Original Research Article

Evaluation of ricevarieties under different systems of cultivation for central Telangana zone

ABSTRACT

A field study was conducted during *kharif*, 2021 at Regional Agricultural Research Station, Warangal to evaluate the performance of rice varieties under different systems of cultivation for central Telangana zone. The treatment consisted of three systems of cultivation i.e., transplanted rice system with 15X10 cm spacing, wet direct seeded rice (Drum seeding) with 30X6-8 cm spacing and dry direct seeded rice at 30 cm row spacing in main plots and four varieties i.e., RNR 15048 (Telanganasona), WGL 44 (Siddi), WGL 915 (Warangal Rice-1) and KNM 118 (Kunaransannalu) in sub plots. Experimental data revealed that transplanted rice recorded significantly superior growth components and yield attributing characters i.e., number of tillers m^{-2}, number of effective tillers m^{-2}, dry matter production,grain yield, straw yield and harvest index (%) compared to other systems of cultivation. Significant higher grain and straw yield was recorded with transplanted rice system followed by wet DSR and least in dry DSR. Under varieties KNM 118 registered higher dry matter production, grain yield, straw yield and harvest index (%) as compared to remaining varieties.

Key words:*dry DSR, wet DSR, varieties, grainyield, harvest index.*

1. INTRODUCTION

Rice (*Oryza sativa* L.) is the principle source of food for almost 60% population of India Biswas et al.[5].The area under rice cultivation in India is the largest among all the rice growing countries and is second in production. Annually in India, around 120 million tonnesof rice is produced in an area of 44 million hectares with a productivity of over two tonnes perhectare of milled rice. It was predicted that a 50 - 60% increases in rice production will be required to meet the food demand of population growth by 2025 Banerjee et al.[3]. In telangana state, rice is the principal crop extensively cultivated in all the districts both *kharif* and *rabi* seasons. In telangana the rice area under production was 42.45 lakh ha and produced 252.63 lakh tons with the productivity of 5948.75 kg/ha during 2020-21 (Agriculture action plan report 2021-22 of Department of Agriculture, Telangana[1]).

About 77% of the global rice production in the world is cultivated by conventional transplanting method in puddled soil (Chakraborty et al.[7], Xu et al. [33]). Conventional transplanting system (TPR) of rice crop production requires labour, water, capital, and energy in large amount so that it has become less profitable at present due to the lack of these resources Chakraborty et al. [7], Gurupremet al.[14], Mahajan et al. [18]. Transplanting takes roughly 25 per cent of the total labour requirement of the crop. A shortage of labour during peak periods causes transplanting operation delayed, which end in transplanting of above-optimal age of rice seedlings that record lower productivity as well as increasing transplanting shock. Decreased availability and increasing cost of labour have increased the cost of rice cultivation through conventional methods. All these factors demand a major shift from puddle transplanted rice production to direct seeding of rice. As the seeds are sown directly, the dry and wet-seeding methods are often jointly referred to as direct seeding method, for both the methods mentioned above.

Wet direct seeding is one of the oldest method of crop establishment, it refers to the process of establishing rice crop by sowing sprouted seeds directly on wet puddled soil (wet seeding) (Farooq et al.[13]). Absence of nursery management, rapid and easy sowing, reduced labour requirement, increased water use efficiency, lower methane emission and higher profit are the advantages of wet direct seeding over transplanted rice (Chauhan et al.[10]). Direct seeded rice matures 1-2 weeks before transplanted rice, thus reducing the risk of terminal drought and allowing earlier planting of a following non-rice crop (Rana et al.[25]).

Dry direct seeding is one of the resource conservation technique, it avoids drudgery of land preparation, nursery raising and transplanting. It saves time and investment compared

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totransplanting. In normal transplanting, repeated puddling adversely affects soil physical properties by destroying soil aggregates, reducing permeability in subsurface layers and forming hard pans at shallow depths. Dry direct seeding also saves water volume which isessential for puddling. Puddling consumes about 20-40 per cent of the total water required for growing the transplanted rice crop, which can be saved in direct seeded rice.

The characteristics of the cultivar such as morphology and growth rate can have a significant effect on crop development and ultimately its yield potential. The morphological and physiological traits of a strongly competitive crop will enable it to capture resources and utilize resources more efficiently. Correct choice of cultivar may also be essential to get higher yields. Hence, it is need of the hour to assess the performances of different high yielding varieties of rice under these alternate crop establishment strategies. A single variety may not always perform better under all crop establishment techniques. Therefore, the present investigation was initiated to study the differences in growth and yield potential of local rice cultivars as affected by different crop establishment methods.

