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Effect of sowing techniques, N and P levels on growth, yield and quality of rainfed rice (*Oryza sativa* L.) in Kymore Pleateau of Central India

S. P. Vishwakarma
Kulbhaskar Ashram P. G. College, Allahabad, Uttar Prdesh 211 001

ABSTRACT

A field study was conducted during kharif seasonsof year 1999 and 2000to assess the effect of sowing techniques, nitrogen, phosphorus levels and quality of rice on short duration rainfed rice (Oryza sativa L.). Maximum plant height, CGR and effective tillers per plant and number of spikelets were recorded in transplanting followed by lehi and least values were observed in direct seeding. It was also recorded the highest values of grain yield (28.67q ha^{-1}), straw yield (36.87 q ha^{-1}) and protein yield (2.8 q ha^{-1}) and maximum N and P uptake. Intermediate values of these characters were recorded with lehi and the lowest with direct seeding. The highest values of growth, yield attributes viz plant height, CGR, effective tillers, panicle length and spikelets were observed at the highest dose of N @ 120 Kg ha^{-1} and P @ 60 Kg P_2O_5 ha^{-1}. Maximum grain yield (28.6 q ha^{-1}), protein yield (3.03 q ha^{-1}) and N uptake (68.6 Kg ha^{-1}) and P uptake (10.96 q ha^{-1}) and net return (Rs. 6935 ha^{-1}) recorded with 120 Kg N ha^{-1}. While application of 60 Kg P_2O_5 ha^{-1} produced superior grain yield (27.33 q ha^{-1}), straw yield (38.32 q ha^{-1}), protein yield (2.67 q ha^{-1}) and N and P uptake. It also harvested maximum net returns (Rs 6076 ha^{-1}).

Key words:*Sowing technique, transplanting, crop growth rate, protein yield.*

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INTRODUCTION

Rice is the principal staple food of India and South Eastern Asia. It occupies about 31 percent area and 42 percent production of food crops of the country. A tremendous increase in rice production from 20.60 million tones (1950–51) to 104.80 million tonnes was done in 2014-15. The contribution of rainfed rice in above achievement cannot be overlooked because about 60 percent area of rice is still rainfed (8 to 10 million ha), which plays vital role and contribute about 55 percent in the production. In the rainfed area, the productivity is yet to be very low ranging from 0.5 to 1.5 tones/ha as compared with irrigated land, which is 4.0 to 5.0 tonnes/ha. Owing to this 80% area of rice is situated under high risk or ecologically handicapped ecosystems. The Kymore Plateau of Madhya Pradesh also comes under this ecosystem. Most of the area of this plateau is tribal dominated belt and rice occupied the prominent position among the field crops of this plateau. But due to unavailability of improved agricultural technology the productivity of this crop is still very low. Therefore, major thrust must be given to develop location specific suitable technology for such neglected areas, which may be helpful to achieve the national demand of rice 140 million tonnes which will be a major part of total food grains demand380 million tonnes by 2025 A.D. as against total present food grain production of 252.68 million tonnes (2015-16) to feed an estimated population of 1350 million rice consumers [1].

In Kymore region the farmers grow rice crop mostly in upland and medium low land situations, and usually adopt lehi method of seeding in which sprouted seeds of rice are

broadcasted in puddled fields.Transplanting method is also laborious, time consuming and causes drudgery to women folk. Hence, an alternative method is needed to overcome the problems encountered in the transplanting technique. Direct seeding and broadcasting of sprouted seeds under puddled conditions (lehi) are the viable alternative techniques for rice transplanting [2].
Nutrient management is by and large, most important resource affecting the production and productivity of rice. It isvery difficult for farmers to adopt the proper nutrients management scheduling and their appropriate application. Since, most of the farmers of these areas are tribal and poor, and they abruptly use only 20–30 kg N/ha, which is insufficient for paddy crop and create imbalances in soil nutrients and badly influence crop yield. The response of nitrogen and phosphorus under rainfed paddy varied from 40 to 120 kg N/ha and 30 to 80 kg P_2O_5/ha, respectively in different agro climatic situations as reported by Paikaray *et al.*, [7] and Lawal and Lawal [3].

