Performance of rice varieties under different systems of cultivation for Southern Telangana Zone

ABSTRACT

A field study was conducted during *kharif*, 2021 at College Farm, College of Agriculture, Rajendranagar, PJTSAU to evaluate the performance of rice varieties under different systems of cultivation for Southern Telangana Zone. The treatments consisted of three systems of cultivation *i.e*., transplanted rice with spacing of 15 cm x 10 cm, wet direct seeded rice (Drum seeding) with a spacing of 30 cm x 6-8 cm and dry direct seeded rice at 30 cm x 5 cm row spacing in main plots and four varieties *i.e.,* RNR 11718, JGL 11118, JGL 24423 and RNR 15048 in sub plots. Experimental data revealed that wet DSR recorded superior growth parameters, yield and yield attributing characters *i.e.,* plant height, number of tillers, number of effective tillers m^{-2}, grain yield and straw yield compared to other systems of cultivation. Significantly higher grain and straw yield was recorded with wet DSR system which was on par with transplanted rice and significantly superior to dry DSR. Among varieties JGL 24423 registered higher grain yield and straw yield.

Keywords: Dry DSR; wet DSR; no. of tillers; grain yield; straw yield.

1. INTRODUCTION

"Rice (*Oryza sativa* L.) is one of the most important staple food crops in the world. More than 90% of rice production and consumption is in Asia continent where more than two billion people are getting 60-70 per cent of their energy requirement from rice and its derived products. Globally, rice is grown in an area of 164 M ha with an annual production of about 750 Mt of paddy according to FAO, 2022. The demand for rice is to be increased in next 30 years by nearly 70% to maintain present per capita availability which is 69 kg annum^{-1}. India is the second largest producer of rice after China. In India, rice occupies an area of 43.78 million hectares with a production of 177.64 million tonnes and productivity of 3878 kg ha^{-1}. Demand for rice is growing every year and it is estimated that in 2010 and 2025 AD the requirement would be 100 and 140 million tonnes respectively. To sustain present food self- sufficiency and to meet future food requirements, India must increase its rice productivity by 3 per cent per annum" (Thiyagarajan and Selvaraju, 2001). Rice production scenario in the country during the past decade presents a gloomy picture of compound growth rate of just 1.7 per cent. To meet a production target of 125 million tonnes by 2025, all inclusive of food requirement, seed for cultivation, storage in buffer stock and a share for exports, productivity in irrigated area needs to be enhanced by 1.5 tons ha^{-1} and in rainfed lowlands by about 1 ton ha^{-1}.

In Telangana, rice is the major crop extensively cultivated in all the districts. The rice area under production was 32.20 lakh ha with production of 196 lakh metric tonnes of rice and productivity of 6098.75 kg ha^{-1} during 2021-2022 (Action plan report 2021-2022 of Department of Agriculture, Telangana). To overcome this low productivity levels, there is a mandatory need to increase the production and productivity to meet the increasing demand of state population.

Agriculture is highly dependent upon labor, labor scarcity during peak periods is now a major concern for the viability of puddled transplanted rice (PTR), and labor costs for hand transplanting have risen sharply in recent years. Different problems like lowering of water table, deteriorating soil health demands some alternative establishment method to sustain rice productivity as well as natural resources. Direct seeded rice (DSR), probably the oldest method of crop establishment, is gaining popularity because of its low-input demand. It offers certain advantages *viz*., it saves labor, requires less water, less drudgery, early crop maturity, low production cost, better soil physical conditions for following crops and less methane emission providing better option to be the best fit in different cropping systems. Comparative yields in DSR can be obtained by adopting various cultural practices *viz*., selection of suitable cultivars, proper sowing time, optimum seed rate, proper weed and water management. It can also be stated that soil problems related to rice and following crops can be solved with direct seeding.

