

Impact of Plant Densities and Nitrogen Levels on Grain Yield and Yield Attributes of Transplanted Rice (*Oryza Sativa. L*)

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Abstract – The present investigation aimed to study the effect of three plant densities (farmers practice - zigzag planting : 26 hills m⁻², 15x15cm : 44.44 hills m⁻² and 25x25 cm: 16 hills m⁻²) and four nitrogen levels (120, 180, 240 and 300 kg ha⁻¹) on grain yield and yield attributes of transplanted rice. A field experiment was carried out at Agricultural Research Institute, Acharya N G Ranga Agricultural University, Rajendranagar, Hyderabad during *Kharif* 2012. The main results showed that plant density of 44.44 hills m⁻² (15x15 cm) gave the highest number of panicles m⁻², spikelets panicle⁻¹, filled spikelets panicle⁻¹, grain yield and straw yield over other plant densities. Application of graded levels of N significantly increased the grain yield, straw yield and yield attributing characters viz., panicles m⁻², spikelets panicle⁻¹, filled spikelets panicle⁻¹ and test weight. The effect was significant up to a level of 180 kg N ha⁻¹ and thereafter there was no significant increase.

Keywords – Nitrogen Levels, Plant Densities, Yield Attributes, Grain Yield, Transplanted Rice.

I. INTRODUCTION

Rice (*Oryza sativa* L.) is considered as one of the most important cereal crop not only in India but also all over the world. Since the world population is increasing at 1.17% annually, an annual increase in rice production by 0.6-0.9% is required until 2050 to meet the anticipated demand (Carriger and Vallee, 2007). The total cultivated area with rice in India was about 42.75 million hectares in 2012-13 which produced 105.23 million tons of paddy rice with an average of 2467 kg ha⁻¹ (Directorate of economics and statistics, 2012-13). Due to the shortage of cultivable land, the scope of its extensive cultivation is very limited in this country. That is why special attention should be given for increasing the yield per unit area by applying improved technology and management practices.

Among the cultural technologies, planting density is one of the important components, manipulation of which is an essence for optimizing yield (Faisal-ur-Rasool *et al.*, 2012). Plant density exerts a strong influence on the rice grain yield, because of its competitive effects, both on the vegetative and reproductive development (Ahmad, 2006). Grain yield increases linearly with plant density until some competitive effects become apparent (Ahmad *et al.*, 2005). Optimum plant spacing ensures plants to grow properly both in their aerial and underground parts through utilization of solar radiation and nutrients, therefore proper manipulation

of planting density may lead to increase in the economic yield of transplanted rice.

A higher output per unit area also demands considerable amounts of external inputs, such as fertilizers. Nitrogen is the kingpin in the fertilizer management programme for rice as it is the key to realize the yield potential of rice varieties. Insufficient and inappropriate fertilizer nitrogen management may account for one half to two thirds of the gap between actual and potential yields. Keeping in view the immense importance of plant stand and nitrogen fertilization, the present study was undertaken to optimize yield of transplanted lowland rice under variable plant density and nitrogen levels.

II. MATERIALS AND METHODS

The experiment was conducted at Agricultural Research Institute, Acharya N G Ranga Agricultural University, Rajendranagar, Hyderabad during the period from July to November 2012. The soil of the experimental site was sandy loam in texture, alkaline in reaction, low in available nitrogen, phosphorus and high in available potassium. The experiment was laid out in a factorial randomized complete block design with three replications. The treatments comprised of three plant densities (farmers practice- zigzag planting : 26 hills m⁻², 15x15cm : 44.44 hills m⁻² and 25x25 cm: 16 hills m⁻²) and four nitrogen levels (120, 180, 240 and 300 kg ha⁻¹).

Rice seeds (var. MTU 1010) were raised in well prepared seed bed. Before raising seeds in the nursery, seeds were water soaked for 24 hours and these were kept in gunny bag in dark conditions. After sprouting, the seeds were sown in wet seed bed on 5 July 2012. Twenty one day old seedlings were uprooted carefully from the nursery and transplanted (2 seedlings hill⁻¹) on the well puddled experimental plots on 26 July 2012. Fertilizers were applied @ 60, 40 and 50 kg ha⁻¹ through single super phosphate (SSP), muriate of potash (MOP) and zinc sulphate. The whole amount of SSP, MoP and ZnSO₄ were applied at the time of final land preparation. Nitrogen was applied as per the treatments in the form of urea (46% N) in three equal splits at planting, 20 days after planting (DAP) and at panicle primordial initiation (PI) stage. Irrigation along with other intercultural operations was done as and when required.