2. MATERIALS AND METHODS

The present investigation was under taken during *kharif* 2021 at Regional Agricultural Research Station, situated in thesamecampusof Agriculturalcollege,Warangal. Theresearchstationisgeographicallysituatedatanaltitudeof 259 m above mean sea level on $18^0$07'911" N latitude and $79^0$59'752" Elongitude.ItisinthecentralTelanganazoneofTelanganastate. The soil was clay loam, alkaline in reaction (pH 7.72), with 0.65% of organic matter, 275kg ha^{-1} of available nitrogen, 75kg ha^{-1} of available P and 256 kg ha^{-1} of available K. The experiment was laid out in strip plot design with 12 treatment combinations and three replications. The treatment combinations consisted of three establishment methods i.e., transplanted rice system (15X10 cm spacing) (M_1), wet direct seeded rice (Drum seeding) with 30X6-8 cm spacing (M_2) and dry direct seeded rice at 30 cm row spacing(M_3) in mainplots and four varieties i.e., RNR 15048 (Telanganasona) (S_1), WGL 44 (Siddi) (S_2), WGL 915 (Warangal Rice-1) (S_3) and KNM 118 (Kunaransannalu) (S_4) in sub plots.The recommended dose of fertilizer for wet DSR and transplanted system was 120 Kg N: 60 Kg P_2O_5: 40 Kg K_2O ha^{-1}.Entire dosage of phosphorus and half of the dosage of potash were applied as basal in the form of singlesuper phosphate (SSP) and murate of potash (MOP), respectively. Nitrogenwas applied in the form of urea. It was applied in three equal splits viz., 1/3rd of the dosage as basal, 1/3rd of the dosage at maximum tillering and remaining 1/3rd at panicle initiation stage for transplanting method. For wet DSR method, N was applied in three equal splits viz.,1/3rd dose at 10 DAS, 1/3rd dose at maximum tillering and remaining 1/3rd at panicle initiation stage. A fertilizer dose of 150:50:40 kg ha^{-1} N, $P_2O_5$and K_2O were applied to allthe plots of dry DSR method. Entire dosage of phosphorus and ½ dosage of potash were applied as basal dose in the form of singlesuper phosphate and murate of potash, respectively. Nitrogenwas applied in the form of urea. It was applied in three equal splits viz.,1/3rd dose at 30 DAS (maximum tillering), 1/3rd dose at 60 DAS and remaining 1/3rd at panicle initiation stage with ½ Potash.

In case of wet direct seeding sprouted seeds were sown on thoroughly puddled and well leveled main field at 30 cm spacing drum seeder provides 30 cm spacing between the rowsand 7 cm spacing between the plants of the row. About 6 rows can be laid withthisdrumseederacrossagivenarea. Whereas in dry direct seeded, lines were formed with the help of cultivator at 30 cm row spacing and manual sowing of seeds was done into the mainfield with spacing of 30 cm x 10 cm. After completion of sowing, the field was given light irrigation to provide moisture required for germination of seed and regular irrigations was provided. Sowing of wet and dry DSR along with nursery for transplanting was carried out on 26th August.

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Fig. 1 Satellite view of the experimental site (Downloaded from Google Earth)

Table 1: Characteristic features of varieties

Characteristics	RNR-15048	WGL-44	WGL-915	KNM-118
Duration	125 days	140-145 days	135 days	125 days
Grain type	Short slender very fine	Medium slender fine	Long bold fine grain	Long slender grain
Resistant	Blast	Gall midge	BPH, Blast	Blast
Average yield	5500-6500 kgha^{-1}	7000-8000 kgha^{-1}	7500-8000 kgha^{-1}	7000-8000 kgha^{-1}
Habit	Non lodging Non shattering	Non shattering	Non lodging Non shattering	Less prone to grain shattering and lodging
Release Year	2015	2012	2020	2015