MATERIALS AND METHODS

Paddy (*Oryza sativa* L.) an early maturing and semi-dwarf variety Govind was sown with three sowing methods, In direct seeding plots, dry seeds @50 Kg/ha^{-1} were sown in 15 cm rows at a maintained plant spacing of 10cm. to get optimum plant population. In lehi method seeds were soaked in water for three days. Soaked seeds were heaped on dry surface in shade to avoid cluster formation and covered with gunny bags. These seeds were uniformly broadcasted @ 50 Kg ha^{-1} in puddled plots. In transplanting, raised seedlings of 25 days old through wet bed method were transplanted manually at 20 x 15 cm apart. Thirty-six treatments comprised of direct seeding, lehi and transplanting in main plots, 0, 40, 80 and 120Kg N/ha in sub-plots and 0, 30 and 60 KgP_2O_5 /ha in sub-sub-plots were tested in split-split plot design with three replications. The main, sub and sub-sub plot sizes were maintained 21m x 13m, 10m x 6m and 6m x 3m, respectively.
Rice plants from each plot were sampled for growth analysis at 15 days intervals between 20 days, 65 days after sowing. The plant samples were oven-dried at $70^o \pm 1^o$ C till constant weight and dry weight was recorded. The soil of experiment site was sandy loam in texture and neutral in reaction (7.4), low in organic carbon (4%), available N (142.6 Kg ha^{-1}) and available P (12.2 Kg ha^{-1}), medium in available K (105.8 Kg ha^{-1}), high in available sulphur (13.3 Kg ha^{-1}). Paddy, wheat, gram, linseed and mustard are mainly grown on this soil.Nitrogen and phosphorus doses were applied as per treatment through urea and single super phosphate, respectively. A uniform dose of potassium @ 20 Kg K_2O ha^{-1} through muriate of potash (60% K_2O) and zinc sulphate (20% Zn) @ 25Kg ha^{-1} were incorporated.
Crop growth rate (CGR) the increase in dry weight per unit ground area of crop in a unit time, was calculated as $(w_2\text{-}w_1)/(t_2\text{-}t_1)$, where w_1 and w_2 are dry weights at times t_1 and t_2, respectively and expressed as gm^{-2} per day.

RESULTS AND DISCUSSION

Growth attributes

Plant height of rice was significantly greater in transplanting but it was statistically on par with lehi. The smallest plants were recorded in direct seeding. The highest plant height was observed in with application of 120 Kg N ha^{-1}and 60 Kg P_2O_5 ha^{-1}this was significantly superior over rest of all lower doses and lowest plant height was registered in rice treatment (Table-1). This was perhaps due to puddling operation which creates favourable condition for uptake of nutrients which ultimately gave better growth. This shows the superiority over direct seeding techniques [5].The dry weight of rice expressed in terms of CGR was low at initial stage and attained its peak between 50-65 days in transplanting but it was constant in direct seeding and decreased in lehi during 35-50 days crop stage significantly greater CGR values were recorded over direct seeding and lehi sowing techniques at all the stages of crop. Intermediate values of CGR were recorded in lehi which were significantly higher over direct seeding technique. Significantly greater CGR was observed with each successive dose of N and it was maximum with 120 Kg N ha^{-1}. P application significantly enhanced CGR with addition of each dose and 60 Kg P_2O_5 ha^{-1} registered maximum CGR. The lowest CGR was with control. In general, continuous improvement in CGR recorded at all crop stages was recorded with application of P and it was maximum at 50-65 days crop stage in all P doses. Transplanting techniques recorded significantly higher CGR values might be due to better plant geometry which helped better nutrition and gave higher effective tillers ultimately more dry matter accumulation showed higher CGR. Low CGR was at initial due to under developed roots and the highest CGR was recorded with maximum doses of N 120 Kg ha^{-1} and P 60 Kg P_2O_5 ha^{-1} which supplied required demand of crop (Prasad *et al.;* 2001).Number of effective tillers per plant was found significantly higher in transplanting over direct seeding and lehi technique. It was 53.2% and 13.9% higher over direct seeding and lehi. It might be due to better plant geometry and rooting pattern in transplanted plots. Application of N @ 120 Kg N ha^{-1} gave significantly higher number of tillers which was 53.2, 25.6 and 13.5% greater over 0, 40 and 80 Kg N ha^{-1}. Similar trend was observed with P doses where 60 Kg P_2O_5 ha^{-1} recorded the highest effective tillers per plant and it was 30.0% and 9.8% more effective tiller over 0 and 30 Kg P_2O_5 ha^{-1}.

