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Outcomes of yield attributes, yield and economics of Rice (*Oryza sativa* L.) through applied the various planting methods and weed management practices

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Abstract
A field experiment was conducted during the *kharif* seasons of 2018 and 2019 to study on outcomes of yield attributes, yield and economics of Rice (*Oryza sativa* L.) through applied the various planting methods and weed management practices. Taking all things together, there were sixteen treatment combinations comprising of four crop planting methods and four weed management practices. The experiment was laid out in Split Plot Design. Planting methods are Transplanting (20cm x 10cm), Direct seeded rice (Sprouted & line sowing) (20cm apart), Drum seeded rice (Sprouted) (20cm x 10cm) and System of rice intensification (20cm x20cm) were kept in main plot and weed management practices are Bispyribac sodium 25 gaiha^{-1}at 25 DAS/T, Bispyribac sodium 25 gaiha^{-1}at 25 DAS/T + hand weeding at 40 DAS/T, two hand weeding 20 & 40 DAS/T and Weedy check in sub-plots and replicated thrice. Rice planting by SRI method had maximum grain yield (32.07 and 34.36 q/ha), harvest index (46.54 and 47.43%), net return (Rs.46757/ha) and benefit: cost ratio (1.42). The two hand weeding at 20 and 40 DAS/T followed by Bispyribac sodium 25 g ai ha^{-1} at 25 DAS/T with hand weeding at 40 DAS/T proved to be most effective in minimizing the density of weeds and their dry weight, and in enhancing the grain yield (34.09 and 36.53 q/ha), harvest index (48.20 and 48.72%), net return (Rs 46525/ha) and benefit: cost ratio (1.35).

Keywords: Weeds, transplanting, herbicides, hand weeding

Introduction
Rice (*Oryza sativa* L.) is one of the most important cereal crops, it belongs to family poaceae (Gramineae). It is a staple food of about more than 60% of total world population followed by wheat. About 90% of the world rice is produced and consumed in Asia. In India, area, production and productivity of rice is 43.79 m ha, 116.42 m tones and 2659 kg ha^{-1}, respectively (Anonymous, 2019) [1]. Uttar Pradesh is one of the biggest rice developing states after West Bengal in the nation, where rice is grown over a zone of 5.75 million hectares with absolute creation of 15.54 million tones having normal productivity of 2703 kg ha-1. The productivity of the Uttar Pradesh is lower in comparison to Punjab, Haryana and Tamil Nadu. The significant reasons of low productivity of rice in Uttar Pradesh are due to non- adoption as well as non-availability of high yielding varieties, poor fertilizer management, irrigation facilities and improper management of weeds. Rice is grown mostly through transplanting in India, in spite of the fact that transplanting is cumbersome practice and requires more labour consuming, cumbersome, time consuming and entails a lot of expenditure on raising nursery, its uprooting and transplanting, etc. (Tuong *et al.*, 2005) [10]. The inadequacy of irrigation water and scarce labour coupled with higher wages during the peak period of farm operations, invariably lead to delay in transplanting. To overcome this problem, farmers are gradually switching over to direct seeding under puddle condition. Direct seeding reduces substantially the amount of labour needed for growing of rice crop. The direct seeding also helps to harvest the crop by 8–10 days earlier than transplanting. It eliminates the use of seedlings and operations such as nursery preparation care of seedlings, pulling, bundling, transporting and transplanting. Weed flora will vary depending on the season as well as climatic and edaphic conditions. Direct seeded rice fields infested with a divergent weed flora. Out of which *Echinochloa colona* (L.), *Echinochloa crus-galli* (L.). Were of grassey group, *Cyperus iria* L., *Cyperus diffor*mis L. of sedges group and *Eclipta prostrata* (L.), *Spheoclea zeylanica* Gaertner and *Ludwigia hyssop* folia of broad leaf group.

Application of different preemergence herbicides including thiobencarb, pendimethalin, butachlor, oxadiazon and nitrofen has been found to control weed satisfactorily in direct seeded rice. Among the post emergence herbicides, ethoxysulfuron, cyhalofop-butyl, pritilachlor, chlorimuron, metsulfuron, bispyribac sodium and penoxsulam effectively controlled weeds in direct seeded rice (Mahajan *et al.*, 2009).