3. RESULTS AND DISCUSSION

3.1Number of tillers m^{-2}

A perusal of the data on number of tillers m^{-2} revealed that, it was higher under transplanted rice system (M_1) at all stages (30 DAS-202, 60 DAS-356, 90 DAS-305) which was at par with wet DSR system (M_2) during 30, 60 and 90 DAS (30 DAS-189, 60 DAS-336, 90 DAS-275). Significantly lowest tillers number m^{-2} was recorded with dry DSR system (M_3) at all stages of crop growth (30 DAS-175, 60 DAS-307, 90 DAS-252). This is mainly due to maintenance of crop plants with proper plant to plant and row to row spacing, which not only reduce competition among plants but also increase the nutrient uptake and light availability to plants leading to more number of tillers in transplanting system. This was supported by Mohantyet al. [22], Tomaret al. [31], Poudelet al. [24], Mohantaet al. [21]. Least number of tillers m^{-2} under dry DSR system (M_3) may be due to closer spacing among plants leading to more competition for available nutrients. In addition to this poor growth than all other systems has resulted in lower number of tillers due to continuous rainfall immediately after sowing and poor plant stand.

In case of varieties, number of tillers m^{-2} ranged from 133 to 223 at 30 DAS, 234 to 387 at 60 DAS and 200 to 327 at 90 DAS. At all the stages of crop growth, higher number of tillers was observed with WGL 44 (S_2) which is at par with RNR 15048 (S_1) and least was in WGL 915 (S_3). This might be due to genetical inherent character of variety to produce lower number of tillers as influenced by different systems of cultivation. These are inlinewiththefindingsof Sampathet al. [26], Chandrikaet al. [9], Anil and Siddi[2] and Nayakaet al. [23].

3.2Number of effective tillers m^{-2}

Number of effective tillers m^{-2} differed significantly by different systems of cultivation and varieties.The data in Table1 indicates that highest number of effective tillers m^{-2} was recorded in transplanted rice system (M_1) (295) which is on par with wet DSR (M_2) (267). Lower number of

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effective tillers was recorded from dry DSR (M_3) (242). Highest number of panicles per square meter in transplanting establishment method might be due to highest plant stand and more number of tillers to panicle conversion ratio. Wet DSR performed superior over the dry DSR in production of number of panicle was due to favourable condition to establish and translocate the assimilates to sink from the source. The similar results were also reported in findings of Barla and Kumar [4], Mohantyet al.[22], Bohra and Kumar [6] and Mohantaet al. [21].

Among the varieties, significantly higher number of effective tillers m^{-2} were recorded in WGL 44 (S_2) (318) which is statistically on par with RNR 15048 (S_1) (293) over KNM 118 (S_4) (274) and least number effective tillerswere recorded in WGL 915 (S_3) (187).The difference in number of effective tillers among the genotypes might be due to their genetic potential, number of tillers, uptake of nutrients by varieties and crop weed competition ability of variety at all crop growth stages. The results are in close conformity with Kumharet al. [16], Chowhanet al. [11], Dileepet al. [12], and Mangarajet al.[20].

3.3 Dry matter production (kg ha^{-1})

Dry matter production recorded at different intervalsduring crop growth is presented in the Table 1 Higher dry matterproductionperunitareaisthefirstpre-requisiteforhighyield.Theamountofdry matterproductiondependsoneffectivenessofphotosynthesisofcrop.

From the data it is evident that the dry matter production was highest under transplanted rice system (M_1) during all the crop stages. At 30 DAS significantly maximum dry matter production was recorded under transplanted rice (M_1) (2489 kg ha^{-1}) over wet DSR system (M_2) (1975 kg ha^{-1}) and minimum dry matter productionwas observed under dry DSR system (M_3) (1677kg ha^{-1}). Dry matter production for 60 DAS ranged between (8135 and 6850 kg ha^{-1}) for 90 DAS ranged between (12200 and 11079 kg ha^{-1}) and for harvest ranged between (13133 and 12087 kg ha^{-1}). At 60 DAS significantly higher dry matter was observed under transplanted rice system (M_1) as compared to dry DSR and which was statistically at par with the wetDSR system (M_2). The same trend was reported at 90 DAS and at harvest. Higher dry matter production in transplanted rice is mainly due to better establishment of seedlings and more number of tillers m^{-2} whereas lowest dry matter production in dry DSR is mainly due to lower plant stand and less number of tillers m^{-2}. This was supported by Shan et al. [28], Mohantyet al. [22], Singh et al. [30], Tomaret al. [31].