Rice varieties selected for direct seeding and transplanting must have both flexible and strong stems to resist lodging at maturity, along with resistance to major biotic stresses. These varieties should possess enhanced foliar growth to combat weeds at the vegetative stage, moderate tillering, less foliar growth, enhanced assimilate export from leaves to stems during the late vegetative and reproductive phases, sustained high foliar NPK concentration at the reproductive stage, and improved reproductive sink capacity with a prolonged ripening period. Therefore, the main objective of the present study is to consider the effects of different cultivation systems and three varieties of rice for Southern Telangana Zone on growth, yield and the yield attributes.

2. MATERIALS AND METHODS

The present study was conducted during *kharif,* 2021 at College Farm, PJTSAU, Rajendranagar, Hyderabad. The farm is geographically located at 17^{0}31' 16.4" North latitude and 78^{0}40' 43" East longitude and situated at an altitude of 542.3 m above mean sea level. This area comes under Southern Telangana Zone of Telangana. The soil was alkaline in pH (8.34), with an EC of 0.762 d Sm^{-1}, low in organic carbon (0.41 %), low in available nitrogen (224.2 kg ha^{-1}), medium in available phosphorus (35.3 kg ha^{-1}) and high in available potassium (332 kg ha ha^{-1}). The experiment was laid out in a strip plot design with three replications.

Table 1. Treatment details

Main Plots (Systems of Cultivation) - 3	Sub Plots (Varieties) – 4
S_1 - Transplanted Rice	V_1-RNR 11718
S_2 - Wet Direct Seeded rice (drum seeding)	V_2- JGL 11118
S_3 - Dry Direct Seeded rice	V_3-JGL 24423
	V_4 -RNR 15048

Cultivars: RNR 11718, Anjana (JGL 11118), Jagtial Rice – 1 (JGL 24423) and Telangana Sona (RNR 15048).

2.1 Characteristics of Varieties

RNR 11718 – Medium duration medium slender variety. Salinity tolerant and Multiple resistant variety (moderately resistant to leaf blast, bacterial leaf blight, brown spot, BPH and stem borer) with high yield potential of 7.8 t ha^{-1}.

Anjana (JGL 11118) – Short duration (115-135 days), resistant to Gall midge, tolerant to BLB and cold, fine grain with average yield potential of 6.0 t ha^{-1}.

Jagtial Rice (JGL 24423) – Short duration (120-125 days), long bold (coarse) grain variety having tolerance to BPH, cold, salinity and grain shattering; suitable for *kharif* and *rabi* with high yield potential of 7.5 to 8.0 t ha^{-1}

Telangana Sona (RNR 15048) – Short slender (very fine) variety with 125 days duration, blast resistant with a yield potential of 5.5 to 6.5 t ha^{-1}.

The recommended fertilizer dose of 120:60:40 kg ha^{-1} of N, P_2O_5 and K_2O for transplanted and wet DSR; 150:50:40 kg ha^{-1} N, P_2O_5 and K_2O for dry DSR was followed. Nitrogen, phosphorus and potassium were applied in the form of urea, single super phosphate (SSP) and muriate of potash (MOP) fertilizers respectively.

2.2 Methodology

"The experimental data recorded on different parameters were analyzed statistically by applying the technique of analysis of variance for strip-plot design and significance was tested by F-test" (Gomez and Gomez, 1984).

Dry Direct Seeded Rice: The seed rate adopted for dry direct seeding is 10 kg $acre^{-1}$. Seeds were sown in solid rows manually with a row spacing of 30 cm in the field.

Wet Direct Seeded Rice: The seed rate adopted is 10 kg $acre^{-1}$. Seeds were soaked in water for overnight and then drained and incubated in moist gunny bags for 24 hours which is known as Priming. The drum seeder is a plastic fiber bodied equipment which can be operated by a single person. It consists of 4 drums each of which can be filled with sprouted seeds up to 3/4th of its capacity. The drum has holes at regular intervals so when it is drawn along the puddled field, the seeds are dropped at regular intervals. A 30 cm spacing drum seeder provides 30 cm spacing between the rows and 7 cm spacing between the plants of the row.

