International Journal of Advanced Chemistry Research

ISSN Print: 2664-6781
ISSN Online: 2664-679X
Impact Factor: RJIF 5.32
IJACR 2022; 4(1): 57-60
www.chemistryjournals.net
Received: 23-03-2022
Accepted: 09-04-2022

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Effect of seed rate and irrigation scheduling on growth and yield of direct seeded rice (*Oryza sativa*)

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DOI: https://doi.org/10.33545/26646781.2022.v4.i1a.80

Abstract
A field experiment entitled "Effect of seed rate and irrigation scheduling on growth and yield of direct seeded rice (*Oryza sativa*)" was conducted at the Students research Farm, Khalsa College, Amritsar during *kharif* season 2020-21. The soil of the experimental field was sandy loam, with neutral soil pH, low in organic carbon and available nitrogen, medium in available potassium and available phosphorus. The field experiment was conducted in randomized block design having 10 treatments with 3 replications described as T_1: DSR with seed rate of 15kg ha^{-1} and first irrigation at 14 DAS, T_2: DSR with seed rate of 15kg ha^{-1} and first irrigation at 18 DAS, T_3: DSR with seed rate of 15kg ha^{-1} and first irrigation at 22 DAS, T_4: DSR with seed rate of 20kg ha^{-1} and first irrigation at 14 DAS, T_5: DSR with seed rate of 20kg ha^{-1} and first irrigation at 18 DAS, T_6: DSR with seed rate of 20kg ha^{-1} and first irrigation at 22 DAS, T_7: DSR with seed rate of 25kg ha^{-1} and first irrigation at 14 DAS, T_8: DSR with seed rate of 25kg ha^{-1} and first irrigation at 18 DAS, T_9: DSR with seed rate of 25kg ha^{-1} and first irrigation at 22 DAS, T_{10}: Transplanting of seedling in puddled conditions. T_{10}: Transplanting of seedling in puddled conditions produced higher grain yield (42.9 q ha^{-1}) and straw yield (66.3 q ha^{-1}) over the DSR. Among the DSR T_7: DSR with seed rate of 25kg ha^{-1} and first irrigation at 14 DAS produce significantly higher grain yield (40.3 q ha^{-1}) and straw yield (61.7 q ha^{-1}) over the other treatments in DSR.

Keywords: Direct seeded rice, seed rate and irrigation scheduling

Introduction
Rice (*Oryza sativa* L.) belongs to the family Poaceae. It is the primary food source for more than one third of world's population. It is cultivated in 114 countries across the world. India has largest area under paddy in the world and rank second in production after China. In India rice is grown in 43.86 million ha. Rice crop occupied 31.03 lakh hectares in Punjab with total production of 191.36 lakh tones (128.2 lakh tone of rice) during 2018-19 (Anon., 2020) [1]. Transplanting of rice seedlings is an age-old practice. In India rice is grown by transplanting in puddled soil. It requires puddling and continuous ponding of water for at least 15 days for establishment of seedlings. Repeated puddling adversely affects soil physical properties. It also causes evapotranspiration losses during hot summer days. To meet the water need of transplanted paddy, underground water is being over exploited by excessive pumping resulting into decline in water table. Direct-seeding of rice (DSR) under unpuddled conditions as appears to be the most credible option and efficient irrigation water technology apart from its cost and labour effectiveness. DSR is labour saving, ensures timely sowing and early maturity (7-10 days) of crop and reduced production cost, improves soil physical conditions. seed rate has a great impact on plant density and the competitiveness of the crop stand, tiller, time to maturity and yield in DSR (Singh *et al.*, 2017) [3]. The objective of the research is to check the effect of seed rate and irrigation scheduling on growth and yield of Direct seeded rice (DSR).

Materials and Methods
The study was carried out at Student's Research farm of P.G. Department of Agriculture, Khalsa College Amritsar, during *kharif* season 2020-2021. The soil of the experimental field was categorized as sandy loam. The soil of the experimental field was categorized as sandy loam. The soil tested low in organic carbon, available nitrogen (N) and available phosphorus (P). However, potassium (K) status was high. The soil pH and electrical conductivity values were within the normal range.