The crop of individual plots was separately harvested at full maturity on 6 November 2012. Data on plant height, number of total and effective tillers/hill, panicle length,

number of grains/panicle, and weight of 1000-grain were collected from each plot. The grain weight for each plot was recorded after proper drying in sun. The collected data were statistically analyzed and mean differences were compared by SAS.

III. RESULTS AND DISCUSSION

Yield Attributes

Panicles m⁻²

Plant densities exerted significant influence on panicles m⁻². Maximum number of panicles m⁻² (333) was observed in PD2 (44.44 hills m⁻²) and was significantly superior to PD1 (28 hills m⁻²) and PD3 (16 hills m⁻²), which in turn recorded the lowest number of panicles m⁻² (291). This might be due to presence of more number of plants with closer spacing (Kumari *et al.*, 2000). Graded levels of nitrogen showed pronounced effect on number of panicles m⁻². The highest number of panicles m⁻² (338) was recorded with N4 (300 kg ha⁻¹) and was comparable with N3 (240 kg ha⁻¹), N2 (180 kg ha⁻¹) but significantly superior to N1 (120 kg ha⁻¹), which in turn recorded significantly the lowest number of panicles m⁻² (250). Any plant growth depends on cell-division and enlargement for which adequate nutrition is essential. Hence, crop receiving more nitrogen produce taller plants and more number of panicles m⁻² (Gardner *et al.*, 1988). The interaction effect of different plant densities and nitrogen levels was not significant on panicles m⁻².

Panicle length (cm)

Plant densities and graded levels of N did not show significant influence on panicle length during the period of investigation

Panicle weight (g)

Plant densities exerted significant influence on panicle weight but graded levels of nitrogen did not show any significant influence on panicle weight. More panicle weight of 4.29 g was obtained in PD3 (16 hills m⁻²) and was significantly superior to PD1 (28 hills m⁻²) and PD2 (44.44 hills m⁻²), which in turn these two were on par (3.79 and 3.74 g) with each other. This might be due to competition of plants for light within the dense plants at closer hill spacing resulted in reduced panicle weight due to reduction in the rate of photosynthesis (Yadav, 2007).

Number of spikelets per panicle

Significant increase in spikelets panicle⁻¹ was observed as the plant densities increased from 16 to 44.4 hills m⁻². More number of spikelets panicle⁻¹ (154) was observed in PD3 (16 hills m⁻²) and was significantly superior to PD1 (28 hills m⁻²) and PD2 (44.44 hills m⁻²), which in turn recorded significantly the lowest number of spikelets panicle⁻¹ (134). Plants at wider spacing produced more spikelets panicle⁻¹ due to higher nutrient availability (Uddin *et al.*, 2011). Levels of N fertilizer significantly affected the spikelets panicle⁻¹. The highest number of spikelets panicle⁻¹ (147) was obtained with N4 (300 kg ha⁻¹) and was comparable

with N3 (240 kg ha⁻¹), N2 (180 kg ha⁻¹) and significantly superior to N1 (120 kg ha⁻¹), which in turn produced less number of spikelets panicle⁻¹ (132). The more number of spikelets panicle⁻¹ obtained in treatments receiving higher nitrogen rates were probably due to better nitrogen status of plant during panicle growth period (Awan *et al.*, 2011).

Number of filled spikelets per panicle

The highest number of filled spikelets panicle⁻¹ (133) was obtained with PD3 (16 hills m⁻²) which was however, comparable with PD1 (28 hills m⁻²) and significantly superior to PD2 (44.44 hills m⁻²) which recorded the lowest number of filled spikelets panicle⁻¹ (118). This might be due to supply of more food materials, moisture and light for the plant under wider spacing and ultimately resulted in more filled spikelets panicle⁻¹ over closer spacing (Uddin *et al.*, 2011). Number of filled spikelets panicle⁻¹ significantly increased with increase in nitrogen levels. The highest number of filled spikelets panicle⁻¹ (131) was obtained with N2 (180 kg ha⁻¹) and was comparable with N3 (240 kg ha⁻¹), N4 (300 kg ha⁻¹) and significantly superior to N1 (120 kg ha⁻¹), which in turn recorded the lowest number of filled spikelets panicle⁻¹ (118). The increase in the number of filled spikelets panicle⁻¹ at higher nitrogen levels might be attributed to better nutrition of panicle primordial which resulted in higher number of filled spikelets panicle⁻¹ (Tripathi *et al.*, 1998).