Transplanted rice: The seed rate adopted for transplanting method of cultivation was 25 kg $acre^{-1}$. Seeds were treated with Carbendazim @ 1g kg^{-1} seed and soaked in water for 24 hours. Later, the water was removed and seeds are incubated for 24 hours so that seeds have sprouted. These sprouted seeds were broadcasted in the nursery.

Number of effective tillers were recorded with in the net plot from each treatment during harvesting stage by using a quadrant of size 1m x 1m ($1m^{-2}$) area. The average was calculated and finally expressed as number of effective tillers per m^{-2}. From each treatment plants were harvested from the net plot area and dried in the field up to 14% moisture, threshed separately and grain yield per plot was recorded and grain yield per hectare was calculated and expressed in kg ha^{-1}. The weight of dried straw from each plot was recorded after threshing and expressed as kg ha^{-1}.

3 RESULTS AND DISCUSSION

3.1 Plant Height

Plant height at 30, 60, 90 DAS/DAT and harvest were recorded and presented in Tables 2 and 3.

Among three different establishment methods, significantly higher plant height was recorded in conventional transplanting method at 30 DAT (S_1 - 44.90 cm) over wet DSR ((direct seeding of sprouted seeds by drum seeded method on puddled land) S_2 - 30.4 cm) and dry DSR (direct seeding of dry seeds by solid line sowing on un-puddled land (S_3 - 28.9 cm)) respectively. Dry and wet DSR methods are found to be on par with each other at 30 DAS. However at 60, 90 DAS/DAT and harvest the plant height was significantly higher in wet DSR which was 70.67cm, 95.67cm and 103.18 cm respectively over dry DSR (63.2 cm,85.76 cm and 91.36 cm at 60,90 DAS and at harvest respectively) and remained on par with transplanting method which recorded 68.73 cm,94.48 and 101.47 cm respectively. Increase in average plant height was rather slow up to 30 DAS in direct seeded plots, thereafter it increased linearly up to 60 DAS and after that although it continued to increase until maturity it occurred at a diminishing rate. The increased plant height in wet DSR might be due to zero depth of planting resulting in better inducement of root growth for anchorage and earlier emergence in wet DSR may also be the reason for higher plant height. These results were same as findings of Yadav and Singh (2006), Kumari and Sudheer (2015) and Muralidharan *et al*. (2015). Lowest plant height was obtained from direct dry seeding which may be because of mutual competition for space, sunlight and nutrient in direct dry seeding method and this was supported by Aslam *et al*.,2008.

Plant height increased progressively among all the varieties from sowing to harvest. The plant height was not significantly influenced by the varieties but the data collected at 60, 90 DAS/DAT and harvest revealed that maximum plant height was observed in JGL-24423 (73.19 cm, 96.9 cm and 102.8 cm respectively) over RNR-11718 (63.90 cm, 88.07 cm and 95.42 cm) and JGL-11118 (62.34 cm, 86.10 cm and 93.87 cm) and is at par with RNR-15048 (70.7 cm, 96.79 cm and 102.59 cm) at 60, 90 DAS/T and harvest respectively. This variation in plant height among varieties may be due to genetically inherent character of these varieties and variation in crop growth during earlier stages of crop growth period. This was supported by Shanta *et al*. (2020).

However, there was no significant interaction effect between different cultivation systems and varieties at all crop growth stages.

