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Growth and yield attributes and grain yield as influenced by varying seed rates and spacing of rice under upland irrigated condition

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ABSTRACT : A field experiment was conducted at Upland Paddy Research Scheme farm, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani during *Kharif* 2012. The soil was low in available nitrogen, medium in phosphorus, high in potassium and low in ferrous sulfate. The experiment was laid out in spilt plot design with fifteen (15) treatment combinations and three replications, with five seed rates in main plot *i.e.* 25 kg/ha, 30 kg/ha, 35 kg/ha, 40 kg/ha and 60 kg/ha and three spacing in sub plot *i.e.* 20 cm, 25 cm, 30 cm. The rice variety 'Avishkar' was sown in first week of July, 2012. Among the different seed rates, higher seed rate of 60 kg/ha showed significantly taller plants than rest of the lower seed rates. The seed rate of 35 kg/ha recorded the higher mean number of functional leaves/plant and mean number of tillers/m^2 over the rest of the seed rates. However, it was at par with seed rate 30 kg/ha for number of functional leaves per plant. The maximum leaf area per plant was at the seed rate of 30 kg/ha at all growth stages and was followed by the seed rate of 35, 40 and 60 kg/ha. Significantly maximum panicle weight, filled grains/panicle and least number of unfilled grains/panicle were observed in the lower seed rate of 25 kg/ha, except for panicle weight with 30 kg/ha and 35 kg/ha of seed rates and number of filled grains with 30 kg/ha of seed rate. However, mean number of panicles/m^2 were maximum under 35 kg/ha and was at par with 40 and 60 kg/ha of seed rates. The maximum grain yield (3145 kg/ha) and NMR (Rs. 30232) was obtained with 35 kg/ha of seed rate. However, it was at par with seed rates 30, 40 and 25 kg/ha for grain yield and with 30 kg/ha seed rate for NMR. The highest B:C ratio obtained from the seed rate of 35 kg/ha (3.02) and was closely follow by 30 kg/ha (2.97). Wider spacing (30 cm) produced significantly more plant height, leaf area/m^2 and number of tillers/m^2 than rest of the closer spacing under study. Similarly the spacing of 30 cm gave significantly more panicle weight, number of panicle/m^2 at harvest than both the closer spacing of 25 cm and 20 cm. This ultimately resulted into higher grain (3065 kg/ha), straw (4045 kg/ha) and biological yield (7110 kg/ha) under the wider spacing (30 cm) than both the closer spacings (25 cm and 20 cm). The highest net monetary returns of Rs. 27139 and B:C ratio (2.91) was observed with the spacing of 30 cm followed by 25 cm (Rs. 2371 and 2.59) and 20 cm (Rs. 18469 and 2.22), respectively.

Key **W**ords : Direct seeded rice, Seed rate, Spacing

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Rice is the main staple food in Asia and particularly in Indian subcontinent. India ranks first in area (42.4 mill ha) and second in rice production with a share of 21 per cent (104 mill tones) of world rice production in 2012. Moreover, rice is major agriculture commodity of India for earning foreign currency and contributes about 338090 million rupees in agricultural exports (20%) in 2012-13 .However, productivity is very low as compared to other rice growing countries like Japan (6.4 tones/ha), China (6.0 tones/ha) and USA (7.5 tones/ha), whereas the average yield of rice in India is only 3.2 tones/ha (Anonymous, 2013). In view of shrinking resources like arable land, irrigation water and energy there is

shifting of rice crop by more remunerative crops like soybean which require less labour and water (Tomar *et al*., 2012). Rice production systems are undergoing several changes and one of such change is shift from transplanted rice to direct seeding *i.e.* aerobic rice (Mishra and Singh, 2011). The main driving forces of these changes are the rising wages, non - availability of labour and scarcity of water. Direct seeding offers certain advantages *i.e.* saves labour, faster and easier planting helps in timely sowing, less drudgery, early crop maturity by 7-10 days, less water requirement, low production cost, more crops and less methane emission (Balsubranmaian and Hill, 2002). Therefore, direct seeded rice (drilling) at least in upland and midland transplanted rice is the need of the day. The crop is sown during either pre-monsoon or with early onset of monsoon, which can avoid higher costs involved in raising rice seedling and transplanting operation in addition to the advantages of early crop maturity by about a week (Datta and Flinn, 1986).

