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Effect of chemical weed management on growth, yield and soil properties in puddled and unpuddled transplanted rice (*Oryza sativa* L.)

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Abstract
A field experiment was conducted at Krishi Vigyan Kendra, Aurangabad and in farmers' field during rainy seasons of 2014 to evaluate Effect of chemical weed management on growth and yield in puddled and unpuddled transplanted rice (*Oryza sativa* L.). Experiment was laid out in a split-plot design with 2 methods of establishment i.e. puddled transplanted rice (PTR) and Unpuddle transplanted rice (UTPR), and four methods of weed control *viz.* W_1: Azimsulfuron 12.5g a.i./ha+ byspyribac-sodium@15g a.i./ha POE, W_2: Azimsulfuron 20g a.i./ha+ byspyribac-sodium@25g a.i./ha POE, W_3: Byspyribac-sodium@25g a.i./ha + pyrazosulfuron 20g a.i./ha POE, W4: Pretilachlor 500g a. i./ha PRE + 1 HW 45 DAT (Farmers' Practice) in a total of ten replications including five at KVK, Aurangabad and five farmers' field during the years. Unpuddled transplanting planting method produced significantly higher grain yield (4509kg/ha) over puddled transplanting method. Higher net return and B-C ratio were recorded with unpuddled transplanting method (Rs. 20873/ha, 1.58) over puddled transplanting. Application of Azimsulfuron 20g ai/ha + bispyribac-sodium@ 25 g ai/ha as POE being at par with bispyribac-sodium 25g a.i./ha.+ pyrazosulfuron 20g a.i./ha, were superior to Azimsulfuron 12.5g ai/ha + bispyribac-sodium@ 15 g ai/ha as POE and pretilachlor 500g a.i./ha PRE + one hand weeding at 45 DAT treatments and it resulted into higher grain yield (4728 kg/ha). Net return and B-C ratio were higher in plots treated with Azimsulfuron 20g ai/ha + bispyribac-sodium @ 25 g ai/ha as POE (Rs.21643/ha and 1.61), which being at par with bispyribac-sodium 25g a.i./ha.+ pyrazosulfuron 20g a.i./ha, was superior to Azimsulfuron 12.5g ai/ha + bispyribac-sodium@ 15 g ai/ha as POE, and pretilachlor 500g a.i./ha PRE + one hand weeding at 45 DAT.

Keywords: Crop establishment, unpuddled, rainfed, drought tolerant rice varieties, economics

Introduction
Introduction In India, the major rice cultivation method used is manual transplanting of nursery grown seedlings into puddled soil. Puddling, a process of cultivating soil in standing water and consumes a large amount of water. Moreover, as water resources are depleting due to intensive use of toxic pesticides and also resulting in scarcity of water in many part of the world, as there is competition between industrial and agricultural consumption of water resources (Mahajan *et al*., 2011, 2012) [2, 7, 8]. There is a great concern that Indian rice growers will probably have inadequate access to irrigation water in the future (Mahajan *et al*., 2013) [9]. Hence, shortage of irrigation water, threatens the sustainability of rice production in irrigated conditions (Chauhan *et al*., 2012, 2014) [1, 2, 3, 8]. Industrialization also threatens rice production due to migration of rural labour to cities in search of job, which causes shortage of manual labour during the peak period of rice cultivation. These results in late transplanting, less acreage under rice, low yield and delay in planting of the next crop. The scarcity of labour has led to use of herbicides for weed control as it is cost effective and easy to apply. Herbicides used in rice for weed control are either pre of post emergence spray. Many new herbicides are present in the market with different composition to control weeds, reduce problem of residue build up and also inhibit resistance of weeds to herbicides (Rajkhowa *et al*. 2006, Saha

et al. 2006) [14, 16]. In the use of herbicide recent trends is to find out an effective method by using low dose, high efficiency which will not only reduce the volume of herbicide but also the application become easier and economical (Pal and Banerjee 2007) [10]. The use of a single herbicide, however, does not provide effective weed control in DSR because of the complex mixture of weed species (Chauhan, 2012) [1, 2, 8]. So, there is high need to make combination of different herbicides for control of complex weed flora in different seeding techniques. Therefore, it was planned to test new molecules at different doses and combination for effective control of weeds in drought tolerant rice varieties under puddled and unpuddled situations in rainfed drought prone ecology.