The field experiment was conducted in randomized block design having 10 treatments with 3 replications described as T_1: DSR with seed rate of 15kg/ha and first irrigation at 14 DAS, T_2: DSR with seed rate of 15kg/ha and first irrigation at 18 DAS, T_3: DSR with seed rate of 15kg/ha and first irrigation at 22 DAS, T_4: DSR with seed rate of 20kg/ha and first irrigation at 14 DAS, T_5: DSR with seed rate of 20kg/ha and first irrigation at 18 DAS, T_6: DSR with seed rate of 20kg/ha and first irrigation at 22 DAS, T_7: DSR with seed rate of 25kg/ha and first irrigation at 14 DAS, T_8: DSR with seed rate of 25kg/ha and first irrigation at 18 DAS, T_9: DSR with seed rate of 25kg/ha and first irrigation at 22 DAS, T_{10}: Transplanting of seedling in puddled conditions. In this experiment Certified seed of variety "Pusa basmati 1509" as per treatments *i.e.* @ 15kg ha^{-1}, 20kg ha^{-1} and 25kg ha^{-1} were sown in lines having 20 cm spacing. Recommended dose of fertilizers (135 kg urea ha^{-1}) were applied to the crop in three equal split 3, 6 and 9 weeks after sowing. Irrigation was applied as per treatments, *i.e.*14 days after sowing, 18 days after sowing, 22 days after sowing. Subsequent irrigations were given at weekly interval and as per requirement (when there is rainfall). Harvesting was done manually with sickle. On October 5, 2020, the crop was harvested. All data on growth, yield and yield component were measured from the central areas of each plot. Statistical analysis of the data recorded was done as per randomized block design using EDA 1.1 software developed by PAU, Ludhiana. The comparisons were made at five per cent level of significance.

Results and Discussion

Dry matter accumulation (DMA)

Dry matter accumulation (DMA) is an important growth parameter which expresses the metabolic efficiency of the plants. As the data presented in table 1, revealed that the DMA of crop increased with the advancement of the stages up to harvest. At harvest, significantly higher DMA was recorded in transplanting T_{10} than all other treatments in DSR but at par with treatment T_7 supported by plant height and LAI. Similar trend was observed from initial growth to harvest *i.e.* 30, 60 and 90 DAS. The increase in DMA under treatment T_{10} was 1.11 percent, 2.26 percent, 5.78 percent and 8.81 percent more than T_7, T_4, T_1 and T_3 respectively. Among the DSR T_7 produce significantly higher DMA at 30, 60, 90 DAS and at harvest as compare to other treatments in DSR but at par treatments with T_4 and T_8. Higher DMA with higher seed rate and more irrigation may be due to more no of plants per unit area as compare to others. The statistically less DMA was recorded in T_3 as compare to the other treatments in which rice sown directly having seed rate 15 kg ha^{-1} and irrigation applied of 22 DAS but at par with treatment T_2 in which 15 kg ha^{-1} seed rate was applied and irrigation at 18 DAS. these results are in agreement with those obtained by the Hayat (2004) [4].

Table 1: Effect of seed rate and irrigation scheduling on dry matter accumulation of direct seeded rice

Treatments	Dry matter accumulation (g/m^2)			
	30 DAT	60 DAT	90 DAT	At harvest
T1 (DSR with seed rate of 15 Kg ha^{-1} and first irrigation at14 DAS)	82.30	268.90	640.87	799.0
T2 (DSR with seed rate of 15 Kg ha^{-1} and first irrigation at 18 DAS)	77.97	260.53	631.27	787.9
T3 (DSR with seed rate of 15 Kg ha^{-1} and first irrigation at 22 DAS)	73.0	251.70	623.47	776.7
T4 (DSR with seed rate of 20 Kg ha^{-1} and first irrigation at 14 DAS)	87.3	303.90	668.13	826.5
T5 (DSR with seed rate of 20 Kg ha^{-1} and first irrigation at 18 DAS)	83.1	291.90	656.10	819.9
T6 (DSR with seed rate of 20 Kg ha^{-1} and first irrigation at 22 DAS)	78.2	283.40	648.37	808.9
T7 (DSR with seed rate of 25 Kg ha^{-1} and first irrigation at 14 DAS)	91.4	310.33	679.90	835.9
T8 (DSR with seed rate of 25 Kg ha^{-1} and first irrigation at 18 DAS)	86.8	301.33	668.70	826.6
T9 (DSR with seed rate of 25 Kg ha^{-1} and first irrigation at 22 DAS)	83.4	294.80	659.70	820.3
T10 (Transplanting of seedling in puddled conditions)	95.9	324.10	691.13	845.2
C.D (p=0.05)	5.10	14.34	17.12	11.32

*DSR (direct seeded rice)