Materials and Methods

The field trials were done during kharif seasons of 2018 and 2019 at Agronomy Research Farm of A. N. D. University of Agriculture and Technology, Narendra Nagar (Kumarganj), Ayodhya (U.P.) which is situated in Ayodhya-Raibarely around 42 km away from Ayodhya city. The trials site falls under sub-tropical conditions with remarkable humidity and lies between 24.40 North scope and 82.120 East longitudes with a height of around 113 m from mean ocean level. The average annual rainfall is 800 mm, a major portion of which is received during the monsoon season. The exploratory field was very much leveled having great water system and seepage offices. The wellspring of water system was tube well. The soil was silty loam with pH 8 the available N.P. and K content in the soil was 198.25, 19.30 and 290.12kg ha^{-1} respectively. There were sixteen treatment combinations comprising of four crop planting methods and four weed management practices. The experiment was laid out in Split Plot Design. Planting methods were kept in main plot and weed management practices in sub-plots and replicated thrice. The treatments comprised four rice planting methods (system of rice intensification, transplanting, drum seeding and direct seeded rice under puddled condition) and four weed control techniques (Bispyribac sodium 25 g ai ha^{-1} at 25 DAS/T, Bispyribac sodium 25 g ai ha^{-1} at 25 DAS/T + hand weeding at 40 DAS/T, Two hand weeding 20 & 40 DAS/T and Weedy check). The variety NDR-97 is short tipped tendency, stigma white, it has resistance to many diseases and moderately resistance to blast and sheath blight. It matures 90-95 days. Under natural field conditions, no major pest has been affecting the variety. The recommended dose of Phosphorous and potassium (60 and 40 kg/ha) were applied consistently through single super phosphate and muriate of potash as basal application during the puddling activity and consolidated in the upper soil. Nitrogen was applied at 120 kg/ha through urea in three equivalent split-portions, one-half as basal, one-fourth as top dressed at early tillering stage and the rest of the quantity applied seven days before panicle initiation stage. The sowing under direct seeding (direct seeding, and drum seeding) treatments, a seed rate of 100 and 20 kg/ha were used for broad-casting and drum seeding treatments, respectively. Sowing in direct seeding plots was done by broadcast and through drum seeder as per treatments.The seed was soaked in water for 12 hours, and piled and covered with moist gunny bag for 24 hours for sprouting. Puddling in drum seeding plots was done just before sowing of seed by giving two cross ploughing with desi plough followed by planking in ponded water, after that sprouted seeds of rice were sown with drum seeder in row at 20 cm a part. For transplanting and SRI, the nursery was raised by sowing of the seed at the rate of 45 kg ha^{-1} and 7 kg ha^{-1}, respectively. In direct seeding methods the sowing was done by broadcasting of sprouted seeds but in other methods planting was done in rows at 20 cm apart. The specing in drum seeding treatment row to row and plant to plant was kept at 20 cm × 10 cm. The date of sowing in the nursery and in main field was kept same and it was done on 28-06-2018 and 30-06-2019, respectively. The plot wise crop was harvested by hand with sickles at the time when upper portion of spikelets looked straw coloured and grain has hard, containing 15-18% moisture. First of all, two border rows were reaped around individual plots leaving only the net area. From width side, 50 cm area from both the sides was harvested. In case of seeding through broadcasting plots, 40 cm in length and 50 cm in width in each side was harvested.

