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Subrahmanyam Tadepalli
M.Sc. (Agronomy) Scholar, Naini Agricultural Institute (NAI), SHUATS, Allahabad, U.P, India.

Rajesh Singh
Assistant Professor, Department of Agronomy, Naini Agricultural Institute (NAI), SHUATS, Allahabad, U.P, India.

Correspondence
Subrahmanyam Tadepalli
M.Sc. (Agronomy) Scholar, Naini Agricultural Institute (NAI), SHUATS, Allahabad, U.P, India.

Effect of crop establishment methods and weed management practices on growth and yield of rice *(Oryza sativa L.)*

Subrahmanyam Tadepalli and Rajesh Singh

Abstract
A field experiment was conducted at Crop Research Farm, Department of Agronomy, SHUATS, Allahabad, (U.P) during *kharif* season of 2016 to study the "Effect of crop establishment methods and weed management practices on growth and yield of rice *(Oryza sativa L.)*"
The experiment consisted of twelve treatments combinations comprising of three crop establishment methods viz., Drum seeding, broadcasting of sprouted seeds and transplanting and 4 weed management practices viz., weedy check, two hand weedings at 15 and 30 DAS, Bispyribac-sodium at 15 DAS at 30g a.i ha^{-1}, Bispyribac-sodium at 15 DAS at 30g a.i ha^{-1} fb-Ethoxysulfuron at 30 DAS 20g a.i ha^{-1}. The experiment was laid out in Randomized Block Design each replicated thrice. The results showed that Drum seeding and two hand weeding recorded maximum number of productive tillers $plant^{-1}$ (29), Grains $panicle^{-1}$ (206), Grain yield (6335 kg ha^{-1}), Straw yield (7661 kg ha^{-1}).The superiority of two hand weedings over remaining treatments might be due to effective control of weeds which is evidenced through table 5 and with higher yield attributes recorded in table 3.

Keywords: Drum seeding, weed management, crop establishment methods, sprouted seeds

1. Introduction
Rice (*Oryza sativa* L.) is one of the most important cereal crop and it is a staple food of more than 70 per cent of world's population (Yadav and Singh, 2006) [1]. Rice occupies 11 per cent of world agricultural land. Asia dominates the world in rice production as it accounts for about 90 per cent of world's rice area and 92 per cent of production (Pandey *et al.,* 2010) [2]. India shares around 21 per cent of global rice production from about 28 per cent of rice area. It ranks first in rice area (35.86 M ha) with second position in production (102 MT) in the world, but its productivity (2844 kg ha^{-1}) is much below than the world's average 4112 kg ha^{-1} (Directorate of Economics and Statistics, 2011) [3]. In India, transplanting is the common method of establishing rice crop. However, this method is not much profitable due to several reasons such as labour shortage, power crisis and water shortage due to late release of water into the canals, higher cost of cultivation and delayed monsoon showers. This forced to identify alternate methods of rice cultivation without reduction in yield in addition to saving energy, water and time. Further, rice production under current inputs and technology fails to meet the projected demand (Leeper, 2010) thus, there is an urgent need to increase rice productivity per unit area in the world. Drum seeding is one of the alternative methods to transplanting, as it reduces labour requirement and performs as good as transplanting method at many places (Yadav and Singh, 2006) [1]. Bispyribac sodium and Ethoxysulfuron are one of the promising herbicides which help to curb the weed infestation in rice fields.

Materials and Methods
The experiment was conducted at CRF (Crop Research Farm) Department of Agronomy, SHUATS, Allahabad, and U.P during *kharif* 2016. Geographically, the experimental site is located between 25°24'42'' North latitude and 81°50'56'' East longitude and at an altitude of 98 m above the mean sea level. The soil of experimental field was sandy loam in texture having organic carbon 0.39%, available N (186.9 kg ha^{-1}), available P (22.5 kg ha^{-1}), available K (84kg ha^{-1}), the pH and EC of the soil was recorded as 7.5 and 0.27 dS m^{-1}, respectively. The experiment was laid down in Randomized Block Design comprising of 12 treatments replicated thrice. The three crop establishment methods were drum seeding, broadcasting of sprouted seed and transplanting and four weed management practices *viz.,* weedy check, two hand weedings at 15 and 30 DAS, Bispyribac-sodium at 15 DAS at 30g a.i ha^{-1}, Bispyribac-sodium at 15 DAS at 30g a.i ha^{-1} *fb*-Ethoxysulfuron at 30 DAS 20g a.i ha^{-1}.The variety used

was Bio seed 786 with a duration of 110 days and seeds were sown at spacing of 20cm ×15cm using the seed rate of 37kg ha^{-1} for Drum seed method, 75kg ha^{-1} for Transplant method, 100kg ha^{-1} for broadcasting method.