Materials and Methods

The field experiments were carried out at the KVK, Aurangabad and farmers' field (Latitude: 24.50^0 N, Longitude: 84.70^0 E, Mean sea level height: 332ft) during wet season 2014 in rainfed drought prone ecology having clay loam soil type. Performance of four weed management practices under different planting method of rice grown with BMPs was evaluated. Sowing of seed in nursery was done on 23rd June, 2014 for all treatments. Preparation of field, planking and other operations were performed as per treatment. In PTR condition, two ploughing followed by planking and puddling was done in ponded water with puddler. In UPTR treatment, two cross ploughings, and planking after each ploughing was done in dry condition after field preparation and field was ponded for transplanting.

Transplanting of the seedlings in all treatment plots was done on 18th July, 2014 in lines, keeping row to row and plant to plant spacing of 20 and 15 cm, respectively. Crop was fertilized with nutrients @ 80:40: 20 N: P_2O_5: K_2O kg/ha and with zinc sulphate @ 25 kg/ha. Half dose of N and full dose of phosphorus, potash and $ZnSO_4$ were applied uniformly as basal application through DAP, urea, MOP and $ZnSO_4$ in PTR and UTPR conditions. Remaining 40 kg of nitrogen was applied into two equal split i.e. at active tillering stage and at panicle initiation stage. Experimental field was under rainfed environment and even puddling was also done by making use of rainy water. Herbicides were applied as per respective treatments by using manually operated knapsack sprayer attached with flat fan nozzle in a spray volume of 500 litre water per hectare. Crop was affected slightly with false smut disease at panicle emergence stage, and stem borer insect and sucking pests were noticed in some patches after panicle emergence stage. Methyl-parathion dust was applied at panicle emergence stage to protect the crop from sucking pests.