The effective $shootsm^{-2}$ at maturity stage was counted by placing a quadrate of 50cm x 50 cm (0.25 m^2) randomly at three places in each plot and total no. of effective $shootsm^2$ was counted during experiment. The five panicles samples were collected randomly from each plot and their length was measured from base to tip of panicle and average values were calculated. Grains of five panicles selected for measuring number of grains $panicale^{-1}$ from each plot were counted carefully and averaged to obtain during investigation. The thousand grains randomly selected and counted from each plot. The counted grains were dried to 14% moisture and then weighed. The grains yield was obtained by straw and separation of cleared grain of each net plot was weighed in kg and finally makes in q/ha for statistical analysis. The straw yield kg/plot was calculated by subtracting grain yield kg/ plot of each net plot. The straw yield was converted into q/ha and analyzed. The harvest index is the ratio of grain yield and biological yield multiplied by 100.It was calculated by following formula –

$$\text{Harvest Index (\%)} = \frac{\text{Economic Yield (Grain yield)}}{\text{Biological Yield (Grain + straw)}} \times 100$$

Cost of cultivation was calculated for different treatments with the prevailing market prices and it was worked out by considering all the expenses incurred in the cultivation of experimental crop and added with common cost due to various operations and inputs. Gross profit was calculated by multiplying the grain/ seed and straw yield/ ha with the prevailing market prices of seed and straw. Benefit-cost ratio was calculated by dividing the net return to the cost of cultivation of the individual treatment combination.

$$\text{B: C ratio} = \frac{\text{Net return}}{\text{Cost of cultivation}}$$

Results and Discussion

Yield Attributes of Rice

Yield attributing characters are the resultant of dry matter accumulation by plants and its translocation for formation of yield attributes. These yield attributes are having direct correlation with the grain yield of rice. The yield attributes namely, number of effective shoots m^{-2}, length of panicles (cm), number of grains per panicle and 1000 grains weight were significantly influenced by different crop planting methods and weed management practices (Table-1) during both the years of investigation. The highest values of these attributes were recorded under SRI (System of Rice Intensification) methods closed to transplanting method especially for effective shoots m^{-2}, length of panicles (cm), number of grains per panicle and 1000grain weight. This might be attributed to comparatively better growth and development of plants due to reduced competitions for available growth resources caused by low density of weeds.

Under this situation, plant absorbed proper moisture, light, nutrient and space which might have enhanced better translocation of photosynthates from source to sink and nutrients uptake. The lower values of effective shoots m^{-2}, length of panicles (cm), number of grains per panicle and 1000-grain weight, were observed with direct- seeding method due to poor growth performance of individual plant in community because of antagonistic effect which was created due to more competition for available growth resources among the plants. The above findings were reported by Yadav *et al.* (2005) he reported that transplanting after puddling produced significantly higher (18.6%, 59.1% and 35.4%) grain yield of rice over drum seeding method during three consecutive years. Jai *et al.* (2010) reported that the better performance of these treatments in terms of grain and straw yield could be attributed to better expression of their yield attributes due to better management practices and reduction in crop-weed competition, resulting in significant reduction in weed dry weight and weed population.

Table 1: Effect of different planting methods and weed management practices on yield contributing characters of Rice

Treatments	Yield contributing characters							
	Effective shoots (No. m2)		Panicles length (Cm)		No. of grain per panicle-1		Test weight (g)	
	2018	2019	2018	2019	2018	2019	2018	2019
Planting methods								
Transplanting (20cmx10cm)	331.11	335.19	17.86	18.81	90.82	95.31	22.37	22.80
Direct seeded rice (sprouted & line sowing) (20cm apart)	251.86	259.17	14.63	15.40	74.36	77.57	21.41	21.08
Drum seeded rice (sprouted) (20cmx10cm)	293.07	299.92	16.25	17.11	82.46	86.60	21.91	21.92
SRI (20cm x 20cm)	350.76	357.32	19.26	20.28	92.36	98.53	22.91	23.04
SEm±	8.97	8.56	0.45	0.50	2.29	2.41	0.61	0.63
CD (P=0.05)	31.05	29.65	1.55	1.73	7.93	8.34	NS	NS
Weed management practices								
Bispyribac sodium	303.16	309.32	16.53	17.41	84.84	88.42	22.16	22.62
Bispyribac sodium + Hand weeding 40 DAS/T	336.08	342.76	18.27	19.24	90.68	95.56	22.40	22.73
Two hand weeding 20&40DAS/T	349.63	357.77	19.19	20.20	91.69	97.65	23.10	23.12
Weedy check	237.92	241.75	14.01	14.75	72.80	76.38	20.95	20.38
SEm±	4.94	5.52	0.29	0.30	1.41	1.48	0.35	0.34
CD (P=0.05)	14.43	16.11	0.87	0.88	4.12	4.33	1.02	1.00

