals. Emerald is fully searchable and available online, the user can view the information needed whenever and wherever (http://www.emeraldinsight.com/).

Project Euclid

Mathematics and statistics are integral part of agricultural sciences. All research work is incomplete without mathematics and statistical analysis. Project Euclid has full-text searching, reference linking, interoperability through the Open Archives Initiative (OAI), and long-term retention of data are all important components of the Project Euclid. About 63 important journals are published in under this project (http://www.projecteuclid.org/).

Project Muse

Project Muse is a unique collaboration between libraries and publishers, providing 100% full-text, affordable and user-friendly online access to a comprehensive selection of prestigious humanities and social sciences journals. Heavily indexed and peer-reviewed journals are available for access. Currently, Muse provides full-text access to current content from over 482 titles representing nearly 100 not-for-profit publishers. Project Muse's mission is to excel in the broad dissemination of high-quality scholarly content. Through innovation and collaborative development, Project MUSE anticipates the needs of and delivers essential resources to all members of the scholarly community (http://www.muse.jhu.edu/journals/)

CSIRO publishing

CSIRO publishing is Australia´s Commonwealth Scientific and Industrial Research Organization. CSIRO publishing operates as an independent science and technology publisher with a global reputation for quality products and services. It is internationally recognized publishing programme covers a wide range of scientific disciplines, including agriculture, the plant and animal sciences, and environmental management. CSIRO publishing publishes journals, books and magazines. The contents CSIRO publishing are available as print and online. (http://www.publish.csiro.au)

Portland press

Portland press is a leading provider of high quality publishing and knowledge dissemination solutions. The available journals can be accessed at http://www.portlandpress.com/pp/. Portland press is a not-for-profit publisher of various journals and books. About 12 peer reviewed journals in the field of biosciences, biochemistry and cell biology are published by Portland press currently (http://www.portlandpress.com).

Oxford University Press

Oxford Journals are published by Oxford University Press, Currently about 230 academic and research journals are published covering a broad range of subject areas, two-thirds of which are published in collaboration with learned societies and other international organizations. The mission of Oxford Journals (Oxford University Press) is to bring the highest quality research to the widest possible audience (http://www.oxfordjournals.org/).

J-STOR

JSTOR is a not–for–profit service that helps scholars, researchers, and students discover, use, and build upon a wide range of content in a trusted digital archive of over one thousand academic journals and other scholarly content. Currently JSTOR is regarded one of the world's most trusted sources for academic content (http://www.jstor.org/).

Medknow

Medknow publications is a publisher for peer-reviewed, online and print+online journals in the area of science, technology and medicine. Medknow is the largest open access publisher publishing on behalf of learned societies and associations. It pioneers and follows in 'fee-less-free' model of open access publishing and provides immediate free access to the electronic editions of the journals. It has more than 135 print+online journals. More than 50,000 manuscripts are available on the Medknow website database (http://www.medknow.com/).

Taylor & Francis

The Taylor & Francis Group publishes more than 1,500 journals and around 1,800 new books each year, with a books backlist in excess of 20,000 specialist titles. The Taylor & Francis Group are providers of quality information and knowledge that enable users to perform their jobs efficiently, continue their education, and help contribute to the advancement of their chosen markets. The users of Taylor & Francis Group are researchers, students, academics and increasingly professionals. Taylor & Francis Group is an Informa business (http://www.informa.com). Informa plc is the global information provider for the academic, professional and commercial markets around the whole world. (http://www.taylorandfrancisgroup.com/).

Springer

Springer is one of the topmost publishers and provide throughout the world scientific and professional communities with superior specialist information. Springer has an history of 165 years publishing. Springer a leading global scientific publisher, delivering quality content through innovative information products and services. Springer eBook Collection has more than 45,000 titles. The product range across all media for high-quality content (books, journals, newsletters, CD-ROMs, online platforms, protocols, databases and conferences). Springer has some 2,000 journals and more than 7,000 new book titles every year. The main publishing fields are science, technology, medicine, business, transport and architecture (http://www.springer.com).

Bentham Science Publishers

Bentham Science Publishers is a major STM journal publisher of 106 online and print journals and related print/online book series, Bentham Science answers the informational needs of the pharmaceutical, biomedical and medical research community. Bentham open publish over 230 peer-reviewed open access journals. These free-to-view online journals cover all major disciplines of science, technology, medicine and social sciences (http://www.benthamscience.com/).

EBSCOhost

EBSCOhost, the most-used premium research service in libraries and other institutions worldwide, EBSCO offers a suite of more than 300 full-texts and secondary research databases covering all subject areas, levels of research, and user communities EBSCOhost Electronic Journals Service (EJS) is the gateway to thousands of e-journals containing millions of articles from hundreds of different publishers (http://www.ebscohost.com/)

National Agricultural Library

The US Department of Agriculture's National Agricultural Library (NAL) is the world's largest and most accessible research library focused on agriculture. NAL serves the world with information germane to agriculture and its related sciences. Many of the Library's services and information resources are available to customers worldwide via the NAL website. NAL collections contain nearly 4 million items. The Library subscribes to more than 16,000 current periodicals, and has access to nearly 4,500 journals and newspapers in electronic formats, as well as about 50 other specialized electronic resources. These NAL resources provide access to billions of pages of information and data covering all aspects of agriculture and its related sciences, dating from the 16th century to the present, an immense array of scientific literature, books and journals, audiovisuals, reports, theses, software, laser discs, artifacts, and images in agriculture are available (http://

www.nal.usda.gov).

NOPR

NOPR stands for, NISCAIR online periodicals repository, NISCAIR (National Institute of Science Communication and Information Resources) hosts online its research journals in NOPR. In all 17 research journals are available under open access mode for accessing the full text. Research communities including students not only in India but all over the world are being benefited by open access of NISCAIR journals. It helps in enhancing the accessibility and visibility base of NISCAIR journals at National and International level. Current issues of all the research journals are published in NOPR for open access well before the publication of print version. The repository has data spanning from 2007 till current issues and for some journals from 2002 onwards. At present the repository has about 6400 articles (http://nopr.niscair.res.in)

Wiley Online Library

Wiley Online Library hosts the world's broadest and deepest multidisciplinary collection of online resources covering life, health and physical sciences, social science, and the humanities. It delivers seamless integrated access to over 4 million articles from 1500 journals, almost 10,000 online books, and hundreds of reference works, laboratory protocols and databases. The main feature are a clean and simple interface, this online service delivers intuitive navigation, enhanced discoverability, expanded functionalities and a range of personalization and alerting options (http://www.wiley.com/).