Effective tillers

Tillering is the most important phase of the crop growth. Effective tillers are considered as the most important component among the yield attributing characters. influenced by scheduling of irrigation in basmati rice with different seed rates. The analyzed data revealed that the Scheduling of irrigation with different seeding rates had significantly affected the number of effective tillers per meter square. It has been observed that the transplanting T_{10} produce significantly higher effective tillers as compare to DSR treatments except T_4, T_7, T_8. Similar results are found in Sorour *et al.* (2005). Among the DSR T_7 produce significantly higher effective tillers as compare to other treatments in DSR but at pat treatments with T_4 and T_8 this may be due to more no of irrigation and high seed rate due to which more no of total tillers per meter square than other treatments. The lowest no of effective tillers were produced by T_3 which significantly at par with T_2 as compare to other treatments in DSR. These results were in line with those observed by Aslam *et al.* (2002).

Panicle length

It is an important yield contributing character. Data revealed that scheduling of irrigation in basmati rice with different seed rates influence the panicle length. Panicle length ranges from 20.59 to 24.7 cm. The significantly higher panicle length was recorder in T_{10} (transplanting) which was at par with treatments T_2 and T_3 as compare to other treatments in DSR. The maximum panicle length was recorded in the treatment T_3 which was at par with treatment T_2 but significantly higher than all other treatments in DSR. Lowest panicle length was observed in treatment T_7 which was at par with treatments T_4, T_8 and T_9. The panicle length highest in T_3 is due to less seed rate due to which competition for light, space and nutrients is less which result in better availability of these factor to the crop and produce more panicle length. These results are in line with the experiment conducted by Phoung *et al.* (2005) [6].

Number of grains/panicle

Number of filled grains/panicle is an important yield contributing character of basmati rice. More number of

filled grains, more will be yield of crop. Data revealed that the number of filled grains per panicle ranged from (48.9 to 54.6) Maximum number of filled grains/panicle was recorded in treatment T_{10} (transplanting) which was at par with treatment T_2, T_3 but significantly higher than all other treatments in DSR. Among the DSR T_3 produce significantly higher no of grain per panicle as compare to other treatments in DSR but at par with treatment T_2, the highest number of grains per panicle is due to less competition for light, space, water and nutrient which resulted in better availability of these factors to the crop and in turn produced more grains per panicle. The lowest number of grains per panicle was observed in T_7 as compare to other treatments but at par with treatments T_4, T_8, T_9 in DSR. Similar results are founded by Phoung *et al.* (2005) [6].

Test weight gm^{-1}

It is an important yield component of basmati rice which determines the nature and extent of grain development. As the perusal of data revealed that scheduling of irrigation in basmati rice (1509) with different seed rates shows nonsignificant effect in test weight. the highest test weight was recorded in treatment T_4. Lowest test weight was recorded in treatment T_9.

Grain yield (q ha^{-1})

Grain yield is main criteria for judging the effect of different treatments. The data present in table 2, revealed that scheduling of irrigation in basmati rice (1509) with different seed rates significantly influence the grain yield. The significantly higher grain yield (42.9q/ha) was observed in transplanting of rice as compare to the DSR treatments except T_4 and T_7. Similar result also found by Choudhary *et al.* (2018). Among the DSR T_7 produce significantly higher yield as compare to other treatments in DSR but at par with treatments T_4, T_5, T_8. This might be due to increase in number of irrigation in T_7 as compare to other treatments. As more number of irrigation were applied, there was no stress affect the crop growth and also in T_7 more seed rate is use due to which more no of effective tillers per meter^2. Similar results also found by Choudhary *et al.* (2018). T_3 produce least yield as compare to others but at par with treatments T_2.

Transplanted treatments (T_{10}**)** produce 6.4 percent and 56.5 percent more yield than T_7 and T_3. Among the DSR T_7 produce 17.4 percent, 2 percent and 47 percent more yield than T_9, T_4 and T_3.

Straw yield (q ha^{-1})

Straw yield is a function of interplay of various yield component such as number of tillers per square meter. The data present in table 2, revealed that the the scheduling of irrigation in basmati rice with different seed rate significantly influence the straw yield. The significantly higher straw yield was observed in T_{10} (transplanting) of basmati rice as compare to DSR treatments except T_7. Among the DSR T_7 produce significantly higher straw yield as compare other treatments but at with treatments T_8 and T_4. The least straw yield was produced by T_3 as compare to others but at par with treatment T_2. The higher straw yield production in T_7 is due to higher seed rate and more irrigation, due to which plants per unit area and dry matter accumulation is more as compare to other treatments. The results are also founded by Shrivastava and Tripathi (1993).

