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Full length Research Paper

Agronomic assessment of Rice (Oryza sativa L.) for plant spacing and seedlings per hill under temperate conditions

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An experiment with rice as a test crop was conducted at the Experimental Farm, Shalimar Campus of Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir during the *kharif* season of 2005 to investigate the influence of different plant spacings and seedlings per hill on growth characters, yield attributes and yield of newly released transplanted rice variety Shalimar Rice-1. The experiment was laid out in Randomized Block Design with factorial arrangement assigning combination of spacings and number of seedlings hill^{-1} with three replications. The results revealed that grain yield, yield attributes and growth characters were influenced by different spacings. Closer spacing (15 × 15 cm) recorded higher plant height, tillers m^{-2}, leaf area index, dry matter accumulation as well as yield attributes. Significantly higher grain yield of 67.1 q ha^{-1}showing a superiority of 8.97% with 15 × 15 cm was observed over that of 20 × 20 cm spacing. Also, the closer spacing intercepted maximum photosynthetically active radiation (PAR) than wider spacing. Among, the number of seedling hill^{-1}, highest grain yield 9.79% with 3-seedings hill^{-1} was recorded than transplanting of 5-seedlings hill^{-1}. Regarding yield attributes higher values were observed with 3-seedlings hill^{-1} being at par with 2-seedlings hill^{-1}.

Key Words: Plant density, rice, seedling number hill^{-1}, tillering, transplanting.

INTRODUCTION

Rice (*Oryza sativa* L.) is a staple food of more than 60% of the world's population and provides more calories per hectare than any other crop. It is estimated that more than 40% world's population use rice as major source of calories (Munson, 1982) should use recent data. In India, rice is extensively grown on an area of 42 million ha with a production and a productivity of 117 million tonnes and 2.91 t ha^{-1} respectively (Anonymous, 2003a). In Jammu and Kashmir state, rice is a staple food covering an area of 2.492 lakh/ha with the production and productivity of 42.23 lakh quintals and 1.708 t ha^{-1} respectively (Anonymous, 2003b). The growth period of rice gets limited by low temperature in spring and autumn also temperature fluctuations at flowering and grain filling stage results in higher spikelet sterility. The plant population and number of seedlings hill^{-1} are the two cultural practices which exercise considerable influence on the stand geometry of the transplanted rice, and

hence its yield. Closer spacing and high number of seedlings hill^{-1} in rice has been found to compensate the loss in yield due to greater number of plants and tiller population per unit area of land (Das et al., 1988). The plant spacing and seedlings hill^{-1} can further influence variations through alteration in the attainment of phenophases and eventually the development of plant canopy.

MATERIALS AND METHODS

The field experiment was conducted during the kharif season of 2005 at the Agronomy Farm of Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Srinagar. The experiment site is situated at an altitude of 1587 m above mean sea level, at a distance of 15 km towards the north of Srinagar between 34° 08' N latitude and 74° 83'E longitude. The experiment was laid out in a randomized complete block design with a factorial arrangement of fifteen treatments replicated thrice. The treatments consisted of three levels of planting spacing viz. S_1 (15 × 15 cm), S_2 (15 × 20 cm), S_3 (20 × 20 cm) and five levels of seedlings hill^{-1} viz. H_1 (1-seedling hill^{-1}), H_2 (2-seedlings hill^{-1}), H_3 (3-seedlings hill^{-1}), H_4 (4-seedlings hill^{-1}) and H_5 (5-seedlings hill^{-1}). The soil before sowing was analysed for various physical, chemical and physico-chemical properties as per the standard procedure described by Jackson (1973). Analysis revealed that soil was silty clay loam in texture, with initial organic carbon 0.58 %, alkaline $KMnO_4$ N 220 kg ha^{-1}, (Olsen et al.,1954), 14.12 kg ha^{-1}, NH_4OAC K 248 kg ha^{-1}, pH of 6.92, solubridge conductivity (EC ds m^{-1} at 25°C) of 0.31 and CEC of 12.4 C mol kg^{-1}. The 30 days old seedlings were transplanted at a spacing of 15 × 15, 15 × 20, 20 × 20 cm with 1, 2, 3, 4 and 5 seedlings ha^{-1} . A basal dose of entire phosphorus, potassium and zinc was applied at 60 kg kg P_2O_5 ha^{-1}, 45 kg K_2O ha^{-1} and 20 kg $ZnsO_4$ ha^{-1} respectively. Nitrogen (120 kg ha $^{-1}$) was applied in 3-splits (50% as basal and the remaining in two equal splits at maximum tillering and panicle initiation). A newly released medium duration (138 to 145 days) rice variety "Shalimar Rice-1" was used as the test crop.