Thieme

Thieme is an award-winning international medical and science publisher serving health professionals and students for more than 125 years. Thieme promotes the latest advancements in clinical practice, publishes the latest research findings, advocates medical education and is known for the high quality and didactic nature of its books, journals, and electronic products. In addition to publishing 70 new book titles every year, Thieme publishes more than 130 medical and scientific journals both in traditional print and electronic format, a number of which are printed on behalf of professional societies, as well as dozens of online products. Thieme still stands apart from its competitors by emphasizing high standards of quality in content and presentation in all of its products. (http://www.thieme.com/)

Compendex

Compendex is one of the most comprehensive engineering literature databases. With over 13 million records across 190 engineering disciplines, Compendex delivers the comprehensive, precise information and insights that researchers need. Compendex is available on Engineering Village, users get results that are consistently accurate. (http://www.ei.org/compendex)

Elsevier BIOBASE

Elsevier BIOBASE is a bibliographic current awareness database providing comprehensive coverage of the entire spectrum of biological research worldwide. Elsevier BIOBASE enables pure and applied scientists to keep up-to-date with literature published in their subject area by providing a subject categorized listing of titles, authors, abstracts, bibliographic details and authors' addresses. Elsevier BIOBASE has a unique, comprehensive classification scheme. Titles are presented under appropriate subject headings, to provide information which is accurate and relevant to the respective person's area of activity/research (www.elsevier.com/wps/product/cws_home/600715).

Embase

Embase is the most comprehensive online source of biomedical answers. With over 20 million records from more than 7,000 active authoritative journals, with Embase your research needs are fully met. Holding over 1,800 biomedical titles not offered by Medline, Embase delivers comprehensive, authoritative, reliable coverage of the most relevant biomedical literature. Embase is supported by unique life science thesaurus Emtree. Comprehensive and polyhierarchically structured, Emtree provides a consistent description of all biomedical terminology, allowing unrivaled drug and disease indexing and retrieval (http://www.embase.com).

Ei EnCompass

The Ei EnCompass Databases aim to meet the information needs of industries by providing timely,

comprehensive, and reliable access to worldwide technical literature, patents, and business and economic views. With access to over 1.5 million selections, the EnCompass database is the premier international information source for the petroleum, petrochemical, downstream, natural gas and energy industries. Providing timely as well as technical literature dating from 1942 and patents from 1963, Ei EnCompass provides historical technical literature, patent information, technology applications, and business news and market intelligence. All information is easily found because of precision searching based on a controlled vocabulary. (http://www.ei.org/encompasslit_pat)

AGRICOLA

AGRICOLA (AGRICultural OnLine Access) is a database created and maintained by the United States Department of Agriculture. The database serves as the catalog and index for the collections of the United States National Agricultural Library, but it also provides public access to information on agriculture and allied fields. AGRICOLA indexes a wide variety of publications covering agriculture and its allied fields, including, animal and veterinary sciences, entomology, plant sciences, forestry, aquaculture and fisheries, farming and farming systems, agricultural economics, extension and education, food and human nutrition, and earth and environmental sciences. Tens of thousands of AGRICOLA records contain links to full-text resources on the web encompassing all aspects of agriculture and allied disciplines and covering materials in all formats. (http://en.wikipedia.org/wiki/AGRICOLA and (http://www.agricola.nal.usda.gov/)

AGRIS

It is International System for Agricultural Science and Technology. AGRIS is a global public domain database with 2644818 structured bibliographical records on agricultural science and technology. 82.09% of records are citations from scientific journals. This database is maintained by FAO, and its content is provided by more than 150 participating institutions from 65 countries. AGRIS allows scientists, researchers and students to perform sophisticated searches using keywords from the AGROVOC thesaurus, specific journal titles or names of countries, institutions, and authors. The bibliographic references contain either links to the full text of the publication or additional information retrieved from related Internet resources (http://agris.fao.org/ and http://en.wikipedia.org/wiki/AGRIS).

ScienceDirect

ScienceDirect is one of the leading full-text scientific database offering journal articles and book chapters from more than 2,500 peer-reviewed journals and more than 11,000 books. There are currently more than 9.5 million articles/chapters, a content base that is growing at a rate of almost 0.5 million additions per year. The platform offers sophisticated search and retrieval functionality that enables the user to maximize the effectiveness of their knowledge discovery process. New tools available in the website facilitate research work flow aids such as access to content at an early publication stage and efficient multiple document downloading of content that can be stored, printed and passed to colleagues(http://www.sciencedirect.com/).

Web of Science

Web of Science ® provides researchers, administrators, faculty, and students with quick, powerful access to the world's leading citation databases. Authoritative, multidisciplinary content covers over 10,000 of the highest impact journals worldwide, including Open Access journals and over 110,000 conference proceedings. You'll find current and retrospective coverage in the sciences, social sciences, arts, and humanities, with coverage available to 1900. Overcome information overload and focus on essential data across 256 disciplines (http://www.isiwebofknowledge.com)

PMN Plant Science Database

The PMN Plant Science Database accesses thousands of indexed, web-based resources, including all articles published in PMN journals, as well as fact sheets, newsletters, product listings, training materials, and other resources hosted at PMN's university, industry, and non-profit partner sites. PMN's basic Public Search function is available to all users. The Public Search locates all items in the Plant Science Database but does not allow for refined searches. (http://www.plantmanagementnetwork.org/).

SciFinder

SciFinder is a research discovery tool that allows college students and faculty to access a wide diversity of research from many scientific disciplines, including biomedical sciences, chemistry, engineering, materials science, agricultural science, and more. With a single source, you can explore scientific information in journal and patent literature from around the world, as well as reputable web sources References from more than 10,000 currently published journals and patents from more than 61 patent authorities' important scientific discoveries from the present to the mid-1800s. (https://scifinder.cas.org/.)

Conclusion

To support experimental research findings relevant reference literature is required and to obtain such suitable previously published results and findings we should be very particular towards what is to be searched, how its is to be searched and from where it is to be searched. The searches should be aimed for obtaining quick results that are genuine, precise, correct and feasible to support experimental research findings. Weakness should be recognized by us and we should always be ready to learn from bodies performing better than us. We should be engrossing new technologies at all levels and should be ready to adopt innovations for creating sustained differentiation in the learned society.

Acknowledgements

The electronic information resources mentioned in the manuscript have been collected and compiled by the authors to make the staff and students aware of the available resources. The authors thank the respective websites and their owners from where the content has been drawn for non commercial and nonprofit use. The authors also thank Indian Council of Agricultural Research (ICAR), National Information Centre (NIC) for giving VSAT connectivity and BSNL-(National Knowledge Network) NKN service for uninterrupted and timely access of websites of publishing houses.