A fibre-bodied plastic drum seeder was used for drum seeding. It had three drums into which the seeds were filled upto 3/4th its capacity. Six rows can be drawn with the help of this drum seeder at one time with a spacing of 20cm between the rows and 7cm between the plants of the same row. The seed rate adopted was 37.5 kg ha^{-1}. For broadcasting, the seeds which were soaked and incubated for 24 hours in gunny bags were broadcasted uniformly in the puddled soil. For the traditional method of rice cultivation i.e., transplanting, the seeds were soaked and incubated for 24 hours. Once the seeds started to sprout they were uniformly broadcasted into the nursery. Irrigation was given in the nursery regularly. The seedlings of 25 days were uprooted and tied into bundles before transplanting into the main field.

A fertilizer dose of 140, 60 and 60 kg N, P_2O_5 and K_2O ha^{-1} was applied. Full dose of Phosphorus and Potash were applied as basal dose in the form of SSP and MOP, respectively. Nitrogen was applied in 3 equal splits *viz.,* 1/3rd basal at the time of transplanting/sowing, maximum tillering and panicle initiation stage. Irrigation was given to the plots as per the requirement and was withheld 15 days before harvesting. The chemical Bispyribac-sodium was applied at 15 DAS @ 30g a.i. ha^{-1}. It is a selective, systemic post emergence herbicide which is effective on grasses, sedges and broadleaved weeds. It controls *Echinochloa sps* effectively. Ethoxysulfuron is applied at 30 DAS @ 20 g a.i. ha^{-1}. It translocates herbicide which is taken up through leaves.

The data on the growth parameters was recorded at regular intervals. Data on dry matter accumulation and weed dry matter was recorded with a quadrant of 0.5 x 0.5 m area. For 1000-grain weight five hand full of grain samples were collected at random from the net plot yield of each individual treatment. The grains were counted and weighed to arrive at test weight. The crop was harvested manually with the help of sickle when the grain almost matured and the straw had turned yellow and data on grain and straw yield was recorded. All the data were subjected to analysis of variance (ANOVA) as per the standard procedures. The comparison of treatment means was made by critical difference (CD) at P=0.05.

Observations on weed

Among the different weed management practices the weed density (Table 2) was invariably recorded the lowest in two hand weeding at 15 and 30 DAS among. Among the chemicals, the application of bispyribac-sodium *fb* ethoxysulfuron under drum seeding (T_4) recorded 7 weeds m^{-2} followed by transplanting with bispyribac-sodium *fb* ethoxysulfuron (T_{12}) and drum seeding with bispyribac-sodium (T_3) recorded 8 weeds m^{-2} each. The highest weed density was recorded in Broadcasting + Weedy check (T_5) recorded as 16 weeds m^{-2}. The weed dry matter was the highest in Broadcasting + weedy check (T_5) and it was recorded as 4.76 g $0.5m^{-2}$ and the least being observed in drum seeding + two hand weedings at 15 and 30 DAS (T_2) as 1.29 g $0.5m^{-2}$. Among the chemically treated plots, the application of bispyribac sodium *fb* ethoxysulfuron in transplanting (T_{12}) recorded 1.87 g $0.5m^{-2}$ followed by drum seeding + bispyribac sodium *fb* ethoxysulfuron (T_4) which recorded 2.10 g $0.5m^{-2}$. The plots treated with bispyribac sodium *fb* ethoxysulfuron registered 18.4% increase in grain yield over the weedy check plot. Similarly, the plots treated with bispyribac-sodium only recorded a 15.4% increase in the yield over the weedy check plot. Though, the herbicides were quite effective in controlling weeds hand weeding proved to be economically feasible because of high price of herbicides.