Test weight (g)

Weight of 1000 grains is one of the most important parameter among the yield by plant densities and N application in the present study (Table 1). The highest test weight (26.44 g) of rice was noticed with PD2 (44.44 hills m⁻²), and comparable with PD1 (28 hills m⁻²) but significantly superior to PD3 (16 hills m⁻²), which in turn recorded the lowest test weight (25.34 g). This might be due to fewer tillers hill⁻¹ under closer spacing, developed better and more stronger resulting in better development of yield attributes (Yadav, 2007). The highest test weight (26.66 g) of rice was recorded with N2 (180 kg ha⁻¹), which was however, comparable with N3 (240 kg ha⁻¹) and significantly superior to N1 (120 kg ha⁻¹) and N4 (300 kg ha⁻¹). Test weight is mostly a genetic factor and is not much influenced by nitrogen levels.

Grain yield (kg ha⁻¹)

Data pertaining to grain yield of rice revealed that, higher grain yield (7494 kg ha⁻¹) was obtained in PD2 (44.44 hills m⁻²), and was significantly superior to PD1 (28 hills m⁻²) and PD3 (16 hills m⁻²), which in turn recorded significantly the lowest grain yield (6647 kg ha⁻¹). The per cent increase of grain yield in PD2 (44.44 hills m⁻²) over PD1 (28 hills m⁻²) and PD3 (25 16 hills m⁻²) was 7 and 13%, respectively. The higher yield in closer plant geometry might be due to more panicle bearing shoots m⁻², number of spikelets panicle⁻¹, filled spikelets panicle⁻¹ and 1000-grain weight (Yadav, 2007).

The difference in grain yield of rice was conspicuous with graded levels of nitrogen application. The highest grain yield

(7486 kg ha⁻¹) was obtained with N4 (300 kg ha⁻¹) and was comparable with N3 (240 kg ha⁻¹), N2 (180 kg ha⁻¹) and was significantly superior to N1 (120 kg ha⁻¹), which in turn recorded the lowest grain yield (6011 kg ha⁻¹). The rate of increase in grain yield with application of 300, 240 and 180 kg N ha⁻¹ was 25%, 24% and 21%, respectively over 120 kg N ha⁻¹. Higher yield at high nitrogen levels might be ascribed to the overall improvement in plant vigour and production of sufficient photosynthates owing to greater availability of nutrients subsequently resulting in better manifestation of yield attributes (Choudhary and Pandey, 2009).

Straw yield (kg ha⁻¹)

Straw yield increased consistently with increasing plant densities (Table.2). The highest straw yield (7540 kg ha⁻¹) was recorded with PD2 (44.44 hills m⁻²), and was however, significantly superior to PD1 (28 hills m⁻²) and PD3 (16 hills m⁻²), which in turn recorded the lowest straw yield (6744 kg ha⁻¹) over other plant densities. This might be due to higher plant population (Singh *et al.*, 2003) as well as due to shading of leaves of one plant to another, since the shaded plants show more vegetative growth (Uddin *et al.*, 2011).

Graded levels of nitrogen significantly influenced the straw yield. The highest straw yield (7853 kg ha⁻¹) was noticed with N4 (300 kg ha⁻¹), and was comparable with N3 (240 kg ha⁻¹), N2 (180 kg ha⁻¹) and significantly superior to N1 (120 kg ha⁻¹) which in turn registered the lowest straw yield (5727 kg ha⁻¹). This might be due to vigorous growth (plant height) with increase in N level, resulted in higher straw yield (Chopra and Chopra, 2004).