यह शोधपत्र कृषि अनुसंधान एवं अन्वेशण से संबंधित सूचनाएँ एवं जानकारियों के इलेक्ट्रॉनिक उपलब्धता के बारे में है । पुस्तकालयों में इन्टरनेट के आगमन से पुस्तकालय उपयोगकर्ता को संसाधन उपलब्ध कराने की क्षमता में असाधरण विकास हुआ है । वर्तमान समय में संगण्क/परिकलक प्रौद्योगिकी और इलेक्ट्रॉनिक विकास के कारण पुस्तकालय सेवाऐं अग्रिम पंक्ति में आ गई हैं । यह शोधपत्र शिक्षक, शिक्षाविदों, वैज्ञानिकों एवं छात्रों को इन्टरनेट पर उपलब्ध विभिन्न शोध प्रकाशन संस्थाओं/संगठनों के बारे में संक्षिप्त विवरण के साथ उनकी जानकारी उपलब्ध कराता है, जिससे जानकारीयों के स्रोतों एवं उनके एकत्रीकरण में मदद मिलती है ।

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Authorship distinctiveness of research papers dealing with agriculture and allied subjects published in JNKVV Research Journal

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Abstract

In the academic world publication of manuscripts in scholarly journals is a matter of repute, reward and also a prepare for getting recognition, gaining reputation, career advancement and for promotional hierarchy. A total of 51 papers including 7 short communications were published in the year 2009 in JNKVV Research Journal. JNKVV Research Journal volume 43, number 1 and 2 contributed towards the result of this study. An analysis of authorship characteristics like gender, status affiliation, rank etc and authorship trend in the present journal were analyzed. The results indicate male dominance in publication of research papers. The tendency of multiple authorship is on the rise and a combination of three authors published maximum papers. Authors of Jabalpur published maximum number of research papers. Madhya Pradesh was the most productive state in terms of paper productivity. The degree of collaboration worked out to be 0.960. Maximum numbers of authors were from Department of Plant Breeding and Genetics

Keywords: author, authorship, JNKVV research journal, research

The authorship of any scientific publication is based on personal effort of author/authors and their research, innovativeness, creativity and originality. Readers often look for authenticity, novelty, knowledge, accuracy and recentness, whereas journal paper, authorship comprises for author's responsibility and accountability of manuscript. Scientific journals are the means by which the scientific community certifies accumulations and additions to its body of accepted knowledge and the means through which scholars are competing (Hargens 1988 and Merton 1957). Measurement of research excellence and quality is an issue that has increasingly interested governments, universities and funding bodies as a measure of accountability and quality sought (Steele et al. 2006). Publication is at the heart of academia, working in whatever field we do, researching without publishing our findings or even our perspectives and thoughts on our discipline is against the public interest, there is quite properly an increasing pressure on academics in all parts of the world to publish (Florence 2008). Scientific productivity is generally measured in terms of the published output. One of the most fundamental norms of science for scientists is to promulgate their research findings among their peers (Gupta et al. 1999). Also according to Karisiddappa et al. (2002) the scientific productivity of authors in the context of R&D is normally measured in terms of their published scientific output (research papers, reports, books and monographs) and technical output (patents, processes, innovations, etc.).

One way of determining how knowledge is transferred and used in science is by studying the literature published in the discipline, especially articles published in journals (Sanni and Zainab 2010). Scientists are not only expected to develop knowledge; they are also required to share the knowledge they develop with other members of peer communities through formal sources in order to be considered to have contributed to knowledge (Mengxiong 1993). Work is valuable, because it provides an opportunity to understand the breadth and depth of inquiry in our discipline (Brunn 1992). Also the evaluation of the scientific performance of individual researchers is mainly based on the analysis of the publication record (Schoonbaert and Roelants 1996). According to Loannidis (2008) the future of single scientists, teams and large institutions increasingly depends on ''publish-or-perish'' (or ''get-cited-or-perish'') principles.

JNKVV research journal is a multidisciplinary agricultural journal publishing in the field of agriculture, forestry, agricultural engineering, veterinary science and animal husbandry. It is an official publication of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh (MP) India. The first issue of the journal was published in the year 1967. At that time the journal was published as quarterly. At present the journal is published biannually, i.e two issues per year. Currently the journal is being abstracted in CAB international abstracting system, Biological Abstracts and Indian Science Abstracts.

Material and methods

Papers required for the present study have been taken from the published issue of JNKVV research journal, volume 43, number 1 and 2, year 2009. The study is conducted on 51 research papers. The main authorship characteristics of authors like name, gender, affiliation, designation hierarchy etc were obtained and then compiled and analyzed for generating result. The degree of collaboration was worked out using the formula given by Subramanyam (1983).

$$D_c = N_m \div (N_m + N_s)$$

Where N_m = number of multi-authored papers and N_s = number of single authored papers

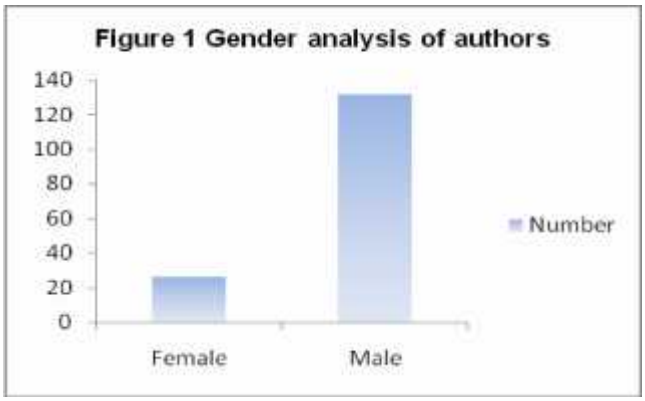
Result and Discussion

The findings of the present work are elaborated here

Author's gender

The main problem bibliometric studies have to face is how to identify male and female authors, since sex is not included in bibliographic databases. (Mauleón and Bordons 2006). Identification was also difficult since in India gender is normally identified by first name and not by surname and in most of the research papers though surname is present but first name is usually absent or only alphabets are designated in place of full names. Since the Journal is published from, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur MP, identification of gender was done on personal basis.

Each paper is considered as an individual separate publication and the data presented in table 1



reveals that out of the total of 158 authors 26 (16.455%) were female and 132 (83.544%) were male. It is of clear evidence that male authors far outnumber the female authors; this may be attributed to the fact that number of female researchers is less as compared to male researchers. There is a growing concern in the most advanced countries about women and science issues and, more specifically, about the under-representation of women in scientific careers (Mauleón and Bordons 2006).