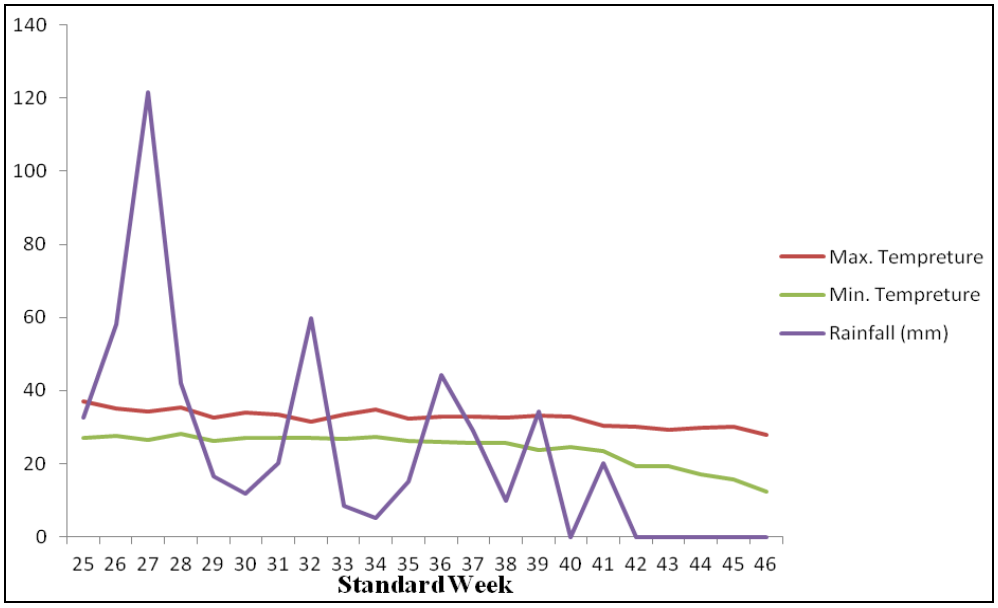

Fig 1: Maximum, minimum temperature (°C) and rainfall (mm) during crop period

Results and Discussion

Effect of planting methods

Plant height, tiller/m^2, days taken to 50% flowering and maturity did not show significant difference in PTR and UPTR (Table 1). However, maximum plant height, days taken to 50% flowering and maturity were recorded with PTR treatment and maximum tillering in UPTR treatment. Number of panicles/m^2, total grains/panicle, filled grains/panicle, chaffy grains/panicle were influenced significantly due to planting methods in rice (Table 2). However, panicle length and test weight were not influenced by planting methods. Similar finding was also recorded by (Singh *et al*., 1997; Singh, 2012) [17, 18]. Maximum and significantly higher number of panicles/m^2 at harvest stage was recorded in UPTR (258.15) over PTR (249.72) (Table 2). Total number of grains/panicle (171.50), number of filled grains/ panicle (156.32), number of unfilled grains/panicle (15.17) recorded in UPTR were significantly more than PTR 164.40, 151.37, and 13.02, respectively. However, panicle length was not significantly influenced by planting methods, but maximum panicle length was recorded with UPTR (26.37 cm) closely followed by PTR (26.23 cm). Test weight was also not significantly influenced by planting methods (Table 2). Prasad *et al*., (2001) also reported similar result.

Biological yield, grain yield, straw yield and harvest index were significantly influenced by planting method (Table 3). Biological yield recorded significantly more in UPTR (10331 kg/ha) which was 6.39% higher over PTR. Grain yield (4509 kg/ha) and straw yield (5822 kg/ha) were also significantly higher in UPTR which were 5.55% and 7.06% more over PTR treatment, respectively. However, HI was not significantly influenced by method of planting.

Cost of cultivation in UPTR was comparatively lower than PTR. Net return (Rs. 20873/ha) and B-C ratio (1.58) achieved

with UPTR were significantly higher over PTR (Table 4). Haque (2009) [6].

Effect of weed management practices

Plant height and tillers/m^2 at harvest stage were significantly influenced by different weed management practices. However, days taken to 50% flowering, maturity (Table 1), total grains/panicle and test weight (Table 2) were not influenced by weed management practices. Panicles/m^2, filled grains, unfiled grains, panicle length (Table 8), biological yield, grain yield, straw yield, harvest index (Table 3) and B-C ratio (Table 4) were significantly influenced by weed management practices.

Plant height at harvest stage was significantly higher with W_2 treatment (126.88 cm) being at par with W_4 (126.74 cm) and W_3 (125.29 cm) they were significantly higher over W_1 (120.29 cm) (Table 1). Number of tillers/m^2 were significantly higher with W_2 treatment (290.25) which was significantly higher over W_3 (282.55), W_4 (280.70), and W_1 (276.85) (Table 1). However, days taken to 50% flowering and maturity were not significantly influenced by various weed control practices. This result was closely confirmed with the result of Upasani *et al*., (2012). This could be ascribed to the better weed control by this herbicide (Singh and Singh, 2013)

Maximum number of panicles/m^2 recorded with W_2 (265.70), which was at par with W_3 (259.90), were both significantly more over W_4 (252.10) and W_1 (238.05) (Table 2). Significantly higher number of filled grains were recorded in W_2 (160.10) which was at par with W_3 (154.30), and both were significantly higher over W_4 (151.50) and W_1 (149.50). Number of unfilled grains/panicle recorded maximum with W_4 treatment (15.65) was at par with W_1 (14.75) and resulted into significantly higher unfilled grains/panicle than W_3 (13.80) and W_2 (12.20). Panicle length was also recorded maximum in W_2 (26.85cm), which was at par with W_1 (26.29cm) and both attained significantly higher plant height over W_3 (26.17 cm), and W_4 (25.90 cm) However, various weed management practices did not significantly influence total number of grains/panicle and test weight. Saha (2005) [15] and Singh *et al*. (2006) [19]. also reported similar result.