3.2 Tillers m^{-2}

Number of tillers m^{-2} were significantly influenced by different cultivation systems during the crop growth period (Table 3). A perusal of data revealed that, the number of tillers m^{-2} produced were significantly higher in wet DSR(S_2) over dry DSR at all the stages (30, 60 and 90 DAS/T). Though wet DSR recorded higher number of tillers m^{-2} than transplanting rice at all stages, both remained on par with each other. Lowest tillers m^{-2} 142, 232 and 257 at 30, 60, 90 DAS/T were noticed in dry DSR. Closer spacing of sprouted seeds which increased the number of hills m^{-2} with early establishment of seedlings followed by an avoidance of root injury and transplantation shock coupled with higher root growth, activity and quicker tiller initiation lead to longer tillering period in direct sown sprouted seeds which might be the reason for higher number of tillers m^{-2} than conventional method. These are in line with the findings of Manjunatha *et al*. (2009) and Kumari and Sudheer (2015).

Among the varieties the number of tillers m^{-2} have shown significant difference during all the growth stages of the crop. Cultivar JGL-24423 (193, 325 and 348 tillers m^{-2} at 30,60 and 90 DAS/DAT respectively) have shown significantly higher tillers m^{-2} over other cultivars and lowest were noticed in cultivar JGL-11118 (122, 214 and 243 tillers m^{-2} at 30,60 and 90 DAS/DAT respectively).The difference in dry matter production among the genotypes might be due to difference in their genetic potential, capacity towards uptake of nutrients, competitive ability of variety for space, light, nutrients and there was no interaction effect between systems of crop cultivation and cultivars.

3.3 Number of Effective tillers m^{-2}

Different establishment methods had significantly influenced number of effective tillers m^{-2} as presented in Table 5. Among them, wet DSR (S_2) with 262 panicles m^{-2} has resulted in significantly higher number of panicles m^{-2} over dry DSR (S_3) (201 effective tillers m^{-2}) and higher effective tillers were found in wet DSR (S_2) than transplanted rice (S_1) (247 effective tillers m^{-2}) but both were at par with each other.

This may be due to higher tiller to panicle conversion ratio in direct seeding by drum seeder, wet DSR(S_2) over conventional transplanting method which might be due to favorable growth conditions and better translocation of assimilates to the sink from the source. In dry DSR poor plant growth reflecting in poor root growth might have resulted in reduced nutrient uptake and production of lower number of tillers and panicles. These results are in line with the reports of Yadav and Singh (2006), Singh and Singh (2010), Jha *et al*. (2011), Kumari and Sudheer (2015), Vivekanandini *et al*. (2018).

Between the varieties under different cultivation systems, variety V_3-JGL 24423 has shown significantly higher effective tillers m^{-2} (256) over V_1-RNR 11718 (227) and V_2-JGL 11118 (223) and variety V_4- RNR 15048 (241). The descending order of effective tillers was $V_3 > V_4 > V_1 > V_2$. The results are in close conformity with Prashanthi *et al*. (2020) and Lavanya and Mallareddy (2019). There was no significant interaction effect between different cultivation systems and rice varieties.

Table 2. Plant height (cm) at 30 and 60 DAS/T of different rice varieties as influenced by different systems of cultivation.

Establishment methods	30 DAS/T					60 DAS/T				
	Varieties					Varieties				
	V_1	V_2	V_3	V_4	Mean	V_1	V_2	V_3	V_4	Mean
S_1	43.94	38.11	49.09	48.43	44.9	66.83	64.82	72.51	70.73	68.73
S_2	30.63	27.69	33.64	29.81	30.4	67.20	62.57	79.09	73.81	70.67
S_3	28.37	27.14	30.87	29.4	28.9	57.61	59.63	67.96	67.61	63.20
Mean	34.3	31	37.9	35.9		63.88	62.34	73.19	70.70	

	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)
Main	1.5	5.9	1.4	5.3
Sub	2.1	NS	2.3	8
Interaction effect				
Sub at same level of main				
	2.73	NS	4.0	NS
Main at same level of sub				
	2.79	NS	3.8	NS

Table 3. Plant height (cm) at 90 DAS/T and harvest of different rice varieties as influenced by different systems of cultivation.