Harvest index

Among the different plant densities the highest harvest index (50.20) was obtained in PD1 (28 hills m⁻²) and it was followed by PD3 (16 hills m⁻²) and PD2 (44.44 hills m⁻²). The lowest harvest index (49.74) was obtained in PD2 (44.44 hills m⁻²). This might be due to increased grain yield at high density that resulted in decreased harvest index (Park, 1988). With regard to the nitrogen levels, the highest harvest index of 51.22 was noticed in N1 (120 kg ha⁻¹). With increase in the dose of nitrogen levels the harvest index was decreased. The lowest harvest index of 48.90 was obtained with N4 (300 kg ha⁻¹). The higher harvest indices with the increase in nitrogen levels were due to more biological yield caused by more availability of nutrients (Hasanuzzaman *et al.*, 2010). Similar results were reported by Sharma *et al.* (2012) where, harvest index decreased with increasing level of nitrogen.

IV. CONCLUSION

The results led to the conclusion that the plant density of 44.44 hills m⁻² and application of 180 kg N ha⁻¹ was found economical to obtain higher yield attributes, grain yield and straw yield under transplanted conditions.

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Table 1: Yield attributes of rice as influenced by nitrogen levels and plant densities

Plant densities	Panicle length (cm)	Panicle weight (g)	Panicles m ⁻²	Spikelets panicle ⁻¹	Filled spikelets panicle ⁻¹	Test weight (g)
Plant densities (PD) (hills m⁻²)						
Farmers practice (28) (PD ₁)	24.4	3.79 ^b	306 ^b	140 ^b	126 ^b	25.87 ^{ab}
15×15cm (44.44) (PD ₂)	24.3	3.74 ^b	333 ^a	134 ^c	118 ^c	26.44 ^a
25×25cm (16) (PD ₃)	24.9	4.29 ^a	291 ^c	154 ^a	133 ^a	25.34 ^b
SEd±	0.3	0.1	5.0	2.7	2.8	0.4
CD (P=0.05)	NS	0.3	9.8	5.5	5.7	0.8
NITROGEN N (Kg ha⁻¹)						
120 (N ₁)	24.1	3.79	250 ^b	132 ^b	118 ^b	24.83 ^c
180 (N ₂)	24.9	4.12	325 ^a	145 ^a	131 ^a	26.66 ^a
240 (N ₃)	24.9	4.10	332 ^a	147 ^a	128 ^a	26.26 ^{ab}
300 (N ₄)	24.3	3.77	334 ^a	147 ^a	125 ^a	25.78 ^{bc}
SEd±	0.4	0.2	5.5	3.1	3.2	0.4
CD (P=0.05)	NS	NS	11.3	6.4	6.6	0.9
Interaction (PD×N)						
SEd±	0.7	0.3	9.5	5.3	5.5	0.8
CD (P=0.05)	NS	NS	NS	NS	NS	NS

Note: Means with same letter are not significantly different

Table 2: Grain yield, straw yield and harvest index (HI) of rice as influenced by plant densities and nitrogen levels

Treatments	Grain yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)	Harvest index
Plant densities (PD) (hills m⁻²)			
Farmers practice (28)(S ₁)	7001 ^b	7009 ^{ab}	50.20
15×15cm (44.44) (S ₂)	7494 ^a	7540 ^a	49.94
25×25cm (16) (S ₃)	6647 ^c	6744 ^b	49.74
SEd±	126	273	
CD (P=0.05)	260	566	
Nitrogen (N) (kg ha⁻¹)			
120 (N ₁)	6011 ^b	5727 ^b	51.22
180 (N ₂)	7244 ^a	7226 ^a	50.08
240 (N ₃)	7448 ^a	7584 ^a	49.64
300 (N ₄)	7486 ^a	7853 ^a	48.90
SEd±	145	316	
CD (P=0.05)	300	654	
Interaction (PD×N)			
SEd±	280	546	
CD (P=0.05)	NS	NS	