RESULTS

Spacing

Plant spacing caused the variation in yield parameters. The plant spacing of 20 ×20 cm significantly recorded higher panicle length, panicle weight more spikelets panicle^{-1}, grain panicle^{-1} as compared to 15 × 20 cm and 15 × 15 cm spacings. The wider spacing adopted appears to be an advantageous factor for better development of panicles, hence more panicle length, panicle weight, spikelets number and filled grains panicle^{-1}. However, the case was just reversed for number of effective tillers m^{-2}, being maximum under 15 × 15 cm spacing and lowest under 20 × 20 cm spacing. The possible reason may be the more number of plants with closer spacing than with wider spacing. Among the plant population tested 15 × 15 cm spaced crop gave significantly more grain and straw yields than 15 × 20 cm and 20 × 20 cm.

Seedlings hill^{-1}

The data on seedlings hill^{-1} showed the higher values of yield attributes with 1-seedlings hill^{-1} followed by the decreasing trend with the increase in seedling number hill^{-1}. The lowest were observed with 5-seedlings hill^{-1}. Planting fewer numbers of seedlings hill^{-1} enabled the plant to produce healthy tillers which had undergone normal physiological growth and field duration, resulting in more healthy panicles with more filled spikelets. Whereas, transplanting 4 to 5-seedlings hill^{-1} resulted in production of weak panicles with less filled spikelets.

DISCUSSION

The crop plants depend largely on temperature, solar radiation, moisture and soil fertility for their growth and nutritional requirements. Among various agronomic factors limiting yield, planting pattern is considered of great importance. Increase in yield can be ensured by maintaining appropriate plant population through different planting patterns (Ather Nadeem et al., 2004). The plant spacing and number of seedlings per hill are two effective factors in planting pattern design. The suitable plant density is an effective factor on yield increases. Optimum plant spacing ensures the plants to grow properly both in their aerial and underground parts through different utilization of solar radiation and nutrients. The optimum plant density depends on different factors that most importance of this factors include: plant characteristics, growth period duration, planting time and methods, soil fertility, plant size, available moisture, sun shin, planting pattern and situation of weeds. Baloch et al. (2002) found that wider spacing had linearly increasing effect on the performance of individual plants. 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. Omina EL-Shayieb (2003) showed that narrow spacing of 10 × 20 cm gave the highest yield and yield components of Giza 177 rice cultivar compared with 20 × 20 cm or 30 × 20 cm. Number of seedling per hill is another important factor that it can play important roles in boosting yield of rice. Because it influences the tiller formation, solar radiation interception, total sunshine reception, nutrient uptake, rate of photosynthesis and other physiological phenomena and ultimately affects the growth and development of rice plant. In densely populated rice field the inter-specific competition between the plants is high in which sometimes results in gradual shading and lodging and thus favour increased production of straw instead of grain. It is, therefore, necessary to determine the optimum plant spacing and number of seedling per hill for high yield. Faruk et al. (2009) reported that the highest grain yield was recorded from single seedlings per hill and the lowest one was recorded from four seedlings per hill.

Table 1. Yield attributes, grain and straw yields of rice as influenced by spacings and seedlings hill^{-1}.

Treatments	Effective tillers (m^{-2})	1000-grain weight (g)	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})
Spacings (cm)				
15 × 15 (S_1)	383.4	23.3	67.1	92.8
15 × 20 (S_2)	359.2	23.0	64.7	90.1
20 × 20 (S_3)	348.6	22.8	61.5	84.7
S.E.(m) ±	2.35	0.35	0.40	0.59
C.D (0.05)	6.81	NS	1.17	1.72
Seedlings hill^{-1}				
1 Seedling (H_1)	358.4	22.7	64.1	89.2
2 Seedling (H_2)	367.7	23.4	65.4	90.8
3 Seedling (H_3)	370.4	23.3	67.9	92.8
4 Seedling (H_4)	362.0	22.9	62.9	87.4
5 Seedling (H_5)	360.1	22.9	61.8	85.7
S.E (m) ±	3.03	0.45	0.52	0.77
C.D (0.05)	8.79	NS	1.52	2.22