Establishment methods	90 DAS/T					At harvest				
	Varieties					Varieties				
	V_1	V_2	V_3	V_4	Mean	V_1	V_2	V_3	V_4	Mean
S_1	89.97	89.17	99.83	98.93	94.48	99.50	97.44	104.71	104.22	101.47
S_2	93.63	90.51	98.74	99.79	95.67	99.73	99.06	106.99	106.94	103.18
S_3	80.62	78.63	92.15	91.66	85.76	87.01	85.10	96.69	96.62	91.36
Mean	88.07	86.10	96.9	96.79		95.42	93.87	102.80	102.59	

	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)
Main	2.0	7.86	2.4	9.3
Sub	2.37	8.21	2.0	6.9
Interaction effect				
Sub at same level of main				
	2.7	NS	3.6	NS
Main at same level of sub				
	3.2	NS	3.9	NS

Table 4. Number of tillers m^{-2} (no.) of rice varieties as influenced by different systems of cultivation.

Establishment methods	30 DAS/T					60 DAS/T					90 DAS/T				
	Varieties					Varieties					Varieties				
	V_1	V_2	V_3	V_4	Mean	V_1	V_2	V_3	V_4	Mean	V_1	V_2	V_3	V_4	Mean
S_1	186	118	200	137	160	282	220	320	271	273	319	257	357	333	316
S_2	182	116	222	147	167	325	241	368	266	300	349	264	368	291	318
S_3	149	131	156	131	142	242	183	286	216	232	254	209	320	246	257
Mean	172	122	193	139		283	214	325	251		308	243	348	290	

	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)
Main	3.5	13.8	9.5	37.3	5.6	21.6
Sub	3.6	12	7.9	27.3	7.6	26.4
Interaction effect						
Sub at same level of main						
	10	NS	14	NS	12.0	NS
Main at same level of sub						
	9.6	NS	12	NS	12.7	NS

3.4 Grain Yield

Grain yield is the integration of various growth and yield attributing characters which includes dry matter production, number of tillers, number of panicles, length of panicle, weight of panicle and number of grains panicle^{-1}.

The data pertaining to grain yield (kg ha^{-1}) is presented in Table .5 revealed a significant influence on grain yield due to different systems of cultivation. The data indicates that among all the treatments, highest grain yield was recorded in wet- DSR using drum seeder method (S_2) (5246 kg ha^{-1}) which was significantly superior to dry DSR method (S_3) (4630 kg ha^{-1}). It was also higher than transplanting method (S_1) (5074 kg ha^{-1}) but was at par with wet DSR method. Drum seeding at 30 cm spacing with wet seed registered an increase of 3.3% over transplanting and 13.3% over dry DSR in yield. This can be attributed to more space, sunlight and nutrients available at wider spacing in drum seeding. The results are in accordance with the findings of Yadav and Singh (2006), Singh and Singh (2010), Shan *et al*. (2012), Singh *et al*. (2017), Vivekanandini *et al*.(2018) and Lavanya and Mallareddy. (2019). Lowest grain yield was obtained in broadcasting of dry seed in unpuddled soil, dry DSR (S_3). It might be due to competition among the plants owing to high population as well as from weeds which was observed in the present study.

Among varieties V_3- JGL 24423 (5412 kg ha^{-1}) showed highest grain yield, among all other varieties and it was significantly higher than variety V_2-JGL-11118 (4489 kg ha^{-1}). The next variety yielding high after V_3 is V_1-RNR-11718 (5148 kg ha^{-1}) which is at par with the variety V_3- JGL 24423. Lower grain yield was obtained by the variety V_2-JGL-11118.The reason behind greater yield of V_3 and V_1 may be due to the coarse grain. The yield of the variety V_4-RNR 15048 (4884 kg ha^{-1}) was at par with the varieties V_3 and V_1. Lower grain yield might be due to lower dry matter production, number of tillers, test weight, panicle weight, number of filled grains panicle^{-1} and panicle length. The results are in conformity with the findings of Lavanya and Mallareddy. (2019), Shanta e*t al*. (2020). Grain yield showed no interaction effects between cultivation systems and varieties.