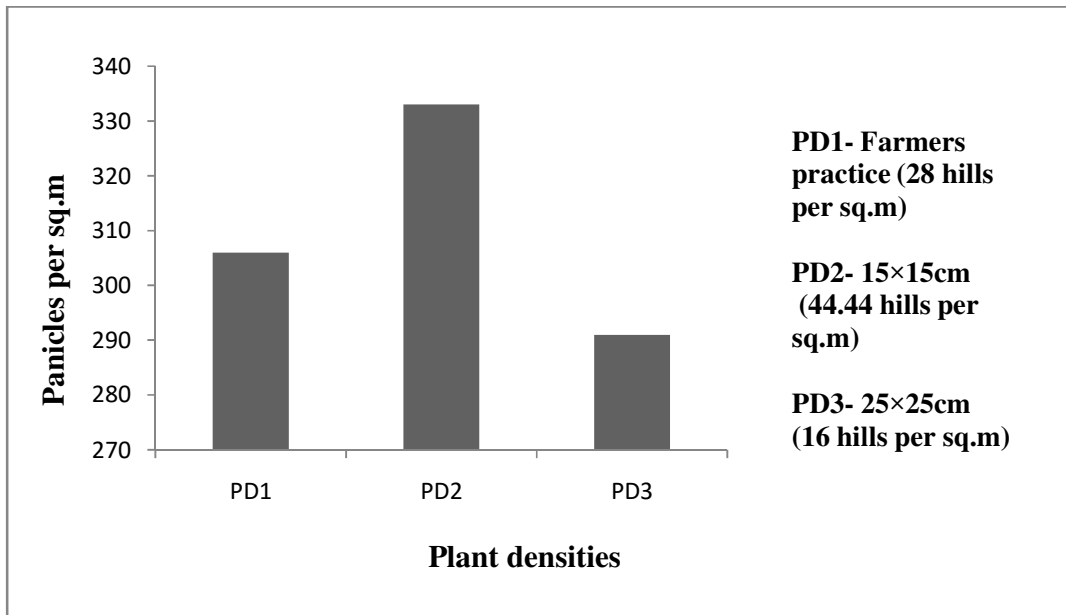


Fig.1. Effect of plant densities on panicles per sq.m

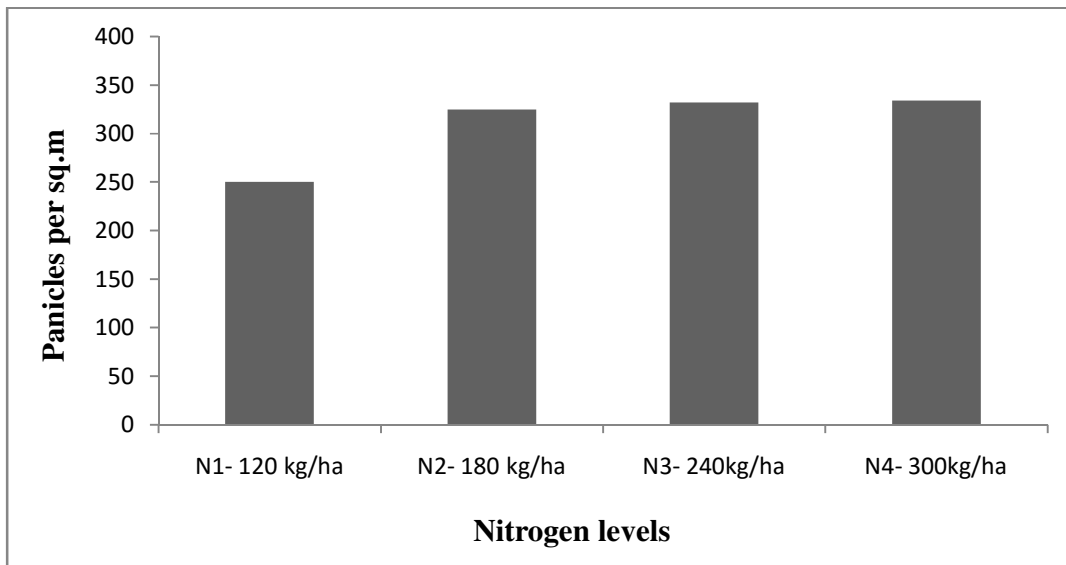


Fig.2. Effect of nitrogen levels on panicles per sq.m

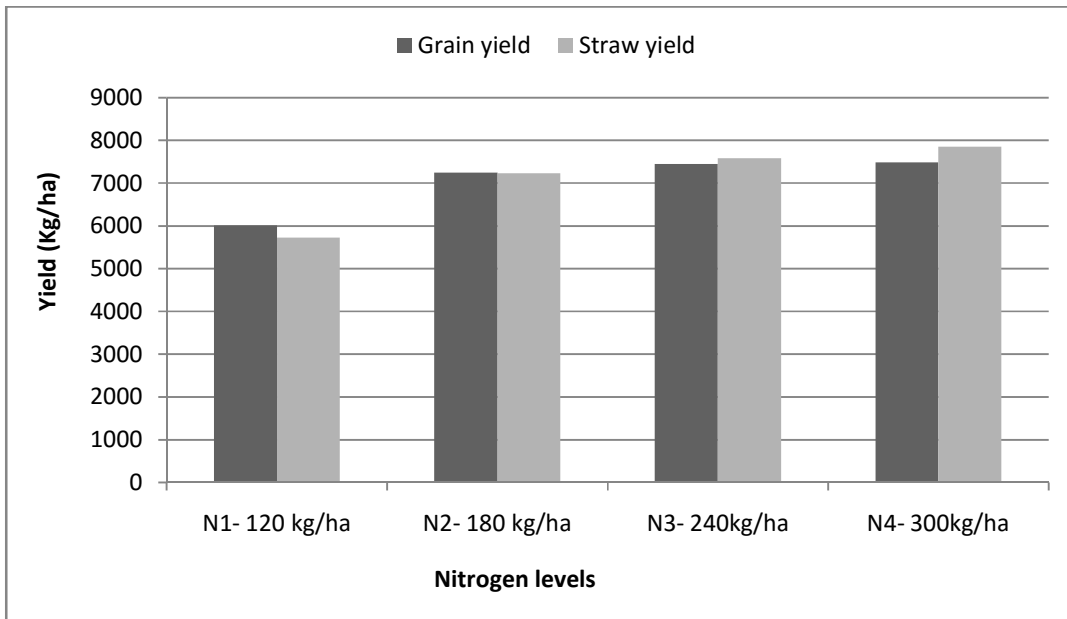


Fig.3. Effect of nitrogen levels on grain yield and straw yield of rice