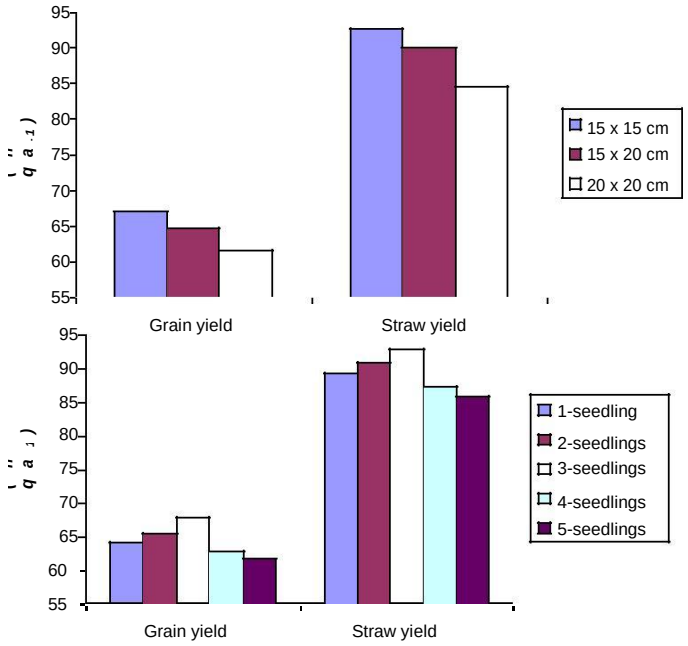

Figure 1. Grain and straw yield of rice as influenced by spacing and seedlings hill^{-1}.

In the present studies the plant spacing of 20 × 20 cm significantly recorded higher panicle length, panicle weight more spikelets panicle^{-1} and grain panicle^{-1} Efficient utilization of growth resources, less intra species competition coupled with higher availability of nutrients among the widely spaced crop plants may be ascribed the reason for superiority in yield components of rice. Similar findings were opined by Kumari et al. (2000) and Singh et al. (2003). However, number of effective tillers m^{-2}, being maximum under 15 × 15 cm spacing. These results are in accordance with the earlier reports of Shrivastava and Tripathi (1998). The different plant spacing did not influence the 1000-grain weight. However, higher values were observed with closer spacing. Similar findings were endorsed by Dongarwar et al. (2002). The grain and straw yields were significantly higher under the treatment 15 × 15 cm. This might be due to cumulative influence of higher plant population, higher temperature in the canopy, more leaf area index, more of light interception and higher number of effective tillers m^{-2} resulting in yield enhancement at 15 × 15 cm spacing maximum grain yield registered under closer spacing was opined by Rajarathinam and Balasubramaniyan (1999) and Singh et al. (2003).

The present study revealed that single seedling hill^{-1} recorded significantly higher yield and its attributes as compared to other treatments of planting. This may be due to healthy and efficient individual plant growth at lesser seedling density. With the increase in number of seedlings hill^{-1}, grain and straw yields increases up to 3-seedlings hill^{-1} but further increase to 5-seedlings hill^{-1} showed decreased trend. This might be due to less number of effective tillers m^{-2} and lesser assimilation rate at 5-seedlings hill^{-1}. The higher yield with low seedling density might be due to higher percentage of productive to total tillers and more interception of light. Also, grain filling is the process of remobilization from stored reserves, particularly from stem, leaves, and from current photosynthesis. So, it may be inferred that the effectiveness of grain filling is decided by the conditions of particular tiller. Hence, planting of fewer seedlings resulted in higher grain yield (Figure 1 and Table 1). The result corroborates the findings of Faruk et al. (2009) and Banik

et al. (1997).

Conclusion

This study confirms the role of plant spacing and seedlings hill^{-1} in increasing the yield and yield attributes of rice. From the results of the experiment, plant spacing of 15 × 15 cm with single seedling hill^{-1} may be recommended for increasing rice yield particularly under temperate conditions of Kashmir Valley. However, before giving final recommendations, the investigation needs to be carried out at different agro-climatic regions of the Valley to arrive at final conclusions.

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