Among varieties, more dry matter accumulation was recorded by KNM 118 (S_4) at all crop growth stages (30 DAS-2272, 60 DAS-8237, 90 DAS-12344 and at harvest-13356 kg ha^{-1}) which was on par with WGL 44 (S_2) (30 DAS-2030, 60 DAS-7862, 90 DAS-11850 and at harvest-12850 kg ha^{-1}). Lowest dry matter production was recorded by RNR 15048 (M_1) (30 DAS-1910, 60 DAS-6711, 90 DAS-10900 and at harvest-11800 kg ha^{-1}). The difference in dry matter production among the genotypes might be due to their genetic potential, capacity towards uptake of nutrients by varieties, competition of variety for space, light, nutrients and differential plant height. The results are similar to the findings of Harish et al.[15], Sampathet al. [26], Chandrikaet al. [9], Sharathchandraet al. [8], Anil and Siddi[2] and Nayakaet al.[23].

3.4 Grain yield (kg ha^{-1})

Grain yield is the interaction 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 experimental data revealed that highest grain yield of 6806 kg ha^{-1} was obtained with transplanted system (M_1) of cultivation. Wet DSR (M_2) system was on par with transplanting system with 6247 kg ha^{-1} of grain yield. The lowest grain yield was recorded with dry DSR (M_3) (5058). This is mainly due to high dry matter production, number of tillers, number of effective tillers, number of grains panicle^{-1} in transplanted rice system compared to other systems of cultivation.

Higher grain yield in transplanted rice system can be attributed to optimum plant population resulting in good rooting and better nutrient uptake of plant, reduced pest and disease incidence and low weed infestation than dry DSR system. The results are in accordance with the findings of Yadav and Singh [32], Shan et al. [28], Singh et al. [29].

Significantly higher grain yield in wet DSR as compared to dry DSR might be due to proper spacing between plant to plant, good sunlight and immediate establishment of seedlings in wet DSR system. The results are in accordance with the findings of Mandhata Singh and Singh [19].

In subplots, significantly higher grain yield was recorded in KNM 118 (S_4) (6617) which is statistically on par with WGL 44 (S_2) (6244), closely followed by WGL 915 (S_3) (5943) and grain yieldwas recorded in RNR 15048 (S_1) (5343). 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 Kumhar et al. [16], Harish et al. [15], Chandrika et al. [9], Dileep et al. [12], Sharath Chandra et al. [8], Anil and Siddi[2], Mangaraj et al. [20].

3.5 Straw yield (kg ha^{-1})

Straw yield (kg ha^{-1}) is presented in Table 2. The data in table revealed that highest straw yield 7692kg ha^{-1}was obtained with transplanted rice system (M_1) which was on par with wet DSR (M_2) (7153 kg ha^{-1}). The lowest straw yield 5992kg ha^{-1} was recorded with dry DSR (M_3). This is mainly due to higher dry matter production by good nutrient uptake from soil, increased rate of metabolic processes, good light absorption rate and photosynthetic activity in transplanted rice system compared to other systems of cultivation whereas lower straw yield might be due to lower dry matter production and lower number of tillers per hill. The results were supported by Shan et al. [28], SandhyaKanthiet al. [27], Singhet al. [29].

Among genotypes, significantly higher straw yield was recordedin KNM 118 (S_4) (7543) which is statistically on par with WGL 44 (S_2) (7159), closely followed by WGL 915 (S_3) (6832) and least straw yieldwas recorded in RNR 15048 (S_1) (6250). Higher straw yield might be due to adequate supply of resources which results higher dry matter production, more number of tillers, maximum leaf area and better portioning of photosynthates resulting maximum straw yield. The results are in line with the findings of Kumhar et al. [16], Harish et al. [15], Chandrika et al. [9], Dileep et al. [12], Sharath Chandra et al. [8], Anil and Siddi[2], Mangaraj et al. [20].

3.6 Harvest index (%)

The harvest index was not significantly influenced either by different systems of cultivation or varieties and even the interaction effect remained non significant as presented in Table 2. The results were supported by Barla and Kumar [4], Lavanya and Mallareddy[17].