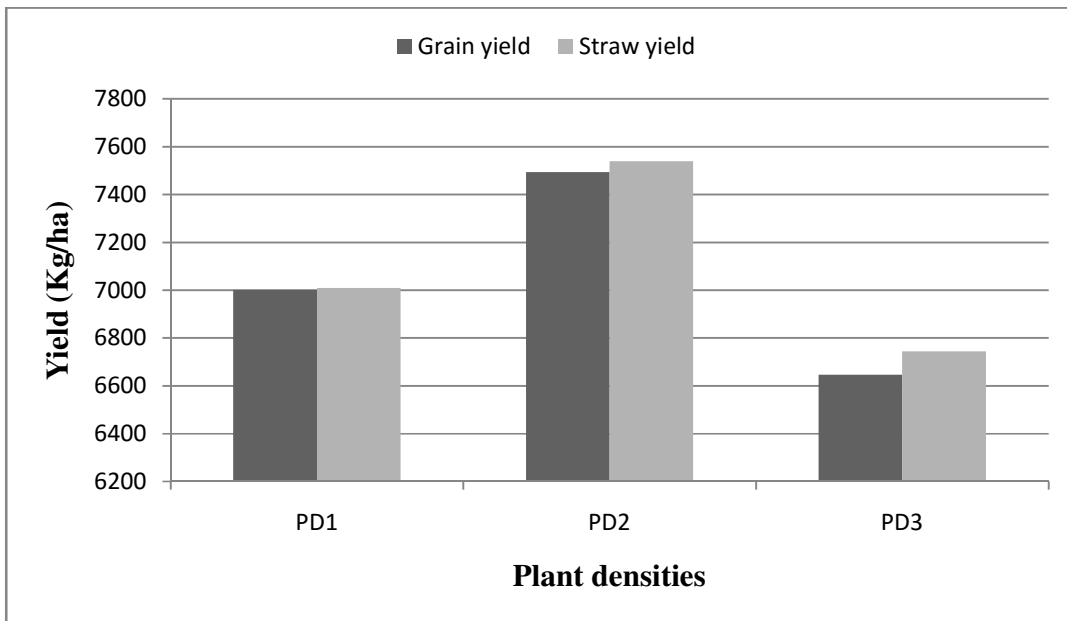


Fig.4. Effect of plant densities on grain yield of rice.

PD1- Farmers practice (28 hills per sq.m); PD2- 15x15cm (44.44 hills per sq.m and PD3- 25x25 cm (16 hills per sq.m)

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