Table 1 : Growth attributes of rainfed rice.

Treatment	**Plant Height (cm)**	**C G R**			**No. of tillers plant^{-1}**
		20-35 days	**35-50 days**	**50-65 days**	
Sowing techniques					
Direct	66.8200	0.0588	0.0588	0.0668	2.9300
Lehi	75.0000	0.0949	0.0893	0.1183	3.9400
Transplanting	76.6300	0.1084	0.1185	0.1265	4.4900
SE (d)	1.1300	0.0015	0.0004	0.0008	0.0900
CD (P=0.05)	3.6400	0.0042	0.0012	0.0023	0.2500
N – Levels (Kg N/ha)					
N_0	67.6400	0.0637	0.0752	0.0800	2.9700
N_{40}	70.6200	0.0854	0.0816	0.0961	3.6100
N_{80}	73.5400	0.0978	0.0837	0.1077	4.0100
N_{120}	79.4700	0.1026	0.1149	0.1317	4.5500
SE (d)	0.8100	0.0010	0.0008	0.0012	0.1100
CD (P=0.05)	1.7200	0.0020	0.0018	0.0024	0.2200
P – Levels (Kg P_2O_5/ha)					
P_0	70.1100	0.0645	0.0767	0.0863	3.2600
P_{30}	73.1800	0.0912	0.0871	0.0997	3.8600
P_{60}	75.1700	0.1064	0.1028	0.1256	4.2400
SE (d)	0.9000	0.0011	0.0006	0.0012	0.0600
CD (P=0.05)	1.8100	0.0021	0.0014	0.0025	0.1100

Yield and Yield attributes

Grain and Straw yield

Transplanting technique recorded significantly longer panicle and higher number of spikelets per panicle and grain and straw yields over both direct seeding and lehi sowing techniques. It gave 50.1% and 10.7% higher grain yield over direct seeding and lehi. Transplanting also gave 17.4% higher straw yield but statistically at par with lehi.It might be due to such differential growth and yield attributes of rice grown in puddled (lehi and transplanting) and unpuddled (direct seeding) condition can be explained through the variations in physical conditions and utilization of natural resources had direct effect on yield. The better performance of growth i.e. plant height, dry matter accumulation and greater number of effective tillers and yield attributes viz. length of panicle and number of spikelets per panicle in transplanting technique were attributed to higher yield of rice. Application of 120 Kg N ha^{-1} and 60 Kg P_2O_5 ha^{-1} gave significantly higher grain and straw yields over their lower respective doses. Lowest grain and straw yields were recorded in control treatments.It was ascribed due to higher values of yield attributes of rice. The result corroborates with the findings of Prasad *et al.* [4].

Table 2 : Yield, yield attributes and protein yield of rainfed rice.

Treatment	Length of panicle (cm)	Spikelets panicle^{-1}	Grain yield (q ha^{-1})	Straw (q ha^{-1})	H I (%)	Protein Yield (q ha^{-1})
Sowing techniques						
Direct	20.04	58.53	19.09	31.77	37.47	1.87
Lehi	21.18	67.85	25.88	36.31	41.38	2.52
Transplanting	22.24	72.44	28.67	36.87	43.99	2.80
SE (d)	0.28	0.75	0.76	0.50	0.81	0.01
CD (P=0.05)	0.79	2.09	2.11	1.39	2.26	0.04
N – Levels (Kg N/ha)						
N_0	19.08	54.50	20.01	29.27	40.42	1.76
N_{40}	20.12	63.56	23.24	31.67	41.91	2.18
N_{80}	22.10	70.00	26.35	37.00	41.27	2.60
N_{120}	23.32	77.08	28.59	42.00	40.18	3.03
SE (d)	0.37	0.55	0.43	0.49	0.45	0.02
CD (P=0.05)	0.79	1.16	0.90	1.04	0.95	0.03
P – Levels (Kg P_2O_5/ha)						
P_0	20.06	61.37	21.70	31.35	40.59	2.12
P_{30}	21.38	66.66	24.62	35.28	40.84	2.39
P_{60}	22.03	70.79	27.33	38.32	41.41	2.67
SE (d)	0.16	0.33	0.26	0.31	0.30	0.02
CD (P=0.05)	0.33	0.67	0.53	0.63	0.60	0.05

