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EFFECT OF PLANT DENSITIES AND AGE OF SEEDLINGS ON GROWTH AND YIELD PARAMETERS OF KHARIF RICE

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Abstract: An experiment was carried out at college farm, college of agriculture, PJTSAU, during 2013, to find out the effects of three plant densities (1, 3 and 5 seedlings hill^{-1}) four age of seedlings (15, 25, 35 and 45 days old seedlings) on *Kharif* Rice in sandy loam soils of Hyderabad. The results revealed that, 5 seedlings hill^{-1} recorded more grain and straw yield of 5817 kg ha,$^{-1}$ 7140 kg ha^{-1}respectively due to more tiller number (429 m^{-2}), LAI (1.41), dry matter production (1296 g m^{-2}) and productive tillers (288) over one and three seedlings hill^{-1}. Among the age of seedlings 25 days old seedlings recorded more number tiller number (407 m^{-2}), LAI (1.58) and dry matter production (1415 g m^{-2}) and productive tillers (286) with more spikelets panicle^{-1} (118), filled spikelets panicle^{-1} (112), panicle length (21.4 cm) and panicle weight (2.5 g) resulted in grain and straw yield of 6583 kg ha^{-1} and 7570 kg ha^{-1}. The higher HI was obtained with 5 seedlings hill^{-1} (45) and 25 days old seedlings (47).
Keywords: Rice, plant densities, age of seedlings, grain yield and straw yield.

INTRODUCTION

Rice is Asia's economically and culturally most important food crop and its production is regarded as the single most important economic activity on the planet. More than 2.7 billion people most of them poor rely on rice as their major source of food. By the year 2025, this number will grow to 3.9 billion people. It is life for thousands of millions of people in the globe. It is deeply embedded in the cultural heritage of their societies.

Although the average yield per area increased tremendously in the last forty years, the yield gap between economically optimal and actual yields remains large in many farmer's fields. This yield gap may be caused by unfavorable environmental conditions and limited material inputs, but inefficient production technologies and lacking knowledge contribute greatly. Unfavorable conditions forced the farmers to use over aged seedlings from the nursery and transplanting of more number of seedlings hill^{-1}. So it is necessary to use properly managed seedbeds with adequate nutrition and optimum seedling densities at appropriate age are important factors to get vigorous plant stands after transplanting.

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Plant densities (no. of seedlings hill^{-1}) are an important factor for rice production because it influences the radiation interception, photosynthetic rate, tiller production, nutrient uptake and other physiological phenomena and ultimately the growth and development of rice plant. The correct age of seedlings used for transplanting is of primary importance for uniform stand and seedling establishment as half of the success of rice cultivation depends upon the seedling age (Aziz *et al.,* 2005).

So this situation necessitates in refining the plant densities and age of seedlings for Kharif rice in Southern Telangana region. Keeping above points in view, the present investigation was carried out.

MATERIAL AND METHODS

The experiment was conducted during *kharif*, 2013 at college farm, Rajendranagar, Hyderabad situated at an altitude of 542.3 m above mean sea level at 17^{o}19' N latitude and 78^{o}23' E longitude. The soil of the experimental site was sandy loam in texture, alkaline in reaction, low in available nitrogen, available phosphorus and available potassium. The experiment was laid out in randomized block design (factorial) with three plant densities (1, 3 and 5 seedlings hill^{-1}) as factor one and four age of seedlings (15, 25, 35 and 45 days old seedlings) as factor two, replicated thrice. Other cultural operations and plant protection measures were followed as per the recommendations. During the cropping period rainfall of 532.4 mm was received in 28 rainy days as against the decennial average of 518.2 mm received in 34 rainy days for the corresponding period.

RESULTS and DISCUSSION

Growth parameters

Plant height: Significantly more plant height (94 cm) was noticed at physiological maturity stage with 1 seedling hill^{-1} (S_1) and was significantly superior over other two plant densities tried. However, 5 seedlings hill^{-1} recorded the lowest (86 cm) plant height at physiological maturity stage (Table 1). The decrease in plant height with increase in the number of seedlings hill^{-1} was might be due to the interplant competition for space and nutrients which might have resulted in attaining the lowest plant height (Islam *et al*., 2008).