Maximum biological yield was recorded with W_2 treatment (10692 kg/ha) which was 4.19%, 11.40 and12.21% more yield over W_3, W_4 and W_1, respectively (Table 3). Grain yield was significantly higher in W_2 (4728 kg/ha) which was at par with W_3 (4617 kg/ha) and both were significantly higher over W_4 (4186 kg/ha) and W1 (4031 kg/ha).W_2 produced 12.95% and 17.30% more grain yield over W_4 and W_1, respectively. Similarly, maximum straw yield was recorded with W_2 treatment (5964 kg/ha) which was at par with W_3 (5645 kg/ha), and both were significantly higher over W_1 (5498 kg/ha) and W_4 (5412 kg/ha). However, maximum harvest index was recorded with W_3 treatment (45.0%) which was at par with W_2 (44.22%) and both were significantly superior over W_4 (43.63%) and W_1 (42.32%). These findings are in close conformity with the findings of Upasni and Barla, (2014) [20] and Chopra *et al*., (2003) [4].

Net return (Rs 21643/ha) was significantly higher with W2 and it was at par with W3 (Rs 20881/ha) and both were significantly superior to W_4 (Rs.15782 /ha) and W_1 (Rs.15246 /ha) (Table 4). Similarly, B- C ratio was also maximum with W_2 (1.61) and it was at par with W_3 (1.60) and both were significantly superior to W_1 (1.45) and W_4 (1.38). Similar finding was also reported by Parvez *et.al.* (2013) [11], Gowda *et al*.(2009) [5]

Effect of planting methods and weed management practices on density and dry weight of weeds

Significantly lowest weed population (numbers /m^2) was recorded with UPTR (21.57) at 30 DAT over PTR (24.25) (Table 5). However, at 60 DAT and at harvest stages, weed population was not significantly influenced by various methods of planting. Weed dry matter at 30 DAT, 60 DAT and harvest stage was also did not vary significantly

Significantly lower weed population (numbers /m^2) at 30 DAT was recorded with W_1 (21.75) and W2 (21.75), which being at par with W_3 (22.50) were significantly superior to W_4 (25.65) (Table 11). Weed population at 60 DAT and at harvest were recorded lowest with W_2 treatment (6.35 and 5.4) which were at par with W_3 (7.65 and 5.65) and both were significantly better than W_1 (8.90 and 6.65) and W_4 (9.45 and6.30). At 30 DAT, minimum dry weight of weeds was recorded with W_3 (4.77g) which was at par with W_2 (4.85g) and both were significantly superior to W_1 (5.77g) and W_4 (5.24g). Weed dry weight was recorded minimum at 60 DAT and harvest stage with W_2 treatment (4.51g and 3.79g) which was at par with W_3 (4.60g and 3.94g) and both were superior to W_1(6.91g and 6.50g) and W_4 (5.50g and 6.33g) (Table 5). (Prakash *et al*. 1995) also reported similar result.

Effect of planting methods on Nutrient status in soils

The nutrient status of soils mainly depends on the input used, through both organic and inorganic sources, and the cropping system followed. Only small variations in nutrient concentrations were found among the different treatments (Table 6). In the topsoil (0–15cm), OC concentration was marginally higher in unpuddled transplanted rice soils than in puddled treatments. The highest OC concentration was recorded in unpuddled transplanted rice ($4.8gkg^{-1}$) and the lowest value in puddled transplanted rice ($4.3gkg^{-1}$). A similar trend was observed for the three major nutrients (N, P, K. Unpuddled treatments recorded higher nutrient content than puddled treatments.