3.5 Straw Yield

The effect of different treatments on straw yield obtained are presented in Table .5 Among the different treatments higher straw yield was observed in wet seeding with drum seeder at 30 cm spacing between the rows (S_2) (6599 kg ha^{-1}) which was on par with conventional transplanting method (S_1) (6347 kg ha^{-1}). Dry seeding in unpuddled soil (S_3) (5906 kg ha^{-1}) resulted in lowest straw yield among all the treatments. By observing the data on straw yield, it was witnessed that conventional transplanting system and wet DSR has reported higher straw yield over dry DSR. It was probably due to more dry matter production and tiller number per unit area caused by better nutrient absorption from soil increased rate of metabolic processes, higher rate of light absorption and increased rate of photosynthetic activity that produced higher plant height and leaf area index as compared to dry DSR system of cultivation. The results were supported by Jha *et al*. (2011) and Prashanthi *et al*. (2020).

Among different varieties higher straw yield was obtained in the variety V_3-JGL 24423 (6734 kg ha^{-1}) followed by the varieties V_1-RNR 11718 (6566 kg ha^{-1}) and variety V_4-RNR 15048 (6216 kg ha^{-1}). Significantly lower yield compared to variety V_3 was obtained from the variety V_2-JGL 11118 (5620 kg ha^{-1}). Higher straw yield was attributed to higher dry matter accumulation caused by better nutrient absorption from the soil, and the increased rate of metabolic processes, rate of light absorption and photosynthetic activity as well as more number of leaves. Similar results were reported by Yadav and Singh (2006), Suryavanshi *et al.* (2012). Straw yield showed no interaction effects between cultivation systems and varieties.

4. CONCLUSION

Significantly higher plant height, number of tillers, grain and straw yield was recorded with wet DSR system which was on par with transplanted rice and significantly superior to dry DSR. Among varieties JGL 24423 registered higher growth characters, grain and straw yield. From the experimental results it can be concluded that for Southern Telangana Zone direct sowing of rice under wet conditions on the field might be suitable over the puddled transplanted rice to reduce the cost of cultivation, obtain higher yields and net returns. Further adopting direct sown rice instead of puddled transplanted rice could reduce the green-house gases emissions in future. The variety JGL 24423 was found superior among the tested varieties and resulted in superior yield in Southern Telangana Zone.

Table 5. Influence of cultivation systems and varieties on number of effective tillers, grain yield and straw yield of rice crop.

Establishment methods	Number of effective tillers (no.m^{-2})					Grain yield (kg ha^{-1})					Straw yield (kg ha^{-1})				
	Varieties					Varieties					Varieties				
	V_1	V_2	V_3	V_4	Mean	V_1	V_2	V_3	V_4	Mean	V_1	V_2	V_3	V_4	Mean
S_1	237	226	264	262	247	5289	4590	5430	4986	5074	6675	5910	6673	6129	6347
S_2	248	256	269	275	262	5328	4896	5680	5080	5246	6626	6115	7112	6545	6599
S_3	197	187	235	185	201	4826	3982	5126	4586	4630	6397	4836	6417	5974	5906
Mean	227	223	256	241		5148	4489	5412	4884		6566	5620	6734	6216	

	Sem (±)	CD (P=0.05)	Sem (±)	CD (P=0.05)	Sem (±)	CD (P=0.05)
Main	10.0	39.3	118	462	129	508
Sub	6.1	20.9	154	534	219	758
Interaction effect						
Sub at same level of main						
	12.4	NS	242	NS	358	NS
Main at same level of sub						
	9.2	NS	240	NS	336	NS

COMPETING INTERESTS

Authors have declared that no competing interests exist

5. REFERENCES

Action plan report 2021-2022 of Department of Agriculture, Telangana.