However, the plant height was significantly highest (99 cm) in 25 days old seedlings, over 15, 35 and 45 days old seedlings at physiological maturity stage (Table 1). The increase in plant height from 25 days old seedlings might be due to more vigour, root growth and lesser transplant shock because of lesser leaf area during initial stages of crop growth, which stimulate increased cell division causing more stem elongation (Pramanik and Bera, 2013).

Tillers m^{-2}: Transplanting of 5 seedlings hill^{-1} produced significantly more tillers m^{-2} at heading stage (429 m^{-2}) and was followed by 3 seedlings hill^{-1} and 1 seedling hill^{-1} (Table 1). The more number of tillers m^{-2} in high density planting might be due to more plants m^{-2}. However, in less density planting total tillers production per plant increased but increase in tillers production failed to meet total tillers m^{-2} due to reduction in initial plant population (Yadav, 2007).

The highest (407 m^{-2}) number of tillers was inscribed in 25 days old seedlings at heading stage and was significantly superior to 15, 35 and 45 days old seedlings. Decreased number of tillers in 15 days old seedlings might be due to more time to recover and establishment after transplantation in the main field and hence resulting in shallow root system which discourages tillering (Patra and Haque, 2011). The decrease in tiller number with aged seedlings might be due to concomitant effect on crop establishment, less tillering period and crop duration in the main field compared to planting of 15 and 25 days old seedlings (Patel, 1999).

Leaf Area Index (LAI): LAI values increased steadily and reached maximum at heading stage thereafter, it decreased as the crop proceeds towards physiological maturity. Significantly higher (1.41) leaf area index was found with 5 seedlings hill^{-1} at physiological maturity stage over 3 seedlings hill^{-1} and 1 seedling hill^{-1} in turn, one seedling per hill recorded the lowest leaf area index values. The lower leaf area index values at lower density of seedlings hill^{-1} was due to the lower tiller number produced from lower number of seedlings hill^{-1} (Hasanuzzaman *et al.*, 2009).

Maximum (1.58) leaf area index was observed with 25 days old seedlings at physiological maturity stage and was significantly superior to 15, 35 and 45 days old seedlings. This might be due to high root activity and photosynthetic activity of young seedlings that cause increase in leaf area and more dry matter than older seedlings (Rewainy *et al.*, 2007).

Dry matter production (g m^{-2}): Significantly more (1296 g m^{-2}) crop dry matter was produced from 5 seedlings hill^{-1} at physiological maturity stage over 3 seedlings hill^{-1} and 1 seedling hill^{-1} (table 1). This might be due to more number of leaves which occupied the same land area and consequently trapped more light and CO_2 resulting in higher photosynthesis and producing more dry matter (Damodaran *et al.*, 2012).

Accumulation of higher (1415 g m^{-2}) dry matter was observed with 25 days old seedlings at physiological maturity stage. However, it was significantly superior to 15, 35 and 45 days old seedlings. The increased dry matter production with younger seedlings might be due to higher tiller production (Hussain *et al*., 2012).

Yield parameters

Panicles m^{-2}: Seedlings hill^{-1} had significant effect on production of panicle bearing tillers. Maximum (288) number of panicles m^{-2} was observed with 5 seedlings hill^{-1} and was significantly superior to 3 seedlings hill^{-1} and 1 seedling hill^{-1}. This might be due to better utilization of growth resources (Singh and Singh, 2009) and higher tiller production per unit area (Miller *et al*., 1991).

Age of seedlings showed remarkable effect on number of panicles m^{-2}. Higher number of panicles m^{-2} (296) were produced from 25 days old seedlings and was significantly superior to 15, 35 and 45 days old seedlings. This might be due to the ability of younger seedlings to had a shorter period of transplanting stress and the plant's ability with faster resumption of the rate of phyllochron development over that of older seedlings due to the higher nitrogen content in the younger ones (Yamamoto *et al.*, 1998). Because of this reason, higher number of effective tillers per hill in 25 days old seedling as compared to 45 old seedlings (Subedi, 2013).