Pre harvest Observation

An appraisal of (Table-1) clearly reveals that maximum plant population was observed in T_5 (Broadcasting + Two Hand weedings at 15 and 30 DAS) which recorded 506 number of plant m^2. This was followed by T_8 (Broadcasting + Bispyribac-sodium *fb* ethoxysulfuron), which recorded 497 plants m^{-2} whereas minimum plant population, 33 plants m^{-2} was observed in treatment T_9 (Transplanting + Weedy check), T_{10} (Transplanting + Two Hand weedings at 15 and 30 DAT), T_{11} (Transplanting + Bispyribac-sodium) and T_{12} (Broadcasting + Bispyribac-sodium *fb* ethoxysulfuron). The population in transplanting treatments was lesser due to wider plant spacing between the rows and within the rows. It was highest in broadcasting (T_5, T_6, T_7 and T_8) due to more number of seeds being broadcasted uniformly over the given area.

Plant height (Table-1) was influenced by different establishment methods and weed management practices. The highest plant height (102.4 cm) was recorded in treatment T_2 (Drum seeding + Two Hand weedings at 15 and 30 DAS) at 100 DAS followed by treatment T_{11} (Transplanting + Two Hand weedings at 15 and 30 DAT) which recorded plant height as 102 cm and was found to be at par to treatment T_2..The lowest plant height was 94.5 cm recorded in treatment T_5 (Broadcasting + Weedy check). It can be also inferred from (Table-1) that the plants were taller under different weed management practices in the respective establishment methods compared to the weedy check method. Better initial establishment of plants due to transplanting and drum seeding on moist puddled soil might have resulted in more plant height under transplanting and drum seeding methods (Yadav *et al.,* 2009) [4].

An appraisal of mean data for number of tillers m^{-2} of (Table-1) clearly revealed maximum number of tillers (31) in treatment T_2 at 80 DAS followed by treatment T_{10} which registered 28 number of tillers/m^2 and was at par to treatment T_2 and significantly superior over broadcasting methods treatment T_5 (Broadcasting + weedy check), treatment T_6 (Broadcasting + Two Hand weedings at 15 and 30 DAS), T_7 (Broadcasting + Byspyribac-sodium) and treatment T_8 (Broadcasting + Byspyribac-sodium *fb* ethoxysulfuron). Productive tillers were also recorded as 29 which was the maximum in drum seeding with hand weeding (T_2) followed by transplanting with hand weeding (T_{10}). This may be due to less competition with weeds for nutrients, moisture, space and light. The other reason may also be due to better control of weeds due to which proper space was available to individual plants and congenial environment ensured proper utilization of nutrients, moisture and solar radiation which resulted in better photosynthesis and ultimately leading to maximum number of tillers/m^2 and productive tillers. These findings are in corroboration with the findings of Parihar, 2004 [5] and Singh and Singh, 2006 [1].

The data on dry matter accumulation (Table-1) revealed maximum dry matter accumulation was recorded as 1396.3 g m^{-2} in treatment T_2 followed by (T_{10}) 1364.0 g m^{-2} at 100 DAS and was found to be at par to treatment T_2. However, treatment T_4, T_3 and T_{12} were also found to be at par to treatment T_2. The probable reason for recording maximum dry matter accumulation in these treatments was due to early

emergence of sprouted seeds in drum seeded method of sowing compared to transplanting method which under goes transplanting shock and lower weed population due to hand weeding and application of herbicides which reduced weed competition for moisture, nutrients and rice plants got optimum space, nutrients and moisture which resulted in higher dry matter accumulation. Similar findings have also been reported by Singh *et al.* 2005 [6].

Post-harvest Observations

The total number of grains per panicle (Table 1) recorded highest value as 206 in treatment T_2 followed by treatment (T_{10}) 202. which was found to be at par to treatment T_2.The probable reason for attaining maximum number of grains per panicle may be due to better growth parameters during vegetative phase to reproductive phase as weed population was minimum in these treatments leading to lower competition with weeds for moisture, nutrient, space and sun light resulting in optimum photosynthesis leading to maximum number of grains per panicle. The other reason may also be due to longer panicle length which resulted in more number of grains to set in the panicles. These findings are in conformity to those reported by Parihar, 2004 [5] and Gill *et al.,* 2004.