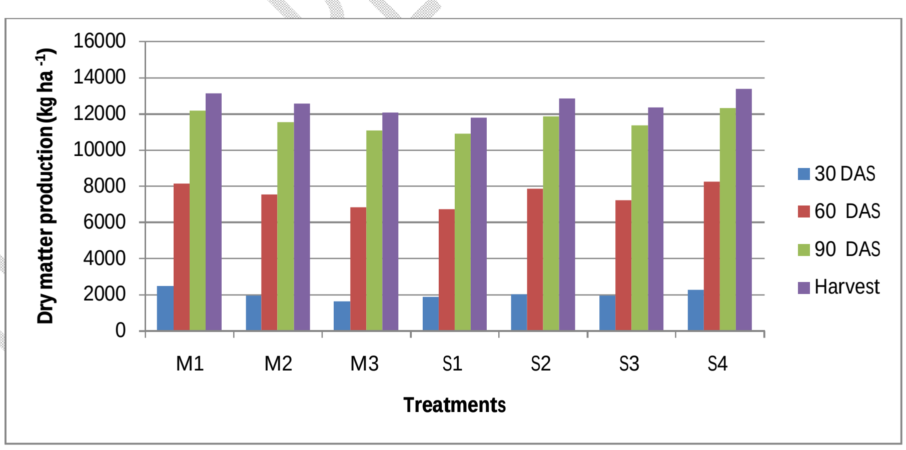

Fig. 2 Dry matter production (kg ha^{-1}) of varieties as influenced by different systems of cultivation

Table 2: Number of tillers, number of effective tillers m^{-2} and dry matter production (kg ha^{-1})of rice varieties as influenced by different systems of cultivation.

Treatments	Number of tillers m^{-2}			Number of effective tillers m^{-2}	Dry matter production (kg ha^{-1})			
	30 DAS	60 DAS	90 DAS		30 DAS	60 DAS	90 DAS	Harvest
Main plot treatments								
M1	202	356	305	295	2489	8135	12200	13133
M2	189	336	275	267	1975	7550	11558	12558
M3	175	307	252	242	1677	6850	11079	12087
SEm (±)	5	9	8	8	89	207	213	199
CD (p=0.05)	19	35	30	33	350	811	835	780
Sub plot treatments								
S1	203	374	301	293	1910	6711	10900	11800
S2	223	387	327	318	2030	7862	11850	12850
S3	133	234	200	187	1977	7237	11356	12367
S4	197	337	282	274	2272	8237	12344	13356
SEm (±)	9	8	8	8	72	265	284	301
CD (p=0.05)	32	27	28	27	248	916	983	1041
Interaction								
Sub plot treatment at same level of main plot treatment								
SEm (±)	15	15	15	13	152	403	575	705
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Main plot treatment at same/different level of sub plot treatment								
SEm (±)	13	17	15	14	168	382	571	705
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Main plots: ***Sub plots:***

***M1** : Transplanted rice **S1** : Telanganasona (RNR-15048)*

***M2** : Wet direct seeded rice (drum seeding)**S2** : Siddi (WGL-44)*

***M3** : Dry direct seeded rice**S3** : Warangal Rice-1 (WGL-915)*

***S4** :Kunaramsannalu (KNM-118)*

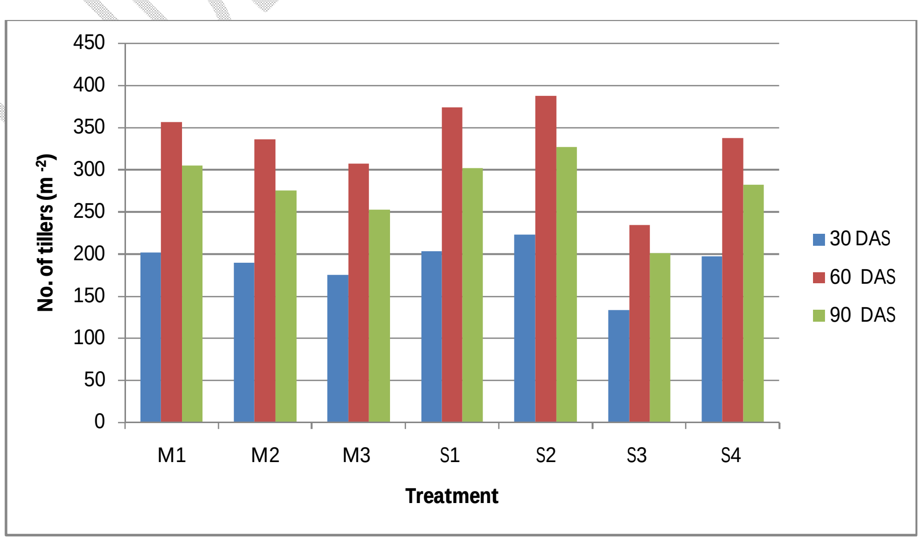

Fig. 3Number of tillersm^{-2}of varieties as influenced by different systems of cultivation

Table 3: Grain yield (kg ha^{-1}), straw yield (kg ha^{-1}) and harvest index of rice varieties as influenced by different systems of cultivation.