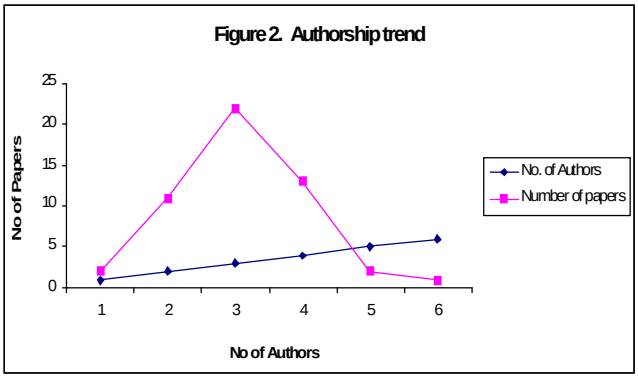
Table 1. Gender of authors

Author Gender	Number	Percentage (%)
Female	26	16.455
Male	132	83.544
Total	158	100

The number of male authors far outnumbers female authors also according to European Commission (2006) it was found that women constituted only just over one third of the researchers in academic medicine, agricultural sciences, social sciences and humanities

Authorship trend

Literature on any subject reflects not only basic publishing pattern but also the characteristics of the authors themselves (Kannappanavar and Vijaykumar 2001). Ownership and authorship determine how intentionality and self knowledge are ascribed, these ascriptions, in turn, have implications for individual and societal attitudes towards those subjects whose behaviour cannot be described in intentional terms (Bortolotti and Broome, 2009). Table 2 indicates visibly that three authors claim maximum percentage (22) (43.137%) of paper followed by four authored paper 13 (25.490%). Two authored papers (11) also claimed 21.56% authorship. Single authored, five authored and six authored papers gained



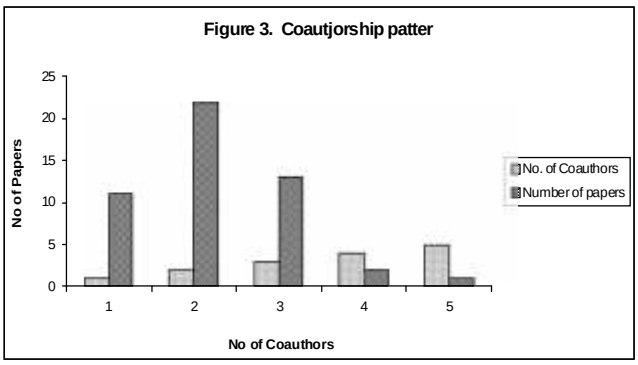
the last scores of 2 (3.922%), 2 (3.922%) and 1 (1.961%) respectively. From the above result it is clear that three, four and two authored form the most preferred type of authorship group, which also indicates teamwork. On seeing the data it becomes well established fact that multi authored papers (96.079%) far outnumber the single authored papers (3.922%).

Table 2. Authorship trend

No. of Authors	Number of papers	Cumulative total	Percentage (%)
Sole/One	2	2	3.922
Two	11	13	21.569
Three	22	35	43.137
Four	13	48	25.490
Five	2	50	3.922
Six	1	51	1.961
Total	51	51	100.00

Co-authorship

Multi-authored documents are now the norm in science as a result of the important role of collaboration in

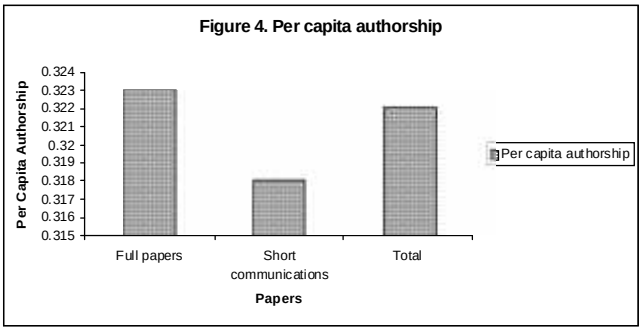


research (Bordons and Go´mez 2000; Hara et al. 2003). Due to the increasing complexity of research, teamwork and inter-scientist collaboration have become essential for the advancement of science, scientists with different skills and specialization profiles may successfully collaborate for the development of research projects and the creation of new knowledge (Costas and Bordons 2011). Number of authors is used as a straight forward variable to reflect co-authorship (Sutter and Kocher 2004).

Table 3. Co-authorship trend

No. of Coauthors	Number of Coauthors	Cumulative total	Percentage (%)
One	11	11	22.448
Two	22	33	44.897
Three	13	46	26.53
Four	2	48	4.081
Five	1	49	2.040
Total	49	49	100

Research is rarely done in isolation, especially research of an experimental rather than a theoretical bent (Fox



1991. The current trend as depicted in table 3 shows that taking coauthors in a paper is increasing one coauthor 11 (22.448%) per paper to two coauthors 22 (44.897%) and three coauthors 13 (26.53%). Taking two coauthors was the most preferred group. Taking four or more coauthors showed a decreasing trend as far as JNKVV Research Journal is concerned. From the data it can be enlightened that small group of upto four authors are able to generate publishable research findings, which show that there is an inclination towards collaborative research.

Per capita authorship

It was found that a total of 51 research papers were published by 158 authors during the publication year 2009.

Table 4. Per capita authorship

Type	No. of paper	Number of authors	Per capita authorship
Full papers	44	136	0.323
Short communications	7	22	0.318
Total	51	158	0.322

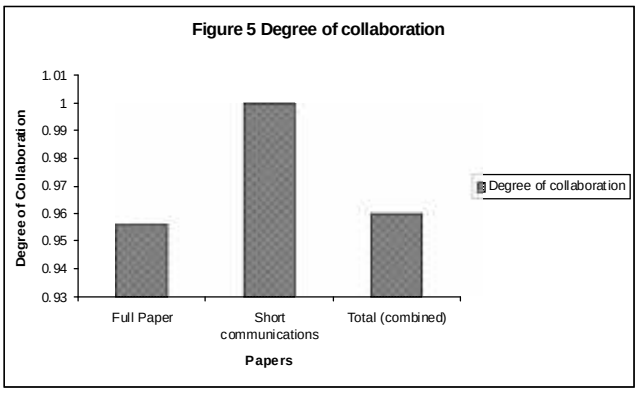
The per capita authorship is calculated as:

Per capita authorship = Number of papers ÷ number of authors

The data pertaining to per capita authorship is presented in table 4 and graphically represented through figure 4. The overall per capita authorship works out to 0.322. The per capita authorship for full research papers is 0.323 and in case of short communications the per capita authorship is calculated to be 0.318. The results indicate that there is more collaborative and multidisciplinary research trend existence.

Degree of Collaboration

In the issue under evaluation only two type of papers were published i.e. either full papers or short communication. Scientific collaboration can be defined as " a process of functional interdependence between scholars in their attempt to coordinate skills, tools, and rewards" (Patel 1972).The data presented in the table 5 clearly shows very high degree of collaboration in the research papers published. The degree of collaboration was more (1.00) in short communications as compared to full papers (0.956). If total publication were compared then the degree of collaboration was 0.960 (Fig 5).