Harvest index

Harvesting index expressed as percentage determine the percentage ratio of economical yield (grain yield to biological yield)**.** Harvesting index indicates portioning of photo assimilates to grain. The data present in table 2, revealed that the the scheduling of irrigation in basmati rice with different seed rate significantly influence the harvesting index. The highest harvesting index recorded in treatment T_5 (39.8) and lowest value recorded in treatment T_1 (37.5).

Table 2: Effect of seed rate and irrigation scheduling on grain, straw yield, biological yield and harvest index of direct seeded rice

Treatment	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Biological yield (q ha^{-1})	Harvest index
T1 (DSR with seed rate of 15 Kg ha^{-1} and first irrigation at14 DAS	31.8	52.9	83.32 79.18	37.5
T2 (DSR with seed rate of 15 Kg ha^{-1} and first irrigation at 18 DAS)	30.7	49.4	71.53	38.3
T3 (DSR with seed rate of 15 Kg ha^{-1} and first irrigation at 22 DAS)	27.4	45.1	97.28	37.7
T4 (DSR with seed rate of 20 Kg ha^{-1} and first irrigation at 14 DAS)	39.5	58.7	90.80	40.2
T5 (DSR with seed rate of 20 Kg ha^{-1} and first irrigation at 18 DAS)	36.3	54.9	83.92	39.8
T6 (DSR with seed rate of 20 Kg ha^{-1} and first irrigation at 22 DAS)	33.5	52.3	102.10	39.0
T7 (DSR with seed rate of 25 Kg ha^{-1} and first irrigation at 14 DAS)	40.3	61.7	93.75	39.5
T8 (DSR with seed rate of 25 Kg ha^{-1} and first irrigation at 18 DAS)	36.5	57.1	87.67	38.9
T9 (DSR with seed rate of 25 Kg ha^{-1} and first irrigation at 22 DAS)	34.3	53.3	107.29	39.1
T10 (Transplanting of seedling in puddled conditions)	42.9	66.3		39.2
C.D (p=0.05)	4.33	6.70	11.08	0.60

*DSR (direct seeded rice)

Economics

The maximum cost cultivation was conducted from the treatment T10 (Transplanting of seedling in puddled conditions). Gross returns are total returns from the crop grain. The data of gross return, net return, total cost and benefit cost ratio have been presented in Table 3 Treatments with benefit cost ratio more than one are considered as profitable. Highest Benefit Cost ratio was observed in T7 (DSR with seed rate of 25kg/ha and first irrigation at 14 DAS) followed by T4 (DSR with seed rate of 20kg/ha and first irrigation at 14 DAS). T3 (DSR with seed rate of 15kg/ha and first irrigation at 22 DAS) produced lowest gross return.

Table 3: Effect of seed rate and irrigation scheduling on economics of direct seeded rice

Treatments	Cost of cultivation	Gross return	Net return	B:C
T1 (DSR with seed rate of 15 Kg ha^{-1} and first irrigation at14 DAS)	45668	89040	43372	0.9
T2 (DSR with seed rate of 15 Kg ha^{-1} and first irrigation at 18 DAS)	45610	85960	40350	0.8
T3 (DSR with seed rate of 15 Kg ha^{-1} and first irrigation at 22 DAS)	45300	76720	31420	0.6
T4 (DSR with seed rate of 20 Kg ha^{-1} and first irrigation at 14 DAS)	45890	1010600	64710	1.4
T5 (DSR with seed rate of 20 Kg ha^{-1} and first irrigation at 18 DAS)	45599	101640	56041	1.2
T6 (DSR with seed rate of 20 Kg ha^{-1} and first irrigation at 22 DAS)	45643	93800	48137	1.0
T7 (DSR with seed rate of 25 Kg ha^{-1} and first irrigation at 14 DAS)	44857	112840	67983	1.5
T8 (DSR with seed rate of 25 Kg ha^{-1} and first irrigation at 18 DAS)	45505	102200	56695	1.2
T9 (DSR with seed rate of 25 Kg ha^{-1} and first irrigation at 22 DAS)	45875	96040	50165	1.0
T10 (Transplanting of seedling in puddled conditions)	48483	102960	54477	1.1

Conclusion

On the basis of present investigation, it may be concluded that sowing of DSR (direct seeded rice) with seed rate 25 kg/ha and first irrigation 14 days after sowing showed superiority over other treatments. So, seed rate of 25 kg/ha and first irrigation 14 days after sowing comes out to be the best treatment proposed to the farmers for improving productivity and profitability of PUSA-basmati-1509 in DSR.

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