The optimum seed rate is important factor that affects crop micro environment by influencing the degree of inter and intra plant competition. Therefore, optimum seed rate is required for direct seeded rice, the plant should be planted neither too thick nor too thin, so that input use efficiency may be enhanced to maximum production as plant spacing affect the grain yield and other characters by influencing the availability of solar radiation, access to available moisture and nutrients and competition with weeds (Kumar *et al*., 2002).

The high seed rate of 60-100 kg ha^{-1} is recommended for direct seeded rice particularly under rainfed situation. Direct sowing of rice is quicker, easier and economical one, but its optimum seed rate need to be tested for better use of resources and minimize weed infestation and cost. With above consideration, it is felt necessary to plan field trial to study the effect of different seed rate and plant spacing in drilled upland paddy, therefore, a field experiment entitled effect of different seed rate and spacing on rice grain yield under aerobic situation. (*Oryza sativa* L.) was conducted on experimental farm of Upland Paddy Research Scheme, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani during the *Kharif* season 2012 with the objectives of to study the influence of seed rates and spacings on growth and grain yield under aerobic rice.

RESEARCH PROCEDURE

A field experiment was conducted at Upland Paddy Research Scheme Farm, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani during *Kharif* 2012. The soil was low in available nitrogen, medium in phosphorus, high in potassium and low in ferrous and zinc. The experiment was laid out in spilt plot design with fifteen (15) treatment combinations and three replications, with five seed rates in main plot *i.e.* 25, 30 , 35, 40 and 60 kg/ha, respectively and three spacing in sub plot *i.e.* 20, 25, 30 cm. The rice variety Avishkar was sown on 2nd July, 2012. The mechanical and chemical analysis of soil revealed that the soil of the experimental area was clayey in texture, medium in organic carbon, medium in available nitrogen, medium in available phosphorus and high in available potassium with slightly alkaline in reaction. The rainfall received during the season was 85.61 per cent of the normal (761.1 mm) rainfall 38 rainy days. The mean maximum and minimum temperature during experimental period were 31.77°C to 21.64°C, respectively.

RESEARCH ANALYSIS AND REASONING

The findings of the present study as well as relevant discussion have been presented under the following heads :

Seed rate :

Growth attributes :

Amongst different seed rates higher seed rate of 60 kg/ha produced significantly taller plant than rest of the lower seed rates (Table 1). This might be due to higher competition for nutrient, moisture and space which resulted into increased height under higher seed rates as compared to lower seed rates and for availing more solar radiation for mitigating the need of photosynthesis for the development of plant due to crowding of plants with higher seed rates. Similar results were reported by Mahajan *et al.* (2006).

The mean numbers of functional leaves per plant were maximum with the seed rate of 35 kg/ha at 90 DAS at harvest as compared to other seed rates except, the seed rate of 30 kg/ha. However, 25 kg seed rate recorded lower number of leaves which might be due to poor establishment of crop as compared to higher seed rates of 30, 35 and 40 kg/ha indicating requirement of optimum population for better establishment of crop. It was evident from data (Table 1) that leaf area per plant was significantly more in seed rate of 30 kg/ha at all growth stages of observation and was followed by 25 kg/ha, 35 kg/ha, 40 kg/ha and 60 kg/ha. The mean number of tillers/m^2 were significantly more under 35 kg/ha of seed rate at 90 DAS and at harvest than rest of the seed rates. It was followed by seed rates of 30, 40, 25 and 60 kg/ha at harvest, respectively. This indicated that number of tillers/m^2 at higher seed rates (60 and 40 kg/ha) were compensated by lower seed rates (30, 35 kg/ha). Moreover, low seed rate of 25 kg/ ha showed less number of tillers per m^2 than 30 and 35 kg/ha at harvest. This indicated the superiority of seed rates @ of 35 and 30 kg/ha over rest of the seed rates for optimum expression into number of tillers which might be due to optimum combination of number of plants/m^2 and number of tillers/plant. This might be attributed to efficient accumulation of photosynthesis in the leaves with better root development due to reduced completion amongst the plants under lower seed rates. The similar results were reported by Reddy (1998).