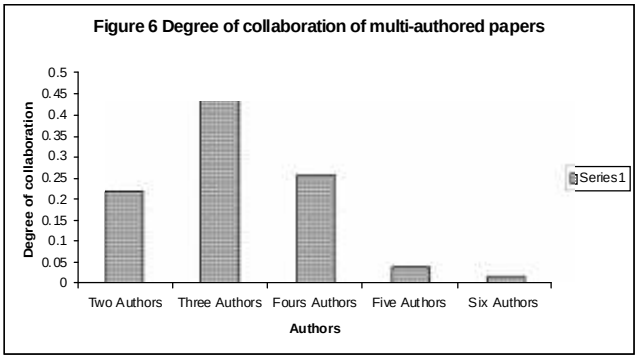


Table 5. Degree of collaboration

Type	Degree of collaboration
Full Paper	0.956
Short communications	1.00
Total	0.960

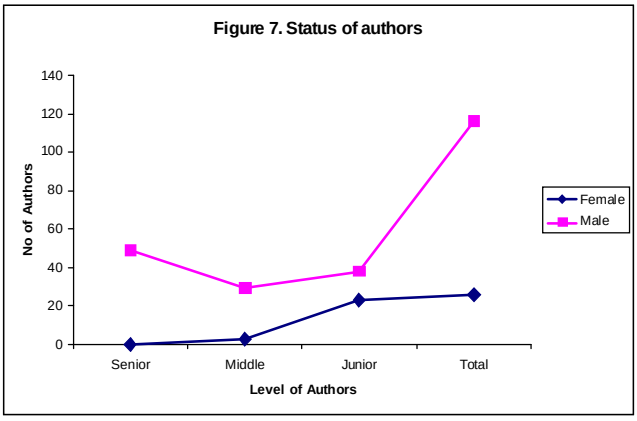
Table 6 signify that degree of collaboration among two, three, four, five and six authors was 0.215, 0.431, 0.254, 0.039, and 0.019 respectively which infers that as the number of author's increases degree of collaboration decreases.

Table 6. Degree of collaboration of multi-authored papers

DC (two-A)	DC (three-A)	DC (four-A)	DC (five-A)	DC (six-A)
0.215	0.431	0.254	0.039	0.019

DC= Degree of collaboration, A= Author

Status of Author



The status of the authors was analyzed; three categories were formed regarding the authorship status senior, middle and junior. The data presented in table 7 clearly shows that no female author exists in the senior category and only 3 female authors were present in the middle

category, followed by 23 authors in the junior category. On the other hand in total there were 132 male authors out of which the status of 16 authors could not be determined. Out of 116 authors 49 authors were of senior category 29 were of middle category and 38 were from junior level.

From the table it can be inferred that no female authors were from senior level but the trend is increasing as more females at junior level are publishing their research findings in journal, in contrast we see that more males are available as senior authors as compared to middle and junior level.

Table 7. Status of Author

Status	Senior	Middle	Junior	Total	Total Percentage (%)
Female	0	3	23	26	18.309
Male	49	29	38	116	81.690
Total	49	32	61	142	100

Analysis of Title

Every research paper has a suitable title provided by its authors. A title is a short summary that represents documents main theme, a title is a compact representation of a document which contains documents main theme, so that the reader can quickly identify the information that is of interest to them (Reddy et al. 2011).

The data related to analysis of title words is presented in Table 8, shows that there are words in title which are repeated and used in many different titles in JNKVV Research Journal; the frequency of use is given in the table. In all agriculturally important 293 words were identified in the title out of which 160 words were used as singly, 25 words were used two times, 5 words were used three times, 2 words were used four times, 4 words were used 5 times, another 4 words were used 6 times and 1 words was used for 7 and 9 times respectively. Although the words used singly and in double are not mentioned here due to paucity of space, but the ones which are repeated more are mentioned here, The words Madhya Pradesh (MP) and the words chickpea was repeated 9 and 7 times respectively in the title followed by the title words nutrient, production, quality and yield which were repeated 6 times each. The words crop, India, rice and soybean were repeated 5 times each whereas the words Jabalpur and seed were repeated 4 times each. The title words genotypes, irrigation, productivity, rainfed and wheat were repeated 3 times each.

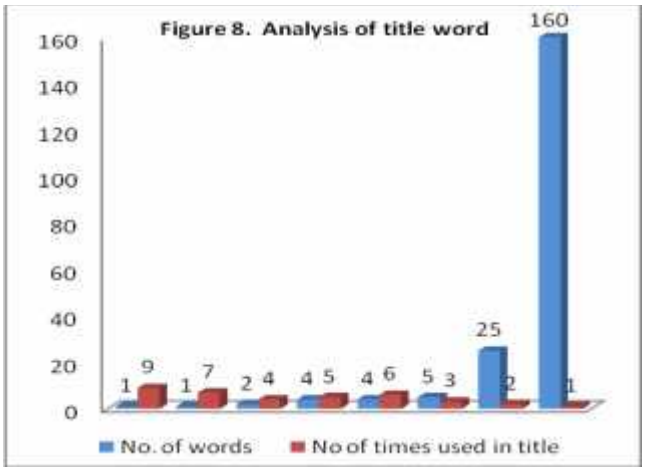
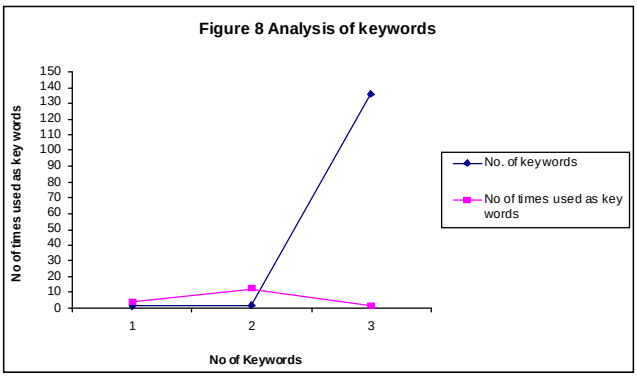


Table 8. Analysis of title

No. of words	No of times used in title	Total	Percentage (%)
1	9	9	3.072
1	7	7	2.389
2	4	8	2.730
4	5	20	6.826
4	6	24	8.191
5	3	15	5.119
25	2	50	17.065
160	1	160	54.608
	Total	293	100

The data clearly indicates that more work was done on chickpea, soybean, rice and wheat crops since these title words are repeatedly used in the title of research paper. Madhya Pradesh is also known as soybean state, ranks in pulse production and rice wheat is the predominant cropping system of the state. The journal is being published under JNKVV so most of the work is based in Madhya Pradesh (9) and it was the most used title word.