Panicle length (cm): More (21.3 cm) panicle length was observed with 1 seedling hill^{-1} (S_1) and it was significantly superior to 3 seedling hill^{-1} and 5 seedlings hill^{-1}. This reduced panicle length at 5 and 3 seedlings hill^{-1} might be due to inter tiller competition for various growth factors in a hill resulted in the reduced panicle length (Sarkar *et al*., 2011).

The highest (21.4 cm) panicle length was observed with D_2 (25 days old seedlings) and it was on par with 15 days old seedlings (D_1) (21 cm), in turn these two were significantly superior to 35 days old seedlings (D_3) and 45 days old seedlings (D_4) as they recorded the less panicle length. This reduced panicle length might be due to less time available for the older seedlings for their vegetative growth and thereby rapidly entered into the reproductive phase producing shorter panicles (Sarkar *et al*., 2011).

Panicle weight (g): Significant decrease in panicle weight was observed, when the plant densities increased from 1 to 5 seedlings hill^{-1}. The highest (2.5 g) panicle weight was noticed at 1 seedling hill^{-1} and it was superior to 3 seedlings hill^{-1} and 5 seedlings hill^{-1}, in turn S_3 recorded the lowest panicle weight. This increased panicle weight might be due to the production of healthy and bold grains (Hossain *et al*., 2003).

Significantly, the highest (2.5 g) panicle weight was obtained with 25 days old seedlings (D_2) and was on par with 15 days old seedling (2.4 g), while these two were superior over 35 days old seedling and 45 days old seedlings as they recorded the lowest panicle weights. This higher panicle weight might be due to higher number of filled spikelets panicle^{-1} in 15 and 25 days aged seedlings (Pramanik and Bera, 2013).

Number of spikelets panicle^{-1}: Significantly the highest (119) number of spikelets panicle^{-1} was observed from 1 seedling hill^{-1} and was significantly superior to 3 seedlings hill^{-1} and 5 seedlings hill^{-1}, in turn the lowest (105) spikelets panicle^{-1} was observed from 5 seedlings hill^{-1}. This decreased number of spikelets in densely hilled plants might be due to more intra row competition between the plants and hence lower number of spikelets panicle^{-1} was observed (Islam *et al*., 2008).

The maximum (118) number of spikelets panicle^{-1} was obtained from 25 days old seedlings (D_2) and it was comparable with 15 days old seedlings (D_1) (118) and significantly superior to 35 (D_3) and 45 days old seedlings (D_4).

Number of filled spikelets panicle^{-1}: More (115) number of filled spikelets were observed from 1 seedling hill^{-1} and was significantly superior to 3 seedlings hill^{-1} and 5 seedlings hill^{-1}, however S_3 recorded the lowest (98) number of filled spikelets panicle^{-1}. This might be due to healthy and efficient individual plant growth at lesser seedling density. Planting less number of seedlings hill^{-1} enabled the plant to produce healthy tillers which had undergone normal physiological growth and duration, resulting in more healthy panicles with more filled spikelets, whereas, transplanting 5 seedlings hill^{-1} resulted in production of weak panicles with less filled spikelets (Rasool *et al*., 2012).

Number of filled spikelets panicle^{-1} significantly increased with increase in seedling age up to 25 days. The highest (112) number of filled spikelets panicle^{-1} was obtained with 25 days old seedlings, in turn it was on par with 15 days old seedlings (110) and were significantly superior to 35 days old seedlings and 45 days old seedlings. However, D_4 recorded the lowest (97) number of filled spikelets panicle^{-1}. The lesser number of filled spikelets with older seedlings might be due to less time available to old age seedlings for their growth, development and filling of grains and resulted in less filled spikelets (Sarkar *et al*., 2011).

Test weight (g): Either plant densities or age of seedlings did not exert any significant influence on test weight.