Treatments	Grain yield (kg ha $^{-1}$)	Straw yield (kg ha $^{-1}$)	Harvest index (%)
Main plot treatments			
M_1: Transplanted rice	6806	7692	46.87
M_2: Wet direct seeded rice (Drum seeder)	6247	7153	46.55
M_3 : Dry direct seeded rice	5058	5992	45.67
SEm (±)	271	241	0.29
CD (p=0.05)	1065	946	NS
Sub plot treatments			
S_1 : RNR 15048	5343	6250	45.95
S_2 : WGL 44	6244	7159	46.53
S_3 : WGL 915	5943	6832	46.41
S_4 : KNM 118	6617	7543	46.58
SEm (±)	190	197	0.13
CD (p=0.05)	656	683	NS
Interaction			
Sub treatment at same level of main treatment			
SEm (±)	507	520	0.33
CD (p=0.05)	NS	NS	NS
Main treatment at same/different level of sub treatment			
SEm (±)	567	565	0.43
CD (p=0.05)	NS	NS	NS

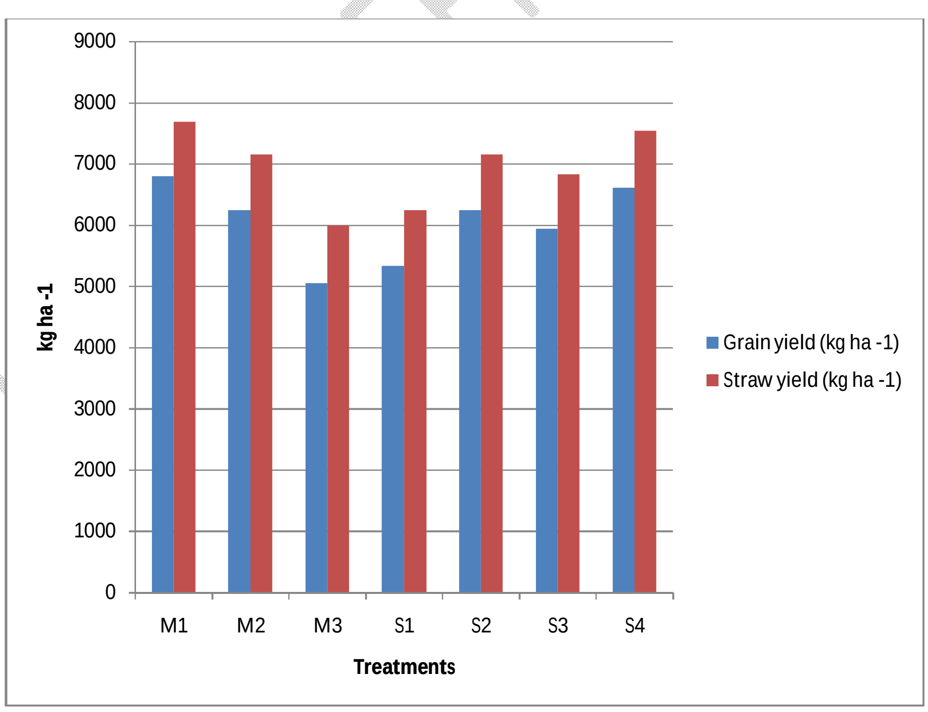

Fig. 4 Grain yield (kg ha^{-1}) and straw yield (kg ha^{-1}) of rice varieties as influenced by different systems of cultivation.

4. CONCLUSION

In conclusion from the above study, transplanted rice system recorded superior growth and yield attributing characters and higher yield due to optimum spacing leading to more light interception,as well as puddling operation resulting in efficient control of weeds and readily availability of nutrients to rice and that resulted in more number of tillers and effective tillers, higher dry matter accumulation ultimately increasing yield. Among varieties KNM 118 was found to be superior in all the yield attributing characters and yield. This might be due to the capacity of variety towards uptake of nutrients, competition for space, light and nutrients which improved better N uptake and leading to greater dry matter production and its translocation to sink.Interaction effect of main plot and sub plots was found to be non significant regarding yield attributing characters.