Analysis of keywords

Keyword analysis is a bibliometric approach which is used widely for profiling a field (Chiu and Ho 2007; McGrath 1996). It can also be used for predicting the trend of a field (Li et al. 2009; Yi and Xi 2008). As per data depicted in table 8 a total of 164 keywords were available to the users, in the two issues/number of JNKVV Research Journal, issue/number 1 had 90 key words whereas issue/number 2 had 74 keywords. Seven short communications did not have any key words. Also two full length papers did not provided their articles with keyword. Keywords were also not present in short communication. It is very clear from the findings that the one keyword soybean was repeated 4 times whereas twelve keywords were repeated 2 times each remaining 136 key words were used only once in keyword compilation. On analyzing the keywords crop-wise we see that papers on only 16 crops (Berseem, Chickpea, Garlic, Karonda, Lemon Grass, Lentil, Mango, Niger, Oat, Pigeon pea, Potato, Rice, Sesame, Sorghum, Soybean and wheat) including agriculture, horticulture and medicinal and aromatic plants were published. Maximum work according of keywords (keyword combination) was done in wheat crop (5) followed by soybean (4) and rice (2). Keywords are an essential part of research paper; it provides us with an overview we expect that might be available in the research paper.

Publication page preference

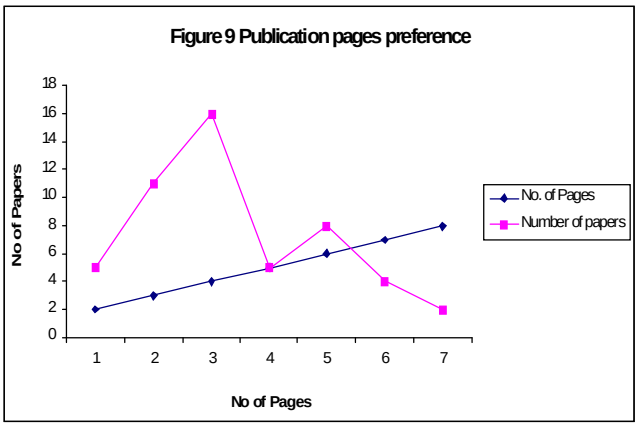


Table 8. Analysis of keywords

No. of key words	No of times used as key words	Total	Percentage
1	4	4	2.439
2	12	24	14.634
1	136	136	82.926
	Total	164	100

Every published research finding is accumulated in certain volume of printed pages. Every journal publishes papers and the numbers of published papers indicate the mindset of authors who confine their research findings to certain number of paper, the table 9 indicates the liking of authors towards publishing number of pages. The data clearly indicates that four printed pages had 16 (31.372%) papers followed by three pages, 11 (21.568%) papers which were the most preferred page choices, while few authors went to publish six pages 8 (15.68%) papers followed by two 5 (9.803%) papers and five pages 5 (9.803%) papers. There were only four papers having seven pages (7.843%) and two papers having eight pages (3.921%). It can be inferred that authors generally tend to confine their research findings in between 3 to 4 printed pages.

Table 9. Publication page preference

No. of pages	Number of papers	Cumulative total total	Percentage (%)
2	5	5	9.803
3	11	16	21.568
4	16	32	31.372
5	5	37	9.803
6	8	45	15.68
7	4	49	7.843
8	2	51	3.921
Total	51	51	100.00

Number of References

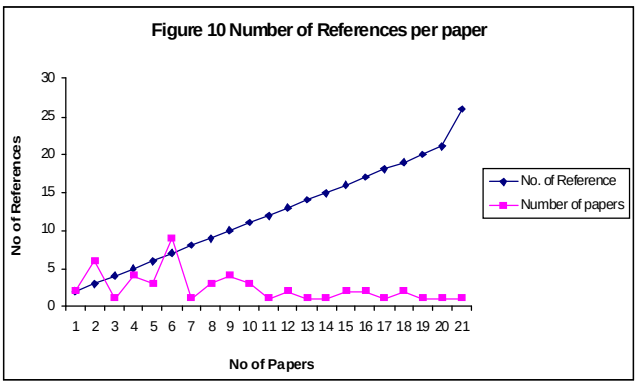


Table 10 summarizes the number of references cited in each paper, on evaluation it was found that 7 was the most cited reference number about 9 papers (17.647%) have quoted it followed by 3 reference which has been quoted in 6 papers (11.765) followed by 10 and 5 references each quoted by 4 papers (7.843%). Highest number of references i.e 26 and were cited by 1 review paper and least number of references quoted was 2

which was cited in 2 papers (3.922%).

Table 10. Number of references

No. of reference	Number of papers	Cumulative total	Percentage (%)
2	2	2	3.922
3	6	8	11.765
4	1	9	1.961
5	4	13	7.843
6	3	16	5.882
7	9	25	17.647
8	1	26	1.961
9	3	29	5.882
10	4	33	7.843
11	3	36	5.882
12	1	37	1.961
13	2	39	3.922
14	1	40	1.961
15	1	41	1.961
16	2	43	3.922
17	2	45	3.922
18	1	46	1.961
19	2	48	3.922
20	1	49	1.961
21	1	50	1.961
26	1	51	1.961
Total	51	51	100.000

Cross reference analysis (single authored references vs multi authored references)

A total of 261 references were present in volume 43 number 1 and 222 references were present in number 2. Overall in both the issues/number a total of 483 references were present. It is evident from Table 11, Fig. 11 that multi authored references surpassed single authored references, only 118 (2.443%) references were single as compared to multi authored references which were 364 (75.556%). This shows that tendency of authors towards multi authorship in rising.

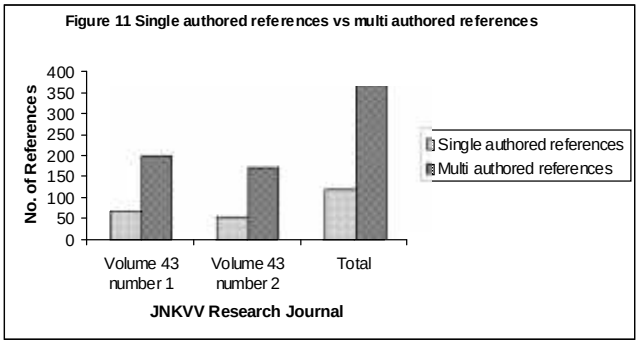
Table 11. Single authored references vs multi authored references

Issue	Single authored references	Percent age (%)	Multi authored references	Percent age (%)	Total number of references
Vol. 43 No.1	65	24.904	196	75.095	261
Vo. 43 No.1	53	23.873	169	76.126	222
Total	118	2.443	365	75.556	483

Departmental affiliation of author

Annual assessment of scientists, academicians and researchers is always done on the basis their contribution to knowledge judged by their volume of publication in journals. As stated earlier JNKVV Research Journal is an open for all multidisciplinary agricultural research journal. All individuals serving agriculture sector either directly or indirectly with laudable finding can publish his/her work in JNKVV Research Journal. Table 12, Fig 12 indicates the affiliation of authors with respect to their field/department of work.