Nitrogen and Phosphorus uptake

Significantly greater N and P uptake was observed in transplanted crop over direct seeding and lehi techniques. Transplanting recorded 42.6% and 9.3% higher N and 51.7% and 10.9% higher P uptake, respectively. Lehi also recorded 30.4% higher N and 36.7% higher P uptake over direct seeding (Table-3).N and P uptake was significantly higher in transplanting is probably due to better plant geometry which provided optimum space for root development and shoot development that cause better utilization of natural resources like moisture, nutrients and solar radiation.

Significant improvement in N and P uptake by rice was recorded with each successive doses of N even up to the highest dose i.e. 120 Kg N ha^{-1}andphosphorus up to 60 Kg P_2O_5 ha^{-1}. Lowest N and P uptake was observed in $N_0$and P_0treatments. This is probably due to favourable effect of N and P on all growth and yield attributes, particularly root and shoot growth which might have facilitated the absorption of these nutrients from a larger area in the soil. Similar results were also reported by Paikray *et al.* [7].

Economics

Significantly maximum net returns of Rs 6463 per ha was obtained in lehi with least cost of cultivation which gave 136% higher net returns 17.5% lower cost of cultivation over direct seeding and 2.9% higher net returns and 18.7% lower cost of cultivation over transplanting, respectively (Table-3).Maximum net returns in lehi was might be due to higher but nearly equal grain and straw yield to transplanting and least cost of cultivation. Minimum grain and straw yields and comparatively higher labour charges in sowing and weeding reduced the net returns in direct seeding.

Addition of each dose of N and P increased the cost of cultivation and it was calculated maximum with the highest doses of N 120 Kg ha^{-1} and $P_2O_5$60 Kg ha^{-1}, respectively. However, the net returns also improved significantly with each successive doses of both N and P and it was the highest at 120 Kg N ha^{-1} and 60 Kg P_2O_5 ha^{-1}, respectively.Cost of cultivation was conspicuously increased with each successive dose of N and P might be due to addition of cost of N and P and its application. The additional cost incurred on N and P with each successive dose significantly improved the grain and straw yield which ultimately resulted higher net returns.

Table 3 : Total N and P uptake and Economics of rainfed rice.

Treatment	Total N and P uptake (Kg ha^{-1})		Cost of Cultivation	Net Returns
	N	P	(Rs ha^{-1})	(Rs ha^{-1})
Sowing techniques				
Direct	43.37	6.81	8300	2736
Lehi	56.54	9.31	8220	6463
Transplanting	61.84	10.33	9754	6282
SE (d)	0.24	0.05		363
CD (P=0.05)	0.66	0.14		1009
N – Levels (Kg N/ha)				
N_0	40.07	6.38	8141	3263
N_{40}	48.52	8.10	8567	4580
N_{80}	58.52	9.83	9358	5863
N_{120}	68.60	10.96		6935
SE (d)	0.36	0.05		210
CD (P=0.05)	0.75	0.10		442
P – Levels (Kg P_2O_5/ha)				
P_0	47.20	6.67	8175	4171
P_{30}	54.03	8.91	8767	5234
P_{60}	60.51	10.87	9332	6076
SE (d)	0.29	0.04		135
CD (P=0.05)	0.59	0.08		273

Quality of rice

The maximum protein yield (2.8 Kg ha^{-1}) was recordedin transplanting which was significantly 49.7% and 11.1% higher over direct seeding and lehi, respectively (Table-2). This might be due tobetter plant geometry that provided appropriate rooting pattern ultimately resulted in higher yields.Significantly maximum protein yield was calculated with 120 Kg ha^{-1} which was 72, 39 and 16.5% higher over N0, N40 and N80 Kg ha^{-1}, respectively. Similar trend was recorded with application of 60 Kg P_2O_5 ha^{-1} which resulted 25.9% and 11.7% higher protein yield over 0 and 30 Kg P_2O_5 ha^{-1}. It is ascribed to maximum uptake of N which played direct role in higher synthesis of protein in rice grains [5].

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