Among crop planting methods, two hand weeding at 20 and 40 DAS/T gave significantly higher number of effective shoots (m^{-2}), length of panicles (cm), number of grains per panicle and 1000-grain weight than other methods and found being at par with bispyribac-Na 25g ha^{-1}coupled with hand weeding at 40 DAS/T during both two years of investigation (Table-1). However, weedy check plot recorded significantly lower values of yield attributes over rest of the weed control treatments. This might because of the treatments which were able to poor crop-weed competition and resulted higher values of yield attributes and yield. The similar findings were supported by Khattak *et al.* (2007) [5], Aslam *et al.* (2008) [2] Gaire *et al.* (2013) [4] and Dubey *et al.* (2017) [3].

Grains yield, straw yield and harvest index of rice

Yield is the result of coordinated interplay of growth characters and yield attributes. Grain and straw yield of paddy were influenced significantly by different planting methods during 2018 and 2019 (Table-2). The SRI method being at par with transplanting produced significantly higher grain and straw yields over all other planting methods. Higher yield under SRI method was due to better crop growth and devolvement resulting into higher yield attributes which increased the grain yield and higher straw yield under SRI method was probably due to more dry matter production per unit area caused by better nutrient absorption from soil, increased rate of metabolic processes, rate of light absorption, photosynthetic activity and a greater number of leaves. Transplanting method also recorded significantly more harvest index over rest of the planting methods and found statistically at par with both SRI and drum seeded rice. This might be due to almost similar increase in grain and straw yield under each method. Singh *et al.* (2013) [9] reported that SRI and transplanting methods gave statistically at par grain yield but straw yield was significantly higher in transplanting method as compared to SRI, while seed quality was superior in SRI as compared to transplanting method. Yadav and Singh (2006) found that the highest grain yield (55q/ha) in transplanting which was 45.5 and 4.5 per cent more than that in direct seeding and drum seeding methods of rice planting, respectively.

Under the different weed management practices, the manual weeding twice (20 & 40 DAS/T) being at par with bispyribac-Na 25g ha^{-1} supplemented with hand weeding at 40 DAS/T produced significantly higher grain and straw yield as compared to bispyribac Na 25g ha^{-1} alone and weedy check. However, bispyribac-Na 25g ha^{-1} alone recorded significantly highest grain and straw yield over weedy check. Weedy treatment produced significantly lower grain and straw yield than all other weed management practices during both the years of experiment. The present results are in accordance with the finding of Yadav *et al.*, (2009) [11].

Table 2: Effect of planting methods and weed management practices on yield of Rice (*Oryza sativa* L.)

Treatment	Grain yield (q/ha)		Straw yield (q/ha)		Harvest index (%)	
	2018	2019	2018	2019	2018	2019
Planting methods						
Transplanting (20cmx10cm)	31.18	33.40	35.81	37.02	46.54	47.43
Direct seeded rice (sprouted & line sowing) (20cm apart)	21.40	22.93	31.54	30.76	40.42	42.71
Drum seeded rice (sprouted) (20cmx10cm)	27.35	29.31	33.23	33.63	45.15	46.57

SRI (20cm x 20cm)	32.07	34.36	37.41	38.60	46.16	47.09
SEm±	0.825	0.884	1.005	0.972	1.239	1.297
CD (P=0.05)	2.856	3.060	3.477	3.365	4.286	4.490
Weed management practices						
Bispyribac sodium	27.66	29.64	38.52	37.47	41.80	44.17
Bispyribac sodium + Hand weeding 40 DAS/T	33.66	36.06	36.46	38.29	48.00	48.50
Two hand weeding 20&40DAS/T	34.09	36.53	36.64	38.45	48.20	48.72
Weedy check	16.59	17.77	26.38	25.80	38.61	40.78
SEm±	0.421	0.451	0.562	0.543	0.711	0.752
CD (P=0.05)	1.230	1.318	1.641	1.585	2.075	2.196