Yield attributes :

Panicle weight, number of panicles at harvest, filled grains per panicle and unfilled grains per panicle were significantly affected due to different seed rates (Table 1). The significantly maximum panicle weight, filled grains per panicle and least number of unfilled grains per panicle were observed with low seed rate of 25 kg/ha and was comparable with 30 kg seed rate for panicle weight and number of filled grains and also comparable with 35 kg/ ha seed rate for panicle weight. The competition among plants for nutrients, light and space at each higher level of seed rate decreased the number of leaves, leaf area which ultimately reduced the grains per panicle, panicle weight, filled grains per panicle and increased unfilled grains per panicle. However, the mean number of panicles/m^2 were maximum under 35 kg/ha and was at par with 40 and 30 kg/ha seed rate this indicated superiority of 35 kg seed rate over low and high seed rates for expressing maximum panicles per unit area due to the combination of number of plants per unit area and yield attributes/plant. Similar results were recorded by Angiras and Sharma (1998). The test weight (1000 grains weight)

Table 1 : Growth and yield attributes as influenced by seed rate and spacing in direct seeded rice

	Plant height (cm) at harvest	No. of leaves at 90 DAS	Leaf area at 90 DAS (cm^2/ plant)	No. of tillers at harvest (per m^2)	No. of filled grains/ panicle at harvest	No. of unfilled grains/ panicle at harvest	Panicle weight at harvest (g/plant)	1000 grain weight (g)
Main plot (seed rates)								
25 kg/ha	72.6	20.8	375	160	136.2	2.3	4.82	29.7
30 kg/ha	77.3	21.4	380	169	132.2	2.8	4.54	27.9
35 kg/ha	77.9	21.7	373	173	128.3	3.1	4.50	28.4
40 kg/ha	78.2	21.1	315	167	124.4	3.8	4.25	27.4
60 kg/ha	82.4	15.4	310	159	109.6	4.6	4.10	26.7
S.E. ±	0.38	0.2	4.8	0.9	2.1	0.07	0.16	0.15
C.D. (P=0.05)	1.14	0.6	14.1	2.7	6.2	0.21	0.49	NS
Sub - plot (row to tow spacings)								
20 cm	74.1	20.2	347	161	3.43	3.4	4.14	27.7
25 cm	77.6	20.3	349	164	3.3	3.3	4.34	27.5
30 cm	81.2	20.0	355	171	3.13	3.13	4.72	28.9
S.E. ±	1.8	0.08	3.3	2.9	0.09	0.09	0.12	0.08
C.D. (P=0.05)	5.4	NS	NS	6.6	NS	NS	0.36	NS
S.E. ±	4.1	0.18	7.2	3.1	3.8	0.2	0.17	0.19
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
General mean	77.7	20.2	350.4	166	126.2	3.3	4.4	28.0

NS = Non–significant

Table 2 : Yield, net monitory returns and gross monitory returns as influenced by seed rate and spacing in direct seeded rice

	Grain yield (kg/ha)	Straw yield (kg/ha)	Gross monitory return (Rs./ha)	Net monitory returns (Rs./ha)	B : C ratio
Main plot (seed rates)					
25 kg/ha	2917	2992	37129	22630	2.56
30 kg/ha	3125	3477	43736	29012	2.97
35 kg/ha	3145	3682	45181	30232	3.02
40 kg/ha	3040	3835	41502	26328	2.73
60 kg/ha	2466	4228	31323	15249	1.81
S.E. ±	88.13	128.2	1264	1226	--
C.D. (P=0.05)	260.2	379.18	3733	3644	--
Sub- plot (row to tow spacings)					
20 cm	2814	3256	33553	18469	2.22
25 cm	2938	3627	37883	23271	2.59
30 cm	3065	4045	41279	27139	2.91
S.E. ±	65.2	113.7	875	845	--
C.D. (P=0.05)	193.4	334.14	2597	2498	--
General mean	2934	3643	38948	24041	2.60

was not significantly affected due to different seed rates.