Aslam, M., Hussain, S., Ramzan, M. and Akhter, M., 2008. Effect of different stand establishment techniques on rice yields and its attributes. *J. Anim. Pl. Sci*, *18* (2-3), pp.80-82.

Food and Agriculture Organization (FAO). Italy. 2022. *Rice Market Monitor* 16 (1). Trade and markets division.

Jha, A.K., Kewat, M.L., Upadhyay, V.B and Vishwakarma, S.K. 2011. Effect of tillage and sowing methods on productivity, economics and energetics of rice (*Oryza sativa*)-wheat (*Triticum aestivum*) cropping system. *Indian Journal of Agronomy*. 56(1): 35-40.

Kumari, C.R and Sudheer, M.J. 2015. On-farm evaluation of paddy drum seeder (8 row) in farmers fields. *Advance research journal of crop improvement*. 11(2): 139-143.

Lavanya, N and Reddy, M.M. 2019. Yield attributes and quality parameters of rice under different establishment methods and varieties with nitrogen levels under late sown conditions in Telangana state. *Journal of Pharmacognosy and Phytochemistry*. 8(3): 4185-4192.

Manjunatha, M. V., Masthana Reddy B. G and Joshi V. R. 2009. Performance of rice (*Oryza sativa*) under different methods of establishment in Tungabhadra canal command, Karnataka. *Karnataka Journal of Agriculture Sciences.* 22(5): 1151-1152.

Muralidharan, P., Rajeev, M.S., Anand, R and Nathan, A.R., 2015. Drum seeding for enhanced profitability of paddy cultivation in Kuttanad region of Kerala. *Journal of Tropical Agriculture*. 53(1): 66-69.

Prashanthi, B., Suresh, K., Ramulu, V and Sridevi, S. 2020. Growth and yield attributes of various rice varieties under saline irrigation water as affected by agronomic management practices. *International Journal of Agriculture Statistical Sciences*. 16(2): 599-606.

Shan, F.A., Bhat, M.A., Ganai, M.A., Hussain, A and Bhat, T.A..2012. Effect of crop establishment and weed control practices on the performance of rice (*Oryza sativa* L.). *Applied Biological Research*. 14(1): 79-85.

Shanta, C.M., Ramesha, Y.M., Krishnamurthy, D., Umesh, M.R. and Bhanuvally, M., 2020. Growth and yield response of direct seeded rice (*Oryza sativa* L.) to dates of sowing and varieties. *International Journal of Crop Sciences.* 8(4): 295-299.

Singh, D.K., Pandey, P.C., Thapliyal, S.D and Nanda, G. 2017. Yield and economics of rice (*Oryza sativa* L.) as influenced by establishment methods and varieties under mollisols, Pantnagar. *International Journal of Current Microbiology and Applied Sciences.* 6(6): 297-306.

Singh, M and Singh, R.P. 2010. Influence of crop establishment methods and weed management practices on yield and economics of direct-seeded rice (*Oryza sativa* L.). *Indian journal of Agronomy*. 55(3): 224-229.

Suryavanshi, P., Singh, Y.V., Singh, K.K and Shivay, Y.S., 2012. Relative efficiency of methods of crop establishment in rice (*Oryza sativa* L.). *Indian Journal of Agronomy*. 57(3): 291-293.

Thiyagarajan, T. M and Selvaraju, R. 2001. Water saving in rice cultivation in India. *Proceedings of an international workshop on water saving rice production systems. Philippine Journal of Science*. 14(7): 165-174.

Vivekanandhini, A., Ravi, V. and Subrahmaniyan, K. 2018. Performance of Different Crop Establishment Methods on Growth, Weeds Dynamics and Yield in Rice-Rice Cropping Sequence. *International Journal of Current Microbiology Applied Sciences*.7(6): 2207-2211.

Yadav, V and Singh, B. 2006. Effect of crop establishment method and weed-management practice on rice (*Oryza sativa* L.) and associated weeds. *Indian Journal of Agronomy*. 51(4): 301-304