In all a total of thirty seven author's affiliations were found published in the journal, the highest number of authors 19 (12.025%) were affiliated to Plant Breeding



and Genetics, followed by Extension Education JNKVV 18 (11.392%), Crop and Herbal Physiology 12 (7.595), Seed Technology Research Unit Rahuri 11 (6.962%) and Food Science and Technology 10 (6.329%). Soil Science and Agricultural Chemistry of JNKVV and Botany of Rahuri both had 8 (5.063%) authors affiliation followed by Agronomy 7 (4.430%) and AICRP sesame and Niger 6 (3.797%). The departments, Agricultural Chemistry and Soil Science Agra, Agricultural Economics and Farm Management, BTC JNKVV, Horticulture , Allahabad, Horticulture Pantnagar, KVK Jabalpur, KVK Rewa, Plant Pathology, Seed Pathology Laboratory Rahuri each had 3 (1.899%) authors affiliation

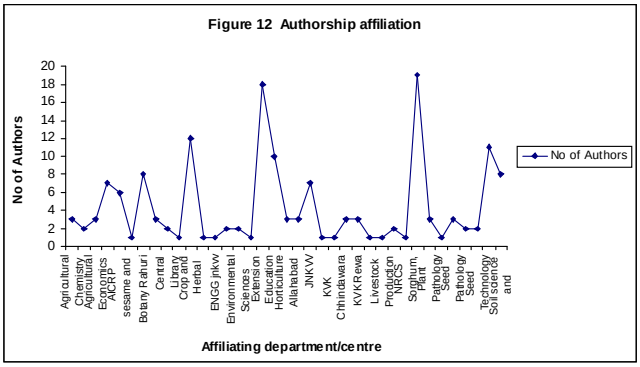


Table 12. Affiliation of authors

S.No.	Affiliation	No of Authors	Cumulative	Percentage
1.	Agricultural Chemistry and Soil Science, Agra	3	3	1.899
2.	Agricultural Economics, AAU, Anand	2	5	1.266
3.	Agricultural Economics and Farm management	3	8	1.899
4.	Agronomy	7	15	4.430
5.	AICRP Sesame and Niger	6	21	3.797
6.	Biochemistry	1	22	0.633
7.	Botany Rahuri	8	30	5.063
8.	BTC, JNKVV	3	33	1.899
9.	Central Library	2	35	1.266
10.	Chotu Ram PG College, Meerut	1	36	0.633
11.	Crop and Herbal Physiology	12	48	7.595
12.	DES, JNKVV	1	49	0.633
13.	Engineering, JNKVV	1	50	0.633
14.	Entomology	2	52	1.266
15.	Environmental Sciences Magadh University, Patna	2	54	1.266
16.	Extension Education, AAU, Gujarat	1	55	0.633
17.	Extension Education JNKVV	18	73	11.392
18.	Food Science and Technology	10	83	6.329
19.	Horticulture, Allahabad	3	86	1.899
20.	Horticulture, Pantnagar	3	89	1.899
21.	JNKVV	7	96	4.430
22.	JNKVV, Tikamgarh	1	97	0.633
23.	KVK, Chhindwara	1	98	0.633
24.	KVK, Jabalpur	3	101	1.899
25.	KVK, Rewa	3	104	1.899
26.	Livestock Farm, JNKVV	1	105	0.633
27.	Livestock Production, AAU, Gujarat	1	106	0.633
28.	MGCGVV, Chitrakoot	2	108	1.266
29.	Sorghum, Plant Breeding and Genetics (NRCS)	1	109	0.633
30.	Plant Breeding and Genetics	19	128	12.025
31.	Plant Pathology	3	131	1.899
32.	Post Harvest Process and Food Engineering	1	132	0.633
33.	Seed Pathology Laboratory, Rahuri	3	135	1.899
34.	Seed Research and Technology Centre, Hyderebad	2	137	1.266
35.	Seed Technology Centre, Faizabad	2	139	1.266
36.	Seed Technology Research Unit, Rahuri	11	150	6.962
37.	Soil Science and Agricultural Chemistry	8	158	5.063
	Total	158	158	100

(AAU – Anand Agricultural University, BTC Biotechnology Centre, JNKVV, Jawaharlal Nehru Krishi Vishwa Vidyalaya, DES Directorate of Extension Services, KVK Krishi Vikas Kendra, MGCGVV Mahatma Gandhi Chitrakoot Gramodaya Vishwa Vidyalaya, NRCS National Research Centre for Sorghum)

followed by departments Agricultural Economics AAU Anand, Central Library, Entomology, Environmental Sciences Magadh University Patna, MGCGVV Chitrakoot, Seed Research and Technology Centre Hyderabad, Seed Technology Centre Faizabad having 2 (1.266%) affiliations each. The departments Biochemistry, Chotu Ram PG College Meerut, DES JNKVV, Engineering JNKVV, Extension Education AAU Gujarat, JNKVV Tikamgarh, KVK Chhindawara, Livestock farm JNKVV, Livestock Production AAU Gujarat, NRCS Sorghum, Plant Breeding and Genetics, Post Harvest Process and Food Engineering each had only 1 (0.633%) author affiliation. The high percentage of authors from Plant Breeding and Genetics shows the dominance of the department in publishing their research findings.

City affiliation of authors

The data presented in the table 13 reveals that maximum number of authors were from Jabalpur 33 (56.897%) followed by Rahuri 7(12.069%). Other city affiliation of authors was 2 (3.448%) each from Anand, Chitrakoot,

Hyderabad and Tikamgarh. The number of papers was more from Jabalpur because Jabalpur is the headquarter of JNKVV and is having all facilities and also the journal is published from Jabalpur.