Yield :

Grain yield and straw yield were significantly influenced due to different seed rates. The maximum grain yield was recorded in 35 kg/ha (3145 kg/ha) and it was at par with seed rate of 30 kg/ha, 40 kg/ha and 25 kg/ha (Table 2). Comparable seed yields were observed for the seed rates (25-40 kg/ha) which might be due to increased values of yield attributes *viz.*, number of panicles/m^2, number of grains/panicle and less number of unfilled grains/panicle under low seed rates compared to higher seed rate which negotiated the grain yield obtained under 25-40 kg/ha of seed rate however, the seed rate of 60 kg/ha produced the lowest grain yield. This might be due to inferior performance of individual plant under high seed rate. Similar results were noted by Jones and Synder (1987). This indicated the plasticity of rice crop under varying seed rates.

Straw yield was significantly more under seed rate of 60 kg/ha due to higher population which gave higher biomass per unit area than lower seed rates. This might be due to improper sink – source relationship which might have resulted in higher dry matter accumulation in plants under higher seed rates per unit area. The significantly lower straw yield was observed under 25 kg/ha. Straw yield was increased with increased seed rates under study.

Economic returns :

Significantly higher Gross Monetary returns (Rs. 45181) and Net Monetary returns (Rs. 30232) were found in the seed rate of 35 kg/ha as compared to other seed rates *viz.*, 25, 40 and 60 kg/ha except, 30 kg/ha (Table 2). This might be attributed to more grain yield than other seed rates. Significantly lowest net monetary returns (Rs. 31323) was obtained with the highest seed rate of 60 kg/ha under present investigation and was followed by lowest seed rate of 25 kg/ha indicating necessity of the optimum plant population for better grain yield and ultimately more returns. The highest B : C ratio was obtained under the seed rate of 35 kg/ha (3.02) followed by 30 kg/ha (2.97), 40 kg/ha (2.73), 25 kg/ha and 60 kg/ ha (1.81).

Spacings :

Growth attributes :

Significantly more plant height, leaf area per m^2 and number of tillers per plant were observed with spacing of 30 cm over spacing of 25 cm, 20 cm, respectively (Table 1). The wider spacing (30 cm) produced significantly more plant height, leaf area per m^2, and more number of tillers per m^2 due to efficient use of nutrients, moisture, solar energy and space by the plants owing to less competition under wider spacing as compared to closer spacing. The similar results were reported by Rautaray (2004) and Verma *et al.* (1988). The mean numbers of functional leaves were not significantly influenced due to spacings under study.

Yield attributes :

Different plant spacings had marked influence on almost all yield attributing characters (traits) except test weight (1000 grains weight) which remained unaffected due to different spacing (Table 1).

Panicle weight, number of filled grains per panicle and number of panicles per m^2 at harvest were significantly higher in wider spacing 30 cm over the spacing of 20 cm however, it was at par with 25 cm for the number of panicles at harvest, panicle weight and panicle m^2. Test weight was not significantly influenced by different spacings. The wider spacing gave more value of yield attributes *viz.*, number of panicles at harvest, number of grains per panicle and filled grains per panicle. This might be due to more number of leaves and leaf area per plant with more number of tillers/plant under wider spacing which resulted into more number of productive tillers and better development of grains due to translocation of nutrients from source to sink giving better values of yield attributes as compared to closer spacings. Test weight was not affected significantly. These results are in conformity with Shridhara *et al.* (2011).

Yield :

The grain and straw yield was significantly varied due to plant spacings. Significantly higher grain yield (3065 kg/ha) was observed under spacing of 30 cm over closer spacing 25 cm and 20 cm, respectively (Table 2). However, it was at par with 25 cm spacing for grain yield. This might be attributed to better root development and availability of nutrients, moisture and space which facilitated better growth of crop and also due to better management of weed under wider spacing due to better tillage operations as compared to the closer spacing which reflected into better yield attributes *viz.*, number of panicles at harvest, number of grains per panicle and filled grains per panicle which ultimately gave more grain yield (3065 kg/ha) under wider spacing 30 cm than both the closer spacing *i.e.* 25 cm and 20 cm similar results were obtained by Kumar *et al.* (2002).

Economic returns :

The data on economic analysis revealed that wider spacing of 30 cm gave more NMR (Rs.27139) and B:C ratio (2.91) as compared to both the closer spacings 25 cm and 20 cm (Table 2). This might be attributed to higher grain yield obtained under wider spacing than both the closer spacings under study.

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