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Response of Growth and Yield of Direct Seeded Rice Cultivars Under Different Planting Patterns

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Abstract: Plant population is largely depends on planting pattern and affect growth and yield of direct seeded rice. A field study was planned to investigate the response of growth and yield of direct seeded rice cultivars under three planting patterns (Broadcast, 11.5 cm row spacing and 23 cm row spacing) in climatic conditions of Sheikhupura, Punjab, Pakistan. Different yield and yield contributing parameters were recorded to assess the genotypic differences in two rice cultivars (Basmati-2000 and KSK-515) in response to planting pattern. The experiment was laid out in randomized complete block design (RCBD) with split plot arrangement, replicated thrice. Recorded parameters plant height, number of total and productive tillers, thousand kernel weight and grain yield were significantly different in both varieties (KSK-515 and Basmati-2000) and three planting methods (Broadcast, 11.5 cm row spacing and 23 cm row spacing) however their interactive affect remained statistically non-significant. In term of grain yield KSK-515 was recorded highest yield (2.69 t ha-1) as compare to Basmati-2000 (2.37 t ha^{-1}) while 23 cm row spacing produced higher yield (3.1 t ha-1) in comparison to other sowing methods i.e., 11.5 cm row spacing (2.40 t ha^{-1}), broadcast (2.06 t ha^{-1}).

Keywords: Direct seeding, Broadcast, Row spacing, Rice cultivars, Kernel yield.

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1. Introduction

Rice (*Oryza sativa* L.) is vital cereal grain used as basic food by one third population over the world. More than hundred countries of the world grow rice approximately on an area of 160 million hectares with an average production of 700 million tons (Alam et al., 2009). World population is predicted to reach 9-11 billion up to 2025 and nearly 4.3 billion population would depends on rice to meet their dietary needs (Bisne et al., 2009). Approximately 90% of rice is cultivated and consumed in Asia and South East Asia, which gives 50-80% calories to Asian population to meet their energy needs (Negalur et al., 2016). Rice is second important cereal crop in Pakistan after wheat which covers almost 2.58 million hectares that produced 5.54 million tons of rice (Mahmood et al., 2016). Depleting water reserves may cause the problem of sustainable food production from irrigated agriculture around the globe (Gleick, 1993; Postel, 1997). Rice requires huge quantity of water from emergence to maturity as compared with other cereal crops (Bhuiyan, 1992). But water use efficiency of rice crop is very low. Transplanted rice is grown in puddled field, aims to minimize percolation losses and to manage the weeds. However, practice of puddling requires large amount of water (Kukal and Aggarwal, 2003).

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Food security aims to grow crops with minimum use of water and maximum production (Barker et al., 1998). Increasing water crisis under changing climatic conditions and escalating labor and input costs are globally threatening rice production (Farooq et al., 2011). Therefore efficient use of water in rice production is an important task to conserve water resources (Wang et al., 2002; Tong and Bouman, 2003). Direct seeding of rice is a crop production practice to attain optimum crop stand and high water use efficiency in water deficit areas (Surpndra et al., 2001). Rao et al. (2007) reported that 23% of rice is grown as direct seeded worldwide. Direct seeding of rice (DSR) has many advantages over transplanted rice (Sing et al., 2005; Nawaz et al., 2017). Direct seeding of rice is an easy way to grow crop, it requires less labor and water (Bhushan et al., 2007).

Optimum environment in field condition plays an important role in yield formation, in that environment planting geometry plays a significant role (Dechard et al., 1978; Rehmani et al., 2014). So, planting geometry greatly influences the growth and yield of rice crop. Wider row spacing and low plant density increases rice yield (Yan et al., 2007). Different plant varieties possess different growing pattern under field conditions. Rice planting density depends upon the type of cultivar. Wider row spacing greatly influence the tiller dynamics of rice crop. Row spacing enhances the radiation use efficiency (RUE) and crop yield (Hai-xin et al., 2012). Optimum row spacing not only influences the morphological characteristics of stem but also enhances the plant physiological characteristics and reduces lodging (Li-Yong et al., 2003).

2. Materials and Methods

2.1 Experimental Site

A field experiment was conducted at Adaptive Research Station, Sheikhupura, Pakistan in kharif season 2015-16. The experimental site is located between 31° to 42° N and 73° to 59° E and 209.77m above sea level. The site is characterized by moist sub humid climate. The experimental soil was clay loam, slightly alkaline and having low organic matter.

2.2 Experimental Design

The experiment was laid out in randomized complete block design (RCBD) with split plot arrangement, replicated thrice with single plot size of 9 m^2. The main plot treatments are comprised of two rice cultivars (Basmati-2000 and KSK-515) and sub plot treatments comprised of three planting patterns (Broadcast, 11.5 cm line sowing and 23 cm line sowing).