The grain yield and straw yield (Table 1) recorded highest value in treatment (T_2) as 6335 kg ha^{-1} and 7661 kg ha^{-1} respectively in treatment T_2 followed by treatment (T_{10}) 6118 kg ha^{-1} and 7526 kg ha^{-1} respectively Drum seeding on an average recorded a 5.4% and 19.9% increase in the grain yield compared to transplanting and broadcasting, respectively. Similarly straw yield recorded an increase of 2.0 and 11.7% over transplanting and broadcasting methods, respectively the probable reason for attaining maximum grain and straw yield may be attributed to greater number of effective panicles, sufficient plant stand, maximum number of tillers and less competition with weeds for growth factors as nutrient, moisture, space, light and better yield attributing parameters. Herbicide treatments also influenced grain yield significantly which may be due to higher yield attributing components and weed control efficiency. The other reason may be due to the fact that photosynthetic food material synthesized in the plants gets deposited in different plant parts resulting in enlargement of plant tissues which cause gradual increment in dry matter, more number of effective tillers, panicle length, grains per panicle ultimately resulting into higher grain yield and straw yield. Similar findings were also observed by Halder and Patra, 2007 and Manjappa and Kataraki (2004) [7, 8].

Economic Analysis

The cost of cultivation (Table 3) was recorded highest ₹37266 ha^{-1} in treatment T_5 (Broadcasting + Weedy check) followed by treatment T_6 (Broadcasting + Two Hand weedings at 15 and 30 DAS) which computed ₹33266 ha^{-1} and lowest treatment T_1 (drum seeding + weedy check) recorded as ₹22322 ha^{-1}. The gross return was recorded highest in treatment (T_2) as ₹110975ha^{-1} followed by treatment (T_{10}) recorded as ₹107440 ha^{-1}. It was the lowest in treatment T_5 ₹74270 ha^{-1}. The net return was recorded highest in drum seeding with hand weeding in treatment (T_2) as ₹85653 ha^{-1} followed by treatment (T_{10}) recorded as ₹79751 ha^{-1} and was lowest for treatment T_5 ₹37004 ha^{-1}. Similar trend was observed for B: C ratio. Which gave values as 3.38, 3.37 and 3.33 in treatment T_2, T4 and T_3 respectively?

Table 1: Mean values of agronomic traits Rice as affected by crop establishment methods and weed management practices on growth and yield of rice

Treatments		Plant height (cm)	No. of tillers hill^{-1}	Dry weight g hill^{-1}	No. of grains panicle^{-1}	Grain yield kg/ha	Straw yield kg/ha
T_1	Drum seeding + Weedy check	97.5	11	51.34	143	4401	5891
T_2	Drum seeding + Two Hand weedings	102.4	27	83.22	206	6335	7661
T_3	Drum seeding + Bispyribac-sodium	99.2	23	61.09	191	5533	6866
T_4	Drum seeding + Bispyribac-sodium fb Ethoxysulfuron	100.7	23	67.92	198	5777	7129
T_5	Broadcasting + Weedy check	94.5	9	43.53	126	4155	5767
T_6	Broadcasting + Two Hand weedings	101.9	16	67.61	161	4928	6456
T_7	Broadcasting + Bispyribac-sodium	98.4	13	50.34	143	4557	6057
T_8	Broadcasting+ Bispyribac-sodium fb Ethoxysulfuron	100.3	13	59.35	158	4747	6306
T_9	Transplanting + Weedy check	96.7	11	46.76	133	4325	5945
T_{10}	Transplanting +Two Hand weedings	102	26	74.82	202	6118	7526
T_{11}	Transplanting + Bispyribac-sodium	98.5	18	54.58	175	5143	6680
T_{12}	Transplanting + Bispyribac-sodium fb Ethoxysulfuron	100.2	23	60.21	178	5269	6760
F test		S	S	S	S	S	S
SEd (±)		0.47	2	5.09	10	395	502
CD (P=0.05)		1.38	2	15.93	29	1160	1472
C.V		0.82	16	14.68	10	13	13

Table 2: Mean values of weeds as affected by crop establishment methods and weed management practices on growth and yield of rice

Treatments		Weed density (m^{-2})	Weed dry weight (m^{-2})
T_1	Drum seeding + Weedy check	14	3.93
T_2	Drum seeding + Two Hand weedings	4	1.29
T_3	Drum seeding + Bispyribac-sodium	8	2.63
T_4	Drum seeding + Bispyribac-sodium fbEthoxysulfuron	7	2.1
T_5	Broadcasting + Weedy check	16	4.76
T_6	Broadcasting + Two Hand weedings	6	1.98
T_7	Broadcasting + Bispyribac-sodium	11	2.83