Table 1: Effect of weed management practices and different planting methods on growth of paddy

Treatment	Plant height at harvest (cm)	Tillers /m^2 at harvest	Days taken to 50% flowering	Days taken to maturity
Planting method				
PTR (Puddled transplanted Rice)	124.90	280.15	85.70	123.40
UPTR (Unuddled transplanted Rice)	124.70	285.02	85.37	123.37
SEm±	0.41	1.87	0.37	0.37
LSD(P=0.05)	NS	NS	NS	NS
Weed management practice				
W_1:Azimsulfuron 12.5g a.i./ha+ byspyribac-sodium@15g a.i./ha POE	120.29	276.85	84.90	123.15
W_2: Azimsulfuron 20g a.i./ha+ byspyribac-sodium@25g a.i./ha POE	126.88	290.25	86.05	124.50
W_3: Byspyribac-sodium@25g a.i./ha+ pyrazosulfuron 20g a.i./ha POE	125.29	282.55	86.10	122.75

W4: Pretilachlor 500g a. i./ha PRE + 1 HW 45 DAT (Farmer's Practice)	126.74	280.70	85.10	123.15
SEm±	0.58	2.65	0.53	0.53
LSD(P=0.05)	1.64	7.50	NS	NS

Table 2: Effect of weed management practices and different planting methods on yield attributing characters of rice

Treatment	Panicles/ m^2 at harvest	Number of Total grains/ panicle	Number of filled grains/panicle at harvest	No. of unfilled grains/ panicle at harvest	Panicles length (cm)	Test weight (g)
Planting method						
PTR (Puddled transplanted Rice)	249.7	164.4	151.4	13.0	26.2	22.9
UPTR (Unpuddled transplanted Rice)	258.2	171.5	156.3	15.2	26.4	23.1
S.Em±	1.85	1.5	1.6	0.4	0.2	0.07
LSD(P=0.05)	5.2	4.4	4.6	1.2	NS	NS
Weed management practice						
W_1:Azimsulfuron 12.5g a.i./ha+ byspyribac-sodium@15g a.i./ha POE	238.1	164.3	149.5	14.8	26.3	22.9
W_2: Azimsulfuron 20g a.i./ha+ byspyribac-sodium@25g a.i./ha POE	265.7	172.3	160.1	12.2	26.9	23.0
W_3: Byspyribac-sodium@25g a.i./ha+ pyrazosulfuron 20g a.i./ha POE	259.9	168.1	154.3	13.8	26.2	23.2
W4: Pretilachlor 500g a. i./ha PRE + 1 HW 45 DAT (Farmer's Practice)	252.1	167.2	151.5	15.7	25.9	23.0
SEm±	2.6	2.2	2.3	0.6	0.2	0.11
LSD(P=0.05)	7.4	NS	6.6	1.6	0.7	NS

Table 3: Effect of weed management practices and different planting methods on yield of rice

Treatment	Biological yield (kg/ha)	Grain yield (kg/ha)	Straw yield (kg/ha)	HI (%)
Planting Method				
PTR (Puddled transplanted Rice)	9710	4272	54388	44.0
UPTR (Unpuddled transplanted Rice)	10331	4509	5822	43.6
SEm±	67.2	31.7	48.1	0.21
LSD(P=0.05)	190	90	136	NS
Weed management practices				
W_1:Azimsulfuron 12.5g a.i./ha+ byspyribac-sodium@15g a.i./ha POE	9529	4031	5498	42.3
W_2: Azimsulfuron 20g a.i./ha+ byspyribac-sodium@25g a.i./ha POE	10692	4728	5964	44.2
W_3: Byspyribac-sodium@25g a.i./ha+ pyrazosulfuron 20g a.i./ha POE	10262	4617	5645	45.0
W_4: Pretilachlor 500g a. i./ha PRE + 1 HW 45 DAT (Farmer's Practice)	9598	4186	5412	43.6
SEm±	95.07	44.8	68.0	0.30
LSD(P=0.05)	269	127	192	0.85