2.3 Sowing Operations

The experimental field was dry tilled with disc plough and twice ploughed with cultivator followed by planking. Dry seeds of both varieties (Basmati-2000 and KSK-515) were sown manually @ 50 kg ha^{-1} in their respective sowing pattern. In addition broadcasting was done manually followed by planking in order to cover the seeds from insects, birds and rodents. Line sowing was done with manual hand drill. Weed control, fertilizer, irrigation and other management practices were the same as recommended.

Table 1. Genotypic differences in days to start of emergence and total number of seedlings (m^{-2}) under different planting methods.

Treatment	Start of emergence (days)	Total no. of seedlings (m^{-2})
Factor A	**Main Plot (Variety)**	
KSK-515	4.63	152.16
Basmati-2000	4.56	151.41
LSD($p \leq 0.05$)	**0.28**	**7.55**
Significance	**ns**	**ns**
Factor B	**Sub-Plot (Planting Patterns)**	
Broadcast	5.05 a	141.48 c
Spacing (11.5 cm)	4.67 b	166.12 a
Spacing (23 cm)	4.08 c	147.75 b
LSD($p \leq 0.05$)	**0.34**	**3.73**
Significance	**	**
Interaction	**Variety × Planting Patterns**	
Significance	**ns**	**ns**

*, $p \leq 0.05$; **, $p \leq 0.01$; ns, non-significant.

Table 2. Genotypic differences in yield contributing parameters as affected under different planting methods.

Treatment	Plant Height (cm)	Total Tillers (m^{-2})	Productive Tillers (m^{-2})	Branches Panicle^{-1}	Grains Panicle^{-1}	TGW (g)	BY (t/ha)	EY (t/ha)	SY (t/ha)
Factor A	Main Plot (Variety)								
KSK-515	81.96 a	330.78 a	314.9 a	9.0	68.71	18.5 a	9.15	2.69 a	6.45
Basmati-2000	58.79 b	305.78 b	286.4 b	8.41	61.26	16.7 b	8.82	2.37 b	6.44
LSD(p≤0.05)	**2.64**	**24.26**	**24.86**	**0.63**	**9.08**	**1.18**	**0.51**	**0.29**	**0.36**
Significance	**	*	*	ns	ns	*	ns	*	ns
Factor B	Sub-Plot (Planting Patterns)								
Broadcast	68.31 b	264.50 c	240.5 c	7.19 c	46.92 c	15.1 c	5.77 b	2.06 c	3.71 c
Spacing (11.5 cm)	70.78 ab	338.0 b	322.8 b	8.85 b	66.62 b	17.4 b	10.58 a	2.40 b	8.18 a
Spacing (23 cm)	72.03 a	352.33 a	338.7 a	10.11 a	81.41 a	20.4 a	10.60 a	3.1 a	7.46 b
LSD(p≤0.05)	**2.79**	**13.66**	**13.79**	**0.63**	**5.17**	**1.0**	**0.22**	**0.12**	**0.18**
Significance	*	**	**	**	**	**	**	**	**
Interaction	Variety × Planting Patterns								
Significance	ns	ns	ns	ns	ns	ns	*	ns	*

BY, Biological yield; EY, economic yield; SY, straw yield; TGW, 1000-grain yield; *, p≤ 0.05; **,p≤0.01; ns, non-significant.

2.4. Observations Recorded

The emergence count was recorded in broadcast by using 100 cm × 100 cm quadrate. In line sowing method 100 cm row length was used and then converted as number of seedlings m^{-2}.

Five representative plants were randomly selected in respective plot to measure plant height by using measuring tape. Total tillers and productive tillers were counted by 100 cm × 100 cm quadrate in broadcast method while in line sowing 100 cm length of the row was used and later on converted in square meter. Grains per panicle were manually counted. 1000-karnel weight of respective sample and yield was calculated with the help of electric balance.

2.5. Statistical Analysis

Collected data processed by Fisher's analysis of variance method. The differences between treatment means were compared by using least significant difference (LSD) test at 5% probability level (Steel et al., 1997).

3. Results and Discussion

The results of different rice cultivars and their sowing methods on days to start and final emergence were shown in Table 1. Laary et al., (2012), also found similar results regarding plant establishment (m^{-2}) under broadcast and drill sowing method. Table 2 shows results of yield and yield contributing traits of two rice cultivars and planting pattern that was obtained from field trial.