REFERENCES

1. Agriculture action plan report 2021-22 of Department of Agriculture,GovernmentofTelangana.*www.agri.telangana.gov.in.*
2. Anil, D and Siddi, S. 2020. Evaluation of pre released rice (Oryza sativa L.) genotypes under different sowing dates in rainy season. *Current Journal of Applied Science and Technology*. *39*: 74-84.
3. Banerjee, H., Samanta, S., Sarkar, S., Garai, S., Pal, S., Brahmachari, K. 2018. Growth, productivity and nutrient uptake of different rice cultivars undercoastal eco-System of West Bengal. *Journalof the Indian Society of Coast Agricultural Research.* 36: 115–121.
4. Barla, S and Kumar, S.S. 2011. Evaluation of rice establishment techniques inJharkhandplateau.*Oryza-An International Journal on Rice.*48(1):79-80.
5. Biswas, B., Timsina, J., Patra, S.R., Mishra, B., Chakraborti, R., Patra, A., Mahato, B., Banerje, P., Ghosh, P.K., Mukherjee. J., Das, S., Sarkar, S., Adhikary, S., Mondal, M., Kanthal, S., Baidya, S., Banerjee, S., Mondal, B., Ray, B.R. 2019. Climate change-resilent rice production technology : A high yielding, water efficient and remunerative option for South Asian farmers. *Global Journal of Agricultural and Allied Sciences*. 1: 20–29.
6. Bohra, J.S and Kumar, R. 2015. Effect of crop establishment methods on productivity, profitability and energetics of rice (Oryza sativa)-wheat (Triticumaestivum) system. *Indian Journal of Agricultural Sciences*. *85*(2): 217-23.
7. Chakraborty, D., Ladha, J.K., Rana, D.S., Jat, M.L., Gathala, M.K., Yadav, S.,Rao, A.N., Ramesha, M.S., Raman, A. 2017. A global analysis of alternative tillage and crop establishment practices for economically andenvironmentally efficient rice production. *Scientific reports*. 7(1): 1–11.
8. Chandra, M.S., Kumar, K.A., Madhavi, M and Chary, D.S. 2019. Dry matter production and nutrient uptake of rice (Oryza sativa L.) varieties under alternate wetting and drying in puddled soil. *Int. J. Curr. Microbiol. App. Sci*. 8(8): 2302-2313.
9. Chandrika, M., Devi, M.U., Ramulu, V and Ramana, M.V. 2017. Evaluation of different varieties ofaerobic rice (Oryza sativa L.) under different fertigation levels on growth and yield parameters. *Int. J. Curr. Microbiol. App. Sci*. *6*(5): 2793-2801.
10. Chauhan, B.S., Singh, R.G., Mahajan, G. 2012. Ecology and management of weeds under conservation agriculture: a review. *Crop Protection*. 38: 57-65.
11. Chowhan, S., Haider, M.R., Hasan, A.F.M.F., Hoque, M.I., Kamruzzaman, M and Gupta, R. 2017. Comparative on farm performance of five modern rice varieties with two local cultivars. *Journal of Bioscience and Agriculture Research.* 13(01): 1074-1086.
12. Dileep, K., Pasupalak, S and Baliarsingh, A. 2018. Effect of establishment methods and sowing time on growth and yield of rice varieties (Oryza sativa L.). *The Pharma Innovation Journal*. *7*(4): 904-907.
13. Farooq, M., Siddique, K.H.M., Rehman, H., Aziz, T., Lee, D.J., Wahid, A., 2011. Rice direct seeding: Experiences, challenges and opportunities. *Soil and tillage research*. 111(2): 87–98.
14. Guruprem., Rakesh choudhary., Amit kumar., Ramesh jhorar., Singh, V.D. 2017. Recent production technologies of rice for its sustainable cultivation in Haryana. *International Journal of Agricultural Sciences*. 13(1): 83-92.
15. Harish, M.N., Choudhary, A.K., Singh, Y.V., Pooniya, V., Das, A., Varatharajan, T and Babu, S. 2017. Effect of promising rice (*Oryza sativa L.*) varieties and nutrient management practices on growth, development and crop productivity in eastern Himalayas. *Annals of Agricultural Research*. 38(4): 375-84.