Table 4: Effect of weed management practices and different panting methods on economics of rice

Treatment	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B-C Ratio
Planting method				
PTR (Puddled transplanted Rice)	35458	51361	15903	1.44
UPTR (Unpuddled transplanted Rice)	34315	54293	20873	1.58
SEm±	-	362.3	683.8	0.01
LSD(P=0.05)	-	1026	1937	0.03
Weed management practice				
W_1:Azimsulfuron 12.5g a.i./ha+ byspyribac-sodium@15g a.i./ha POE	33582	48827	15246	1.45
W_2: Azimsulfuron 20g a.i./ha+ byspyribac-sodium@25g a.i./ha POE	35147	56789	21643	1.61
W_3: Byspyribac-sodium@25g a.i./ha+ pyrazosulfuron 20g a.i./ha POE	34397	55278	20881	1.60
W_4: Pretilachlor 500g a. i./ha PRE + 1 HW 45 DAT (Farmer's Practice)	36420	50412	15782	1.38
SEm±	-	512.4	967.10	0.015
LSD(P=0.05)	-	1451	2739	0.042

Table 5: Effect of weed management practices and different planting methods on population and dry weight of weeds

Treatment	Weed population No./ m^2at 30 DAS	Weed dry weight (g/m^2) at 30 DAS (g)	Weed population (No./m^2) at 60DAS	Weed dry weight (g/m^2) at 60DAS (g)	Weed population (No./m^2) at harvest	Weed dry weight/m^2 at harvest (g/m^2)
Planting method						
PTR(Puddled transplanted Rice)	24.25	5.14	8.10	5.30	6.15	5.00
UPTR (Unpuddled transplanted Rice)	21.57	5.19	8.07	5.46	5.85	5.28

SEm±	0.47	0.09	0.26	0.09	0.19	0.11
LSD (P=0.05)	1.34	NS	NS	NS	NS	NS
Weed management practices						
W_1:Azimsulfuron 12.5g a.i./ha+ byspyribac-sodium@15g a.i./ha POE	21.75	5.77	8.90	6.91	6.65	6.50
W_2: Azimsulfuron 20g a.i./ha+ byspyribac-sodium@25g a.i./ha POE	21.75	4.85	6.35	4.51	5.40	3.79
W_3: Byspyribac-sodium@25g a.i./ha+ pyrazosulfuron 20g a.i./ha POE	22.50	4.77	7.65	4.60	5.65	3.94
W_4: Pretilachlor 500g a. i./ha PRE + 1 HW 45 DAT (Farmer's Practice)	25.65	5.24	9.45	5.50	6.30	6.33
SEm±	0.67	0.13	0.37	0.13	0.28	0.16
LSD (P=0.05)	1.89	0.36	1.07	0.39	0.79	0.46

Table 6: Soil pH and electrical conductivity (EC, DSM–1) and nutrient status (GKG–1) after wheat harvest in 2014 -15 Values are means ± standard error of mean.

Treatment	pH	EC	Org. carbon	Nitrogen	Phosphorus	Potassium
0–15cm						
PTR (Puddled transplanted Rice)	7.79±0.02	0.10±0.01	4.3±0.02	201.8±5.2	23.8±1.21	195.0±8.9
UPTR (Unuddled transplanted Rice)	7.64±0.11	0.11±0.01	4.8±0.02	210.3±9.3	29.5±4.38	214.3±14.9
15-30cm						
PTR (Puddled transplanted Rice)	7.71±0.07	0.10±0.01	3.2±0.01	185.7±2.1	15.2±0.90	218.9±6.1
UPTR (Unuddled transplanted Rice)	7.73±0.11	0.11±0.01	3.6±0.03	190.5±20.5	17.3±3.53	228.9±10.1

Conclusion

Unpuddled transplanting planting method produced significantly higher grain yield (4509kg