3.1. Vegetative Parameters

Two different cultivars of rice KSK-515 and Basmati-2000 does not significantly affected days to start of emergence and final emergence. While planting patterns significantly affect days to start of emergence with highest value (5.05 days) followed by row spacing 11.5 cm (4.67 days) and minimum value (4.08 days) was observed in 23 cm row spacing. Final seedling emergence was also significantly affected by sowing patterns, maximum number of seedlings (166.12 m^{-2}) was counted in 11.5 cm row spacing, while 23 cm row spacing contained (147.75 m^{-2}) number of seedlings whereas minimum number of seedlings (141.4 m^{-2}) were counted in broadcast method. Oyewole and Attah (2007) concluded that broadcast method provided low plant establishment as compared to line sowing method.

Two different cultivars significantly affected plant height with maximum height was measured in KSK-515 (81.96 cm) in contrast Basmati-2000 showed minimum plant height (58.79 cm). Planting patterns also significantly affects the plant height with maximum plant height (72.03 cm) was observed in 23 cm row spacing but (68.31 cm) plant height was observed in broadcast method. Findings of Kikon and Gohain (2016) elaborated that line sowing method had maximum plant height as compared to broadcast method in two different rice cultivars.

The interactive effect between planting pattern and rice genotypes on number of total tillers and productive tillers were found statistically non-significant. Maximum number of total tillers (330.78

m^{-2}) and productive tillers (314.89 m^{-2}) were observed in KSK-515 followed by (305.78 m^{-2}) and (286.44 m^{-2}) in Basmati-2000. Regarding planting pattern wide rows of 23 cm recorded with maximum number of total tillers (352.33 m^{-2}) and productive tillers (338.67 m^{-2}) whereas broadcast method was recorded minimum number of total tillers (264.50 m^{-2}) and productive tillers (240.50 m^{-2}). Tillering pattern of this experimental study were also matched with the presented results of Kikon and Gohain (2016).

3.4. Yield Parameters

KSK-515 and Basmati-2000 does not significantly effects number of branches/panicle. Maximum number of branches (10.11) was observed in 23 cm wider rows and minimum number of branches/panicle (7.19) in broadcast method. Both the varieties does not significantly affected number of grains/panicle while planting patterns have significant effect on grains/panicle with maximum number (81.41) and minimum number (46.92) in 23 cm row spacing and broadcast method respectively. Maximum thousand kernel weight (18.55 g) was weighed in KSK-515 and minimum value (16.7 g) was observed in Basmati-2000. In relation to planting patterns 1000-kernel weight is significantly different in different sowing patterns. Highest thousand kernel weight (20.40 g) observed in 23 cm row spacing and minimum weight (15.08 g) observed in broadcast method. Das et al., (2017) resulted that number of grains per panicle were maximum in wider rows and 1000-kernel weight was also maximum in wide rows under different cultivars.

Both the cultivars have non-significant effect on biological and straw yield but sowing methods have significant effect. Row spacing of 23 cm produced (10.60 t ha^{-1}) which was significantly at par with 11.5 cm row spacing (10.58 t ha^{-1}) and minimum biological yield (5.77 t ha^{-1}) was observed in broadcast method. Planting patterns significantly affects the production of straw yield. Maximum straw yield (8.18 t ha^{-1}) was obtained in 11.5 cm row spacing whereas minimum straw yield (3.71 t ha^{-1}) obtained in broadcast method. Bazaya et al., (2009) also found the similar results.

In term of economic yield both KSK-515 and Basmati-2000 are significantly different from each other. Maximum yield (2.69 t ha^{-1}) was obtained in KSK-515 while Basmati-2000 produced minimum (2.37 t ha^{-1}) kernels yield. The mean value of kernel yield was significantly different in different planting methods. In case of 23 cm row spacing maximum average kernel yield (3.1 t ha^{-1}) was obtained followed by (2.40 t ha^{-1}) in 11.5 cm whereas minimum yield (2.06 t ha^{-1}) was produced by broadcast method. Regarding interaction of rice varieties and sowing methods the results are non-significant. Das et al., (2017) quantified that maximum yield was obtained in wider rows as compared to other sowing method in different rice cultivars.

4. Conclusion

KSK-515 performed better in terms of plant height, number of total and productive tillers, thousand kernel weight and economic yield but in contrast KSK-515 and Basmati-2000 are not statistically different in number of branches/panicle, number of grains/panicle, biological yield and straw yield. While rice sown at 23 cm row spacing performed better in comparison to 11.5 cm row spacing and broadcasting method under climatic conditions of Sheikhupura, Punjab, Pakistan.

Author Contribution: ALV, NA and MMS planned research and collected data. AM and AB performed statistical analysis.GH assisted in initial manuscript write-up and table data presentation. All the authors discussed the results and assisted in preparation of manuscript and their revision.

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List of abbreviations: DSR, Direct seeded rice; LSD, Least significant difference; Ns, Non-significant; RCBD, Randomize complete block design; RUE, Radiation use efficiency.

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