16. Kumhar, B.L., Chavan, V.G., Rajemahadik, V.A., Kanade, V.M., Dhopavkar, R.V., Ameta, H.K and Tilekar, R.N. 2016. Effect of different rice establishment methods on growth, yield and different varieties during *kharif* season. *Int. J. Plant Ani Environ. Sci.* 6: 127-132.
17. 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.
18. Mahajan, G., Chauhan, B.S., Timsina, J., Singh, P.P., Singh, K. 2012. Crop performance and water and nitrogen-use efficiencies in dry-seeded rice in response to irrigation and fertilizer amounts in Northwest India. *Field Crops Research.* 13(4):59-70.
19. Mandhata Singh and Singh, R.P. 2010. Influence of crop establishment methodsandweedmanagementpracticesonyieldandeconomicsofdirect-seeded rice *(Oryzasativa)*. *Indian Journal of Agronomy.*55(3):224-229.
20. Mangaraj, S., Sahu, S., Panda, P.K., Rahman, F.H., Bhattacharya, R., Patri, D., Mishra, P.J., Phonglosa, A and Satapathy, S.K. 2021. Assessment of stress tolerant rice varieties under rainfed condition in North Eastern Ghat of Odisha. *International Journal of Environment and Climate Change*. 11(4): 128-134.
21. Mohanta, S., Banerjee, M., Malik, G.C., Shankar, T., Maitra, S., Ismail, I.A., Dessoky, E.S., Attia, A.O and Hossain, A. 2021. Productivity and profitability of kharif rice are influenced by crop establishment methods and nitrogen management in the lateritic belt of the subtropical region. *Agronomy.* 11(7): 1280.
22. Mohanty, TR., Maity, SK and Roul, PK. 2014. Response of rice to establishmentmethodsandnutrientmanagementpracticesinmediumland.*Oryza.*51(2):136-142.
23. Nayaka, G.V., Reddy, G.P and Kumar, R.M. 2021. Dry matter production and partitioning in different plant parts of rice cultivars under irrigation regimes and systems of cultivation. *Indian Journal of Agricultural Research. 55*(3): 347-352.
24. Poudel, K., Timilsina, R.H and Bhattarai, A. 2020. Effect of crop establishment methods on yield of spring rice at Khairahani, Chitwan, Nepal. *Big Data In Agriculture (BDA).* 3(1): 6-11.
25. Rana, M.N., Al Mamum, M.A., Zahan, A., Ahmed, M.N., Mridha, M.A.J. 2014. Effect of planting methods on the yield and yield attributes of short duration aman rice. *American Journal of Plant Sciences.* 5**:** 250-255.
26. Sampath, O., Srinivas, A., Avil, K.K and Ramprakash, T. 2017. Effect of plant density and fertilizer levels on growth parameters of rice varieties under late sown conditions. *International Journal of Agricultural Science and Research*. 7(3): 375-384.
27. SandhyaKanthi, M., Ramana, A.V and Ramana Murthy, K.V. 2014. Effect ofdifferentcropestablishmenttechniquesandnutrientdosesonnutrientuptakeandyieldofrice(*Oryzasativa*L.).*KarnatakaJournalofAgriculturalSciences.*27(3):293-295.
28. Shan, F.A., Anwar Bhat, M., Manzoor A.Ganai., Hussain, A and TauseefA.Bhat. 2012. Effect of crop establishment and weed control practices on theperformanceofrice(*Oryzasativa*L.).*AppliedBiologicalResearch.*14(1):79-85.
29. 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 of Pantnagar. *International Journal of Current Microbiology and Applied Sciences.* 6(6): 297-306.
30. Singh, S.K., Abraham, T., Kumar, R and Kumar, R. 2016. Response of crop establishment methods and split application of nitrogen on productivity of rice under irrigated ecosystem. *Environment and Ecology*. 35(2A): 859-862.
31. Tomar, R., Singh, N.B., Singh, V and Kumar, D. 2018. Effect of planting methods and integrated nutrient management on growth parameters, yield and economics of rice. *J. Pharmacogn. Phytochem*. 7(2): 520-527.
32. Yadav, V and Singh, B. 2006. Effect of crop establishment method and weedmanagement practice on rice *(Oryza sativa)* and associated weeds. *IndianJournalofAgronomy.*51(4):301-303.
33. Xu, L., Li, X., Wang, X., Xiong, D., Wang, F. 2019. Comparing the grain yields of direct-seeded and transplanted rice: A meta-analysis. *Agronomy* 9(11):767.