Table 13. City affiliation of authors

City	Occurrence	Cumulative	Percentage (%)
Agra	1	1	1.724
Allahabad	1	2	1.724
Anand	2	4	3.448
Chhindwara	1	5	1.724
Chitrakoot	2	7	3.448
Faizabad	1	8	1.724
Hyderabad	2	10	3.448
Indore	2	12	3.448
Jabalpur	33	45	56.897
Meerut	1	46	1.724
Pantnagar	1	47	1.724
Patna	1	48	1.724
Rahuri	7	55	12.069
Rewa	1	56	1.724
Tikamgarh	2	58	3.448
Total	58	58	100

State affiliation of authors

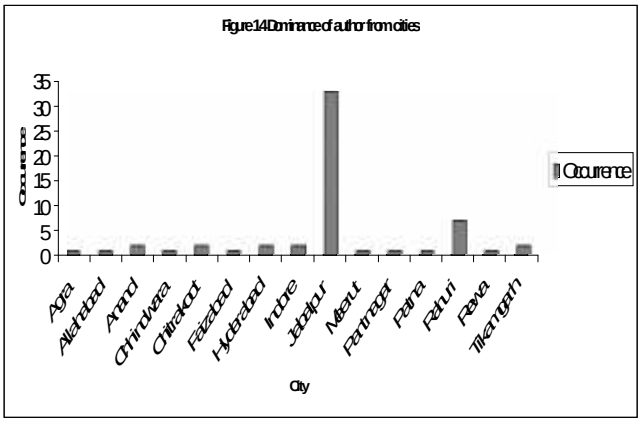
JNKVV Research Journal is an official and prestigious publication of Jawaharlal Nehru Krishi Vishwa Vidalaya, Jabalpur. Madhya Pradesh, India but it is open for all and any one devoted to research can publish the papers if it is found suitable by editor and reviewers. Our country is having many States and almost all States are having an Agriculture University and most of them are publishing their own journals. Still with the development of information and communication technologies and library exchange programme researchers get information about journals and opt to publish their research according to choice. The information presented portrays how JNKVV Research Journal is influencing authors from all over the country. The data presented in table 15 clearly shows the dominance of authors from Madhya Pradesh 42 (72.414%) followed by Maharashtra 7 (12.069%) and Uttar Pradesh 4 (6.897) and than by Andhra Pradesh and Gujarat with 2 (3.448) each.

Table 15. State affiliation of authors

State	Occurrence	Total	Percentage (%)
Andhra Pradesh	2	2	3.448
Bihar	1	3	1.724
Gujarat	2	5	3.448
Madhya Pradesh	42	47	72.414
Maharashtra	7	54	12.069
Uttar Pradesh	4	58	6.897
	Total	58	100.00

Ranking of Authors

Publication record of a scientist is representative of his/her scientific performance (Kostoff, 1998). The ranking of the authors according to JNKVV Research Journal 2009 is presented in table 16. It is very clear that 1 author contributed 5 papers followed by another author who published 4 papers there were two authors who published 3 papers each. Followed by 28 authors who are having 2 papers each to their credit. Lastly there were 87 authors whose name has occurred only once i.e. having 1 paper to their credit either as author or as coauthor. Dr. V.K. Mandhare has published 5 papers and holds the first rank followed by A.V. Suryawanshi whose name has occurred in 4 papers, followed by Dr. K.K. Saxena and Dr. S.B. Gawade whose name has occurred in 3 papers.



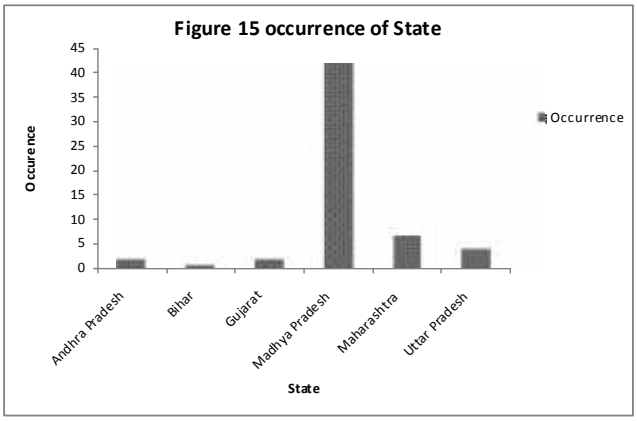


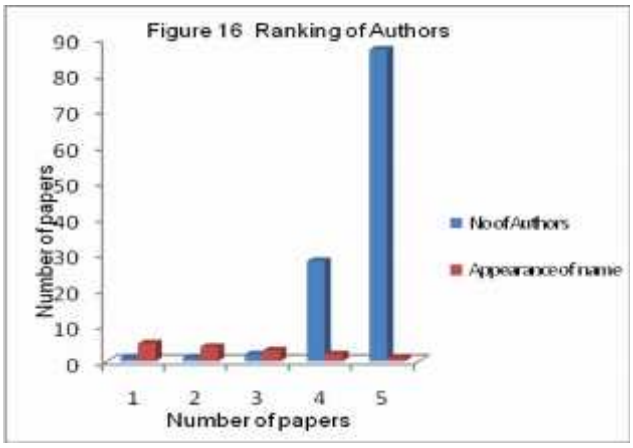
Table 16. Ranking of Authors

No of Authors	Appearance of Name in Papers
1	5
1	4
2	3
28	2
87	1

Findings

From the data presented the following inference is drawn

- The overall per capita authorship works out to 0.322.
- Majority of authors were male which shows predominance of male authors.
- The highest number of authors 19 (12.025%) were affiliated to Plant Breeding and Genetics
- For JNKVV Research Journal degree of collaboration was 0.960, which is very high and clearly indicates dominance upon sole authorship.
- Analysis of authorship trend reveals that three authors claim maximum percentage (43.137%) of paper (22) published.
- Taking two coauthors was the most preferred group i.e. taking per paper to two coauthors 22 (44.897%).
- Multi authored references surpassed single authored references; only 118 (24.481%) references were single as compared to multi authored references which were 364 (75.518%).
- Four printed pages 16 (31.372%) was the most preferred page number for getting the results published.
- 7 was the most cited reference number and 9 papers (17.647%) have quoted 7 references each.
- A total of 293 title words were identified and analysis of title word shows that 1 word was common to 9 research papers.
- 293 title words were identified and the title word Madhya Pradesh (MP) and the word chickpea was repeated 9 and 7 times respectively.
- 164 keywords were present and there was 1 word which was repeated 4 times as keywords.
- City affiliation shows that in terms of research paper productivity city Jabalpur produced 33 (56.897%) research papers, out of total 58 research papers.
- State affiliation shows that in state of Madhya Pradesh Jabalpur produced 42 (72.414%) research papers, out of total 58 research papers.



- The ranking of authors revealed that Dr. V.K. Mandhare published the maximum number of papers in the single volume and occupied the first place with 5 publications.

Conclusion

The current study portraits many important issues related JNKVV Research Journal which were not touched before. The study reflects the authorship choices and provides a platform for effective and efficient dissemination of researcher's findings. Advancement in science and technology is dependent upon the scientific work done and is brought in front of the public through publications. The prevailing trend shows that contribution to agricultural research is growing and more researchers are moving into it. Assessment has a key role if taken positively for further improvement and excellence of current journal. Efforts are needed to improve the way we promote and adopt research and research findings.

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