Economics of Rice

The adoption of any technology in modern agriculture can only be acceptable and adoptable by farmers if it is economically viable. Economic viability is a function of gain and loss like gross income, net income and benefit-cost ratio (BCR) are important to evaluate the influenced of the different treatments during the experimentation. The highest gross return (Rs.76247/ha and Rs. 85368/ha) was recorded under system of rice intensification with two hand weeding at 20 and 40 DAS/T followed by SRI method with bispyribac-Na and one hand weeding and transplanting with two hand weeding at 20 and 40 DAS/T. It might be due to higher yield of rice. The lowest gross return of (26931/ha and Rs. 29787/ha) was recorded under direct-seeded method with weedy check plot due to poor yield of rice.

The more net return (Rs. 37798/ha and Rs. 46757/ha) was attained under SRI with bispyribac-Na and one hand weeding followed by SRI method with two hand weeding at 20 and 40 DAS/T and drum seeded rice with bispyribac-Na and one hand weeding. However, the minimum net return of was recorded in direct seeded rice with weedy check treatment. The maximum B:C ratio (Rs. 1.18/ha and Rs. 1.42/ha) was recorded under drum seeded rice along with bispyribac-Na and one hand weeding at 40 DAS/T followed by drum seeded rice with two hand weeding at 20 and 40 DAS/T and drum seeded rice with bispyribac-Na alone (Rs. but, the minimum B:C ratio (0.05 and 0.15/ha) was recorded under direct seeded rice along with weedy check treatment. The similar findings are correlated with Prasad *et al.* (2001) [7], Shivaramu and Krishnamurthy (2011) [8], Gaire *et al.* (2013) [4] and Dubey *et al.* (2017) [3].

Table 3: Effect of planting methods and weed management practices on Economics of paddy crop (*Oryza sativa* L.)

Treatments	Gross return (Rs/ha)		Net return (Rs/ha)		B-C ratio	
	2018	2019	2018	2019	2018	2019
S_1W_1	61930	68464	25023	31316	0.68	0.84
S_1W_2	73118	81910	33549	42100	0.85	1.06
S_1W_3	74002	82885	33185	41839	0.81	1.02
S_1W_4	37836	41836	2343	6114	0.07	0.17
S_2W_1	43989	48644	17021	21383	0.63	0.78
S_2W_2	51756	57217	22126	27294	0.75	0.91
S_2W_3	52377	57903	21499	26744	0.70	0.86
S_2W_4	26931	29787	1377	3952	0.05	0.15
S_3W_1	54719	60496	27789	33401	1.03	1.23
S_3W_2	64557	72013	34965	42256	1.18	1.42
S_3W_3	65336	72872	34496	41879	1.12	1.35
S_3W_4	33445	36982	7929	11313	0.31	0.44
S_4W_1	63823	70557	28946	35612	0.83	1.02
S_4W_2	75337	84364	37798	46757	1.01	1.24
S_4W_3	76247	85368	37460	46525	0.97	1.20
S_4W_4	38997	43119	5534	9600	0.17	0.29

Conclusion

System of rice intensification and transplanting methods were found more effective in reducing weed infestation and removal of nitrogen by weeds resulted in enhancement in yield attributes and yield. Hand weeding at 20 and 40 DAS and post emergence application of bispyribac sodium @ 25g ai ha^{-1} at 25 DAS supplemented with one hand weeding at 40 DAS were found most promising to minimized the weed infestation markedly which accelerate the yield attributes and enhanced the yields of paddy. On the basis of economics, it may be concluded that post- emergence application of bispyribac sodium @ 25g a. i. ha^{-1} at 25 DAS supplemented with one hand weeding at 40 days after sowing or transplanting in conjunction with planting of paddy by drum seeder was found most remunerative which record the net income per rupee investment of Rs 1.18 and 1.42 followed by hand weeding 20 and 40 DAS in presence of drum seeding of rice which provided the net return per rupee investment of Rs 1.12 and 1.35 during first and second year, respectively.

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