Grain yield (kg ha^{-1}): Higher (5817 kg ha^{-1}) grain yield was obtained from 5 seedlings hill^{-1} and was significantly superior to 3 seedlings hill^{-1} and 1 seedling hill^{-1}, in turn S_1 recorded the lowest (5134 kg ha^{-1}) grain yield. The increased grain yield of rice might be due to higher plant population, more leaf area index, more light interception and more number of effective tillers m^{-2} resulting in yield enhancement in 5 seedlings $hill^{-1}$ (Rasool *et al*., 2012). In addition to that, improvement of yield contributing characters like number of effective tillers $hill^{-1}$, panicle length, spikelets $panicle^{-1}$ and test weight also contributed to yield enhancement (Islam *et al*., 2013).

The grain yield of rice was declined with age of seedlings. The highest (6583 kg ha^{-1}) grain yield was noticed in 25 days old seedlings, which was significantly superior to 15, 35 and 45 days old seedlings. In turn the lowest (3559 kg ha^{-1}) grain yield was recorded from D_4. The higher grain yield production in the younger seedlings of 25 days might be attributed to the vigorous and healthy growth, development of more productive tillers and leaves ensuring greater resource utilization as compared to old age seedlings (Pramanik and Bera, 2013). The younger seedlings also aid to better phyllochron development and better tillering and thus, increase the final grain yield (Datta, 1980). Even though on par results observed in terms of panicle length, panicle weight, total spikelets per panicle and filled spikelets per panicle, the reduced yield in 15 days old seedlings over 25 days old seedlings was due to lesser effective tillers m^{-2}. This might be due to the mortality of young (15 days old) seedlings right after transplanting was reported as a reason for the lower yield compared to 25 days old seedlings (Bagheri *et al*., 2011).

Straw yield (kg ha^{-1}): Significantly more (7140 kg ha^{-1}) straw yield was recorded with 5 seedlings $hill^{-1}$, and was superior to 3 seedlings $hill^{-1}$ and 1 seedling $hill^{-1}$. Higher straw yield under 5 seedlings $hill^{-1}$ was probably due to more dry matter accumulation per unit area due to better nutrients absorption from soil, which increases metabolic process, rate of light absorption, photosynthetic activities and more number of leaves (Singh and Singh, 2005). The lowest straw yield was obtained from 1 seedling $hill^{-1}$ was due to the lowest number of total tillers m^{-2} (Bhowmik *et al*., 2012).

Age seedlings exerted a significant influence on straw yield. The highest (7570 kg ha^{-1}) straw yield was observed in 25 days old seedlings (D_2) and was significantly superior to 15, 35 and 45 days old seedlings, in turn D_4 recorded the lowest (6173 kg ha^{-1}) straw yield. The increased straw yield in the present study with 25 days old seedlings was due to more number of tillers and dry matter production when compared to 15 days old seedlings, where significantly less number of tillers and dry matter was obtained.

Harvest index: The highest (45) harvest index was observed with 5 seedlings $hill^{-1}$ and was followed by 3 seedlings $hill^{-1}$ and 1 seedling $hill^{-1}$. This might be due to better partitioning of photosynthates from vegetative part to the reproductive part of the plant (Singh and Singh, 2005).

With increase in age of seedlings, harvest index was decreased. The highest (47) harvest index was observed in 25 days old seedlings and was followed by 15 and 35 days old seedlings. The lowest harvest index was noticed in 45 days old seedlings. The decreased harvest index of 15 days old seedlings compared to 25 days old seedlings from the present result was due to reduced grain yield and straw yield with less number of tillers m^{-2}. The highest harvest index from 25 days old seedlings might be due to the proper crop growth and development and assimilate synthesis in the grains (Pramanik and Bera, 2013).

Conclusions

Under transplanted conditions, plant density of 5 seedlings $hill^{-1}$ was found to be economical to obtain higher grain yield (5827 kg ha^{-1}) and straw yield (7140 kg ha^{-1}). Using 25 days old seedlings was found to be economical to obtain higher yield (6583 kg ha^{-1}) and straw yield (7570 kg ha^{-1}).

