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Full Research Article

Performance of *Kharif* Rice (*Oryza sativa* L.) under Different Nursery Densities and Plant Population

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Abstract

A field experiment was conducted at Agricultural Research Station, Kampasagar Nalgonda, Telangana during the *kharif* seasons of 2011 and 2012 to find out the effect of different nursery densities and plant population on grain yield and yield attributes in rice. Tiller number and panicle number m^{-2} were significantly higher at 44 hills m^{-2} plant population than 33 hills m^{-2} and 25 hills m^{-2}. Panicle length, filled grains panicle^{-1} and 1000 grain weight were significantly not influenced with plant population. Though there was non significance difference of grain yield with different plant populations, adopting 44 hills m^{-2} recorded superior grain yield (5.39 t ha^{-1}) over 33 (5.08 t ha^{-1}) and 25 hills m^{-2} (4.95 t ha^{-1}). Among nursery densities, 2.5, 5 and 7.5 kg seed 40 m^{-2} did not show any significant influence on yield attributes and grain yield. Numerically, higher grain yields were observed in 2.5 kg seed 40 m^{-2} (5.3 t ha^{-1}) than 5 kg seed 40 m^{-2} (5.12 t ha^{-1}) and 7.5 kg seed 40 m^{-2} (5.01 t ha^{-1}). Nutrient uptake was higher in 44 hills m^{-2} than 33 and 25 hills m^{-2}. NPK uptake was significantly higher at 2.5 kg seed 40 m^{-2} than 7.5 kg seed 40 m^{-2}. Higher gross and net returns were earned in 44 hills m^{-2} (₹ 80850 and ₹ 50325) than 25 hills m^{-2} (₹ 74250 and ₹ 48750). 2.5 kg seed 40 m^{-2} recorded higher gross and net returns (₹ 79500 and ₹ 52640) than other seed densities.

1. Introduction

The crop performance depends largely on temperature, solar radiation, moisture and soil fertility for their growth and nutritional requirements. A thick population crop may have limitations in the maximum availability of these factors. Rice production has been limited by a number of factors, such as water scarcity, high inputs, non-availability of skilled labour, sub-optimal plant population, weeds and pest infestation. The key of maintaining optimum plant population by using appropriate planting technique has been reported by many scientists for increasing the productivity of rice (Ghosh and Sharma, 1997).

In canal commands, late release of canal water is become more common in present climatic situations. There is huge demand of labour during transplanting once the canal water releases. In contract labour system, labour motto is more area coverage with in less time for earning money at the cost of sparse plant population. *Kharif* rice to be transplanted at 33 to 44 hills m^{-2} depending on duration of the variety to achieve optimum yields. Due to contract labour system, the population ranging from 22–28 hills m^{-2} only in the farmers fields irrespective of the variety, time of planting and soil conditions. The influence of plant population on rice grain yields is highly inconsistent in farmers fields. It is varies with duration of variety, time of planting, site specific soil characteristics and climatic conditions. Significant variations in yield trends among different duration groups like higher yield with wider spacings in mid and late duration varieties and vice versa in early group varieties. Chandrakar and khan (1981) reported results of different spacings among early, mid and late varieties where mid and late varieties performed well in wider spacing but in closer spacing, early varieties yields were high. On similar lines (Raju et al., 1989) also reported that wider spacings in long duration rice variety gave significant increase in grain yield over closest spacing of 10×10 cm^2 proven plasticity in rice to adjust for plant population. In contrary, (Borkar et al., 2008) stated the superiority of closer spacing over wider spacing in SRI. However, (Baloch et al., 2002) reported 22.5×22.5 cm^2 gave significantly higher grain yield than the 20×20 cm^2, 25×25 cm^2. These research results also varying in different spacings.

Though, importance of spacing being stressed particularly for different group varieties, soil and climatic situations in many extension forums, farmers are not practicing accordingly due to contract labour system and delaying the plantings due to late monsoons. In view of research data on influence of plant population on grain yield is dynamic with variety, time of planting under different agro climatic situations and very few concurrent studies under given situation, there is need to standardize the optimum plant population for a particular variety in a given agro climatic conditions.