T_8	Broadcasting+ Bispyribac-sodium fb Ethoxysulfuron	9	2.12
T_9	Transplanting + Weedy check	13	2.91
T_{10}	Transplanting +Two Hand weedings	5	1.78
T_{11}	Transplanting + Bispyribac-sodium	10	2.59
T_{12}	Transplanting + Bispyribac-sodium fb Ethoxysulfuron	8	1.87
F test		S	S
SEd (±)		1	0.18
CD (P=0.05)		3	0.52
C.V		17	12.16

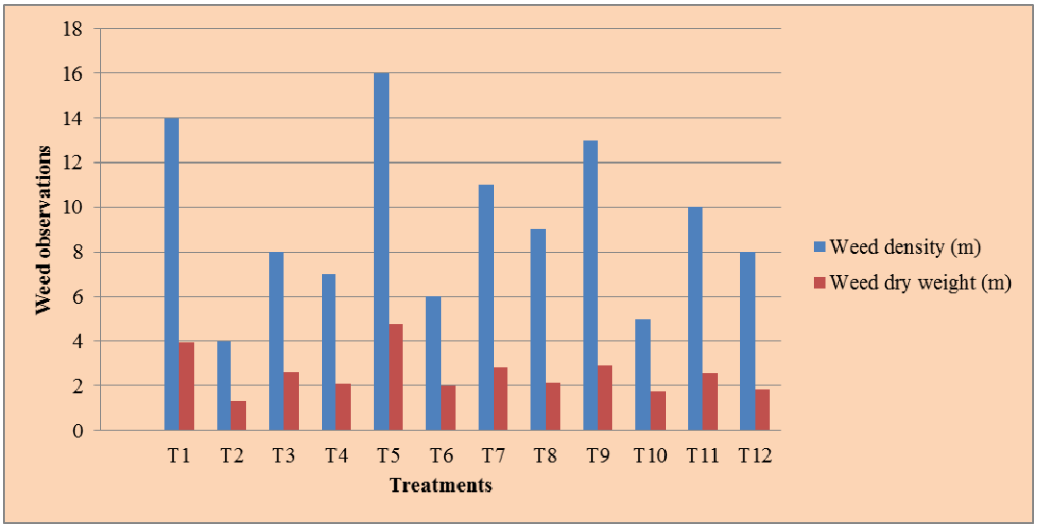

Fig 1: Weeds as affected by crop establishment methods and weed management practices on growth and yield of rice

Table 3: Economics of different treatment combinations of Rice

Treatments		Cost of Cultivation (₹ha^{-1})	Gross returns (₹ha^{-1})	Net returns (₹ha^{-1})	B:C ratio
T_1	Drum seeding + Weedy check	22322	78243	55921	2.51
T_2	Drum seeding + Two Hand weedings	25322	110975	85653	3.38
T_3	Drum seeding + Bispyribac-sodium	22478	97275	74797	3.33
T_4	Drum seeding + Bispyribac-sodium fb Ethoxysulfuron	37266	101490	78266	3.37
T_5	Broadcasting + Weedy check	33266	74270	37004	0.99
T_6	Broadcasting + Two Hand weedings	28422	87320	54054	1.62
T_7	Broadcasting + Bispyribac-sodium	29168	80919	52497	1.85
T_8	Broadcasting+ Bispyribac-sodium fb Ethoxysulfuron	24689	84292	55124	1.89
T_9	Transplanting + Weedy check	248444	77202	52513	2.13
T_{10}	Transplanting +Two Hand weedings	27689	107440	79751	2.88
T_{11}	Transplanting + Bispyribac-sodium	24844	91015	66171	2.66
T_{12}	Transplanting + Bispyribac-sodium fb Ethoxysulfuron	25591	93076	67486	2.64
	Grain Price:Rs 15.10kg Straw Price:Rs 2.5kg				

Conclusions

On the basis of foregone studies, it is concluded that direct seeding by drum seeder is the profitable crop establishment method even under late planting condition. Transplanting was comparatively superior to Broadcasting, which reflected in high gross return, net return and returns per rupee invested. Sequential Two Hand weedings at 15 and 30 DAS was found to be a suitable and an effective method to control weeds in either in direct seeded or transplanted rice when compared to bispyribac-sodium fb-ethoxy sulfuron and bispyribac-sodium alone. As this study was for one year, further research is needed for conformation and recommendation.

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