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Table1: Different growth parameters at physiological maturity stage under varied plant densities and age of seedlings.

Treatments	Plant height (cm)	Tillers m^{-2}	LAI	Dry matter production (g m^{-2})
Plant densities(S)				
S_1 (1 seedling hill^{-1})	94^a	284^c	1.13^c	1177^c
S_2 (3 seedlings hill^{-1})	91^b	397^b	1.27^b	1231^b
S_3 (5 seedlings hill^{-1})	86^c	429^a	1.41^a	1296^a
SEm±	0.8	3.3	0.04	17.3
CD (p=0.05)	2.5	9.9	0.1	50.9
Age of seedlings (D)				
D_1 (15 days old seedlings)	93^b	379^b	1.31^b	1321^b
D_2 (25 days old seedlings)	99^a	407^a	1.58^a	1415^a
D_3 (35 days old seedlings)	88^c	353^c	1.18^c	1230^c
D_4 (45 days old seedlings)	81^d	340^d	1.00^d	974^d
SEm±	1.0	3.9	0.04	20.0
CD (p=0.05)	2.8	11.4	0.12	58.7
Interaction (S X D)				
SEm±	1.7	6.8	0.08	34.7
CD (p=0.05)	NS	NS	NS	NS

Note: Means with same letter are not significantly different

Table 2: Yield attributes of rice under varied plant densities and age of seedlings

Plant densities	Panicles m^{-2}	Panicle length (cm)	Panicle weight (g)	Spikelets $panicle^{-1}$	Filled spikelets $panicle^{-1}$	Test weight (g)
Plant densities (S)						
S_1 (1 seedling $hill^{-1}$)	249^c	21.3^a	2.5^a	119^a	115^a	21.1^a
S_2 (3 seedlings $hill^{-1}$)	266^b	20.3^b	2.3^b	112^b	104^b	21.3^a
S_3 (5 seedlings $hill^{-1}$)	288^a	19.7^c	2.0^c	105^c	98^c	21.3^a
SEm$\pm$	3.0	0.1	0.1	2.0	1.6	0.2
CD (p=0.05)	7.9	0.4	1.4	4.8	4.8	NS
Age of seedlings (D)						
D_1 (15 days old seedlings)	284^b	21.0^a	2.4^a	117^a	110^a	21.2^a
D_2 (25 days old seedlings)	296^a	21.4^a	2.5^a	118^a	112^a	21.6^a
D_3 (35 days old seedlings)	251^c	20.0^b	2.2^b	109^b	102^b	21.4^a
D_4 (45 days old seedlings)	240^d	19.3^c	2.0^c	102^c	97^c	20.8^a
SEm$\pm$	3.0	0.2	0.1	2.0	2.0	0.3
CD (p=0.05)	9.0	0.5	0.2	5.0	6.0	NS
Interaction (S X D)						
SEm$\pm$	5.4	0.3	0.1	3.0	3.3	0.4
CD (p=0.05)	NS	NS	NS	NS	NS	NS

Note: Means with same letter are not significantly differe

Table 3: Grain yield, straw yield and harvest index (HI) of rice under varied plant densities and age of seedlings

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index
Plant densities (S)			
S_1 (1 seedling $hill^{-1}$)	5134^c	6647^c	43
S_2 (3 seedlings $hill^{-1}$)	5457^b	6859^b	44
S_3 (5 seedlings $hill^{-1}$)	5817^a	7140^a	45
SEm$\pm$	95.4	51.6	
CD (p=0.05)	279.8	151.5	
Age of seedlings (D)			
D_1 (15 days old seedlings)	6060^b	7155^b	46
D_2 (25 days old seedlings)	6583^a	7570^a	47
D_3 (35 days old seedlings)	5676^c	6630^c	46
D_4 (45 days old seedlings)	3559^d	6173^d	36
SEm$\pm$	110.1	59.6	
CD (p=0.05)	323.1	174.9	
Interaction (S X D)			
SEm$\pm$	190.8	103.2	
CD (p=0.05)	NS	NS	

Note: Means with same letter are not significantly different