To achieve optimum growth of rice nursery, spreading of rice seed evenly and uniformly is prerequisite. Earlier studies recommended adopting seed density of 5 kg seed 40 m^{-2}. But farmers with pre conceived ideas adopting seed rate of 10–12 kg seed 40 m^{-2} resulting in thin, lanky and very poor nursery growth. As the seedling growth is very poor, farm labour will be transplanting 6–8 seedlings $hill^{-1}$ instead of 2–3 seedlings $hill^{-1}$, thus defeating the very purpose of the transplanting. Conventionally the mid hill farmers of Lamjung and Tanahun district, Nepal are using very high seed rates (in average 607 g m^{-2}) in their nursery, resulting in non-vigorous seedlings, and they used 4–10 seedlings $hill^{-1}$ at transplanting (Adhikari et al., 2013). The yield and yield components of the rice crop are affected negatively by using high seed rates in the nursery (Singh et al., 1987). By making a small investment in raising healthy and vigorous seedlings in the nursery, farmers could harvest an additional yield of up to 2 t ha^{-1} (Panda et al., 1991). It is suggested to use 200 g of seeds m^{-2} as optimum for obtaining healthy vigorous seedlings that will perform better after transplanting (Wopereis et al., 2009). In MSRI also the basic principle is to attain robust seedlings through very thin sowing (Anonymous, 2014). Moreover, in seed production also not more than 10–15 kg nursery seed is used for transplanting one acre of main field for higher seed yield. It saves the cost of seed ha^{-1} basis. Thus, optimum nursery density plays a pivotal role in obtaining healthy seedlings and better grain yield. Further the interaction studies on nursery seed densities and plant population are also lacking. As no research studies were carried out in this aspect, the present experiment was planned.

2. Materials and Methods

The experiment was conducted at the Agricultural Research Station, Kampasagar during *kharif* 2011 and 2012. The experimental soil was of sandy clay loam with P^H of 6.8 and E C of 0.208 ds m^{-1}. The nutrient status was medium in available N (287 and 282 kg N ha^{-1} in 2011 and 2012 respectively) and available phosphorous (22.62 and 24.22 kg P_2O_5 ha^{-1} in 2011 and 2012 respectively) and high in available potassium (339 and 327 kg K_2O ha^{-1} in 2011 and 2012 respectively). BPT 5204 was the test variety. The experiment was carried out with three different nursery densities i.e., 2.5, 5.0 and 7.5 kg seed 40 m^{-2} and three different plant populations i.e., 44 hills m^{-2} (15×15 cm^2), 33 hills m^{-2} (20×15 cm^2) and 25 hills m^{-2} (20×20 cm^2). The layout of the experiment was RBD with factorial design. The three different seed rates of 2.5, 5.0 and 7.5 kg seed 40 m^{-2} were adopted in nursery. 30 days old 2–3 seedlings $hill^{-1}$ were transplanted in well puddled and leveled field at a spacing of 15×15 cm^2, 20×15 cm^2 and 20×20 cm^2 to maintain plant population of 44, 33 and 25 hills m^{-2} respectively. The fertilizers of N, P_2O_5 and K_2O at 120:60:40 NPK kg ha^{-1} were applied. The entire phosphorous and half of the recommended potassium was applied as basal dose during transplanting and another half of recommended potassium was applied during panicle initiation stage. Nitrogen was applied in 3 equal splits at transplanting, active tillering and panicle initiation stage. The crop was managed well keeping free from weeds, pest and disease. Oxadiargyl was applied @ 90 g ha^{-1} 4^{th} day after transplanting and further weed growth was checked by hand weeding at 20 and 35 days after transplanting. For controlling leaf folder and stem bores at the initial stages carbofuran granules were applied @ 25 kg ha^{-1} at active tillering stage. Acephate @ 750 g ha^{-1} and trycyclozyle @ 250 g ha^{-1} were applied to control the leaf folder and paddy blast respectively. Profinophos @ 1 l ha^{-1} was applied to control panicle mite during panicle initiation stage.

The data on grain yield and yield attributes like tiller number m^{-2}, panicle number m^{-2}, panicle length (cm), filled grains $panicle^{-1}$ and 1000 grain weight were recorded at harvest. The data was analysed statistically by the standard procedure.

Crop samples collected at harvest were utilized for chemical analysis. These samples were used for estimation for NPK content. Nitrogen was estimated by kelplus nitrogen analyser (Piper, 1966). Phosphorus was estimated by di acid digestion method (HNO_3 and $HCLO_4$ in the ratio of 9:1) and by using UV Visible spectro photo meter (Jackson, 1967). Potassium was estimated by di acid digestion method using Flame photometer (Jackson, 1967). The N, P and K contents were expressed as percentage. The N, P and K uptake was computed by multiplying the percentage content with grain and straw yield and expressed as kg ha^{-1}. Economics were calculated as per procedure (Perin et al., 1979)

3. Results and Discussion

3.1. Yield attributes

Tiller number and panicle number m^{-2} significantly higher at 44 hills m^{-2} than the 33 and 25 hills m^{-2} (Table 1) due to more number of plants $unit^{-1}$ area than other populations. Other yield attributing characters did not vary significantly. Pooled data

Table 1: Yield attributes, grain yield and economics under different spacing and nursery densities in rice(Pooled data)

Treatment	Tiller Number m^{-2}	Panicle Number m^{-2}	Panicle length (cm)	Filled grains panicle^{-1}	1000 grain weight (g)	Grain yield (t ha^{-1})	Gross returns (₹ ha^{-1})	Cost of cultivation (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C ratio
Spacing										
15×15 cm^2 (44 hills m^{-2})	390	374	20.5	156	13.2	5.39	80850	26250	54600	3.1
20×15 cm^2 (33 hills m^{-2})	353	326	20.7	167	13.3	5.08	76200	25875	50325	2.9
20×20 cm^2 (25 hills m^{-2})	312	294	21.6	159	13.5	4.95	74250	25500	48750	2.9
SEm±	6	5	0.9	6	0.3	0.12	2110	260	2010	0.06
CD (p=0.05)	20	17	NS	NS	NS	NS	NS	NS	NS	NS
Nursery densities										
2.5 kg seed 40 m^{-2}	342	320	22	169	13.2	5.30	79500	26860	52640	3.0
5 kg seed 40 m^{-2}	358	340	20	157	13.4	5.12	76800	27515	49285	2.8
7.5 kg seed 40 m^{-2}	355	335	20	157	13.4	5.01	75150	28170	46980	2.7
SEm±	6	5	0.9	6	0.3	0.12	1415	465	1860	0.06
CD (p=0.05)	NS	NS	NS	NS	NS	NS	4310	1250	5600	0.2
Interaction										
SEm±	11	10	1.5	10	0.4	0.21	3250	345	3800	1.3
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

revealed that significant tiller and panicle number m^{-2} recorded in 44 hills m^{-2} than 33 and 25 hills m^{-2}. significant tiller and panicle number were observed between 33 and 25 hills m^{-2}. Different nursery densities did not show any significant difference in yield attributes (Table 1). Though lower tiller and panicle registered interestingly, 2.5 kg seed 40 m^{-2} recorded numerically more filled grains panicle^{-1} than higher densities due to lower seedling competition for nutrient, light and space resulting in more filled grains panicle^{-1}. Interaction was found non significant in all the parameters (Table 1).

3.2. Nutrient uptake

Though numerically 44 hills m^{-2} recorded higher nutrient uptake than other populations, NPK uptake in both straw and grain did not vary significantly among different populations ranged from 25 hills m^{-2} to 44 hills m^{-2} except k uptake in straw where uptake was significantly higher in 44 hills m^{-2} than 25 hills m^{-2} due to more population and higher tiller number reflected in large population (Table 2). K uptake in straw at 33 hills m^{-2} was on par with both 25 hills m^{-2} and 44 hills m^{-2}. In SRI, (Gautam et al., 2013) in their study confirmed similar results that 20×20 cm^2 and 30×30 cm^2 did not show any significant variation in NPK uptake both in grain and straw. Thorat and Sonawane (2007) also concluded that different spacing had no significant influence on N and P content in grain and straw of rice. Ghansham and Singh (2008) reported non significant difference in nutrient uptake between 15 and 20 cm row spacing in upland rice.

Table 2: Nutrient uptake under different spacing and nursery densities in rice (Pooled data)

Treatment	N (kg ha^{-1})		P_2O_5 (kg ha^{-1})		K_2O (kg ha^{-1})	
	Straw	Grain	Straw	Grain	Straw	Grain
Spacing						
15×15 cm^2 (44 hills m^{-2})	18.8	49.9	11.6	15.9	43.7	25.0
20×15 cm^2 (33 hills m^{-2})	18.7	49.1	11.5	15.5	41.8	23.5
20×20 cm^2 (25 hills m^{-2})	18.3	49.1	11.2	15.5	40.6	23.4
SEm±	1.1	2.0	0.7	0.6	1.5	1.6
CD (p=0.05)	NS	NS	NS	NS	3.1	NS
Nursery densities						
2.5 kg seed 40 m^{-2}	20.7	51.0	12.2	17.3	45.6	24.7
5 kg seed 40 m^{-2}	19.7	50.9	11.3	15.4	42.6	21.8
7.5 kg seed 40 m^{-2}	17.3	46.6	11.2	14.9	39.6	21.6
SEm±	1.1	1.3	0.6	0.6	2.8	1.6
CD (p=0.05)	2.4	2.8	NS	1.2	5.7	3.2
Interaction						
SEm±	2.3	2.7	1.5	1.2	3.0	3.3
CD (p=0.05)	NS	NS	NS	NS	NS	NS

Whereas (Borkar et al., 2008) reported that the spacing 20×15 cm^2 recorded higher N uptake as compared to wider spacing of 20×20 cm^2, 25×25 cm^2 and 30×30 cm^2 in SRI. (Jacob et al., 2005) confirmed that 50 hills m^{-2} recorded significantly higher NPK uptake than 44 hills m^{-2} and 67 hills m^{-2}. (Mahato et al., 2007) concluded that in medium duration rice variety 10×10 cm^2 spacing recorded significantly higher NPK uptake than 20×15 cm^2 and comparable with 15×15 cm^2 spacing.

Different nursery seed rates influenced the nutrient uptake significantly except P uptake in straw. N and K uptake in straw were significantly higher at 2.5 kg seed 40 m^{-2} than 7.5 kg seed 40 m^{-2} (Table 2). 5 kg seed 40 m^{-2} recorded significantly higher N uptake in straw than 7.5 kg seed m^{-2} and K uptake in straw was similar with both 2 kg seed 40 m^{-2} and 7.5 kg seed m^{-2} as compared to 5 kg seed m^{-2}. In grain, 2.5 kg seed 40 m^{-2} registered significantly higher N uptake than 7.5 kg seed m^{-2} and significant PK uptake than 5 and 7.5 kg seed m^{-2}. Uptake was comparable between 2.5 and 5 kg seed m^{-2} and 5 and 7.5 kg seed m^{-2} in case of N and PK respectively. Less competition, healthy and vigorous seedling, encouraging better root anchorage, proliferation and resulted with enhanced uptake of nutrients in lower seed density as compared to higher nursery seed density. Ghansham and Singh (2008) reported non significant difference in nutrient uptake among 40, 50 and 60 kg ha^{-1} seed rate in upland rice. Interaction was found non significant (Table 2).

3.3. Grain yield

Though grain yield was non significant among different populations, numerically higher grain yields were observed in 44 hills m^{-2} (5.39 t ha^{-1}) than 33 hills m^{-2} (5.08 t ha^{-1}) and 25 hills m^{-2} (4.95 t ha^{-1}), which was 6.1% and 8.8% were higher respectively than 33 and 25 hills m^{-2} (Table 1). Pooled data revealed that significant tiller and panicle number m^{-2} recorded in 44 hills m^{-2} than 33 and 25 hills m^{-2} did not yield significant grain yield difference due to less variation of other yield attributing characters of panicle length and filled grains $panicle^{-1}$ and 1000 grain weight. The plants grown with wider spacing have more area of land around them to draw the nutrition and had more solar radiation to absorb for better photosynthetic process and hence performed better as individual plants. The reason for deviation of this linearity in case of grain yield $plot^{-1}$ is that the yield does not entirely depend upon the performance of individual plant but also on the total number of plants $plot^{-1}$ and yield contributing parameters within plant.

In long duration varieties like BPT 5204, planting at a spacing of 25 hills m^{-2} to 44 hills m^{-2} did not yield much difference because of wider spacing with plenty of time for vegetative growth has the equal yield advantage that of closer spacing in long duration varieties. This is true in case of MSRI and SRI systems where 23 hills and 16 hills m^{-2} are maintained in principle where yield advantage is more through wider spacing. (Borkar et al., 2008) reported that, in SRI, though wider spacing of 30×30 cm^2 recorded more number of tillers and dry matter production than closer spacing of 25×25 cm^2, 20×20 cm^2 and 20×15 cm^2 could not compensate the grain yield on unit area basis showing the superiority of closer spacing over wider spacing as number of plants $unit^{-1}$ area were more in closer spacing than wider spacing. (Raju et al., 1989) in their study on long duration rice varieties revealed that wider spacings in long duration rice variety gave significant increase in grain yield over closest spacing of 10×10 cm^2. (Ram et al., 2014) that, found that wider spacing significantly recorded higher grain yield than other closer spacing in SRI. (Baloch et al., 2002) reported in their study that, the increased plant spacing considerably resulted in vigorous plant growth and caused a significant increase in number of panicles $hill^{-1}$, grain yield $hill^{-1}$, filled grain $panicle^{-1}$ and 1000 grain weight. The spacing 22.5×22.5 cm^2 gave significantly higher grain yield than the spacings of 20×20 cm^2 and 25×25 cm^2.

Some of the findings on spacing studies reported where Eunus and Sadeque (1974) found that the number of panicles $plant^{-1}$ and straw yield increased with increased spacing in transplanted rice. (Shahi et al., 1976) studied the effect of spacings 20×20 cm^2 and 15×15 cm^2 on the paddy yield of dwarf rice variety Jaya. Although they did not find significant differences in the yields, yet the yields in case of 20×20 cm^2 spacing tended to be higher than that of the other two spacings. Chandrakar and Khan (1981) studied the effect of spacings of 10×10 cm^2, 15×10 cm^2 and 20×10 cm^2 on the grain yields on early, medium and late duration tall growing indica rice varieties and found that the spacing of 20×10 cm^2 gave the highest yields of medium and late varieties, while the spacing of 10×10 cm^2 gave higher yield in case of early maturing varieties. (Singh et al., 1983) studied the effect of row spacing in combination with nutrient supply on grain yield of semi-dwarf up-land rice variety Narendra 1 (IET 2232). The crop was grown by direct seeding in rows at three spacings of 15×15 cm^2, 20×15 cm^2 and 25×25 cm^2. The grain yield was more with 25×25 cm^2 spacing as compared to other spacings.

Different nursery densities did not show any significant difference in grain yield (Table 1). Two years pooled data revealed that numerically 2.5 kg seed 40 m^{-2} recorded higher grain yield (5.3 t ha^{-1}) than 5 kg seed 40 m^{-2} (5.12 t ha^{-1}) and 7.5 kg seed 40 m^{-2} (5.01 t ha^{-1}). The percentage increase of grain yield with 2.5 kg seed 40 m^{-2} was 3.5 and 5.7 respectively over 5 and 7.5 kg seed 40 m^{-2}. The results of more tiller, panicle number, filled grains and grain yield after the use of low seeding density in the nursery are most likely due to lower seedling competition for nutrient, light and space resulting in more vigorous seedlings. Our findings concur with the (Naeem et al., 2011) reported that transplanting 20-days old fertile seedlings grown at low seeding density produced similar yields to transplanting younger seedlings grown at higher densities than the older seedlings. Where as (Adhikari et al., 2013) found in their study that more productive tillers were observed and significantly higher grain yields recorded with the use of low seeding density over higher seed density. The interaction was also found non significant (Table 1).

3.4. Economics

Different populations did not influence the economic parameters significantly but numerically higher gross and net returns were earned in 44 hills m^{-2} (₹ 80850 and ₹ 54600) than 25 hills m^{-2} (₹ 74250 and ₹ 48750) and 33 hills m^{-2} (₹ 76200 and ₹ 50325) (Table 1). Higher B:C ratio was observed in 44 hills m^{-2} (3.1) as against 33 (2.9) and 25 hills m^{-2} (2.9). (Borkar et al., 2008) observed that spacing of 20×15 cm^2 recorded maximum net monetary return and increased B:C ratio than 20×20 cm^2, 25×25 cm^2 and 30×30 cm^2 in SRI. (Jacob et al., 2005) reported that 50 hills m^{-2} registered significantly higher net income and benefit cost ratio than 44 hills m^{-2} and 67 hills m^{-2}. (Mahato et al., 2007) in their findings observed that spacing 15×15 cm^2 gave the highest economic return as compared to wider spacing of 20×10 cm^2 and very closer spacing of 10×10 cm^2.

In 2.5 kg seed 40 m^{-2}, gross and net returns were significantly higher (₹ 79500 and ₹ 52640) than 7.5 kg seed m^{-2} (₹ 75150 and ₹ 46980) due to significantly low cost of cultivation and identical with 5 kg seed m^{-2} (₹ 76800 and ₹ 49285) and significantly higher B:C ratio registered in 2.5 kg seed 40 m^{-2} (3.0) than 5 kg (2.8) and 7.5 kg seed m^{-2} (2.7) (Table 1). Interaction was found non significant (Table 1).

4. Conclusion

Kharif season in long duration varieties, spacing of 25 hills m^{-2} has equal yield advantage with that of 33 and 44 hills m^{-2}. The percentage yield difference was 2.6 and 8.8 with 33 and 44 hills m^{-2} respectively in comparison with 25 hills m^{-2}. 2.5 kg seed 40 m^{-2} in nursery is optimum to obtain robust seedlings. In addition, seed requirement and cost can be reduced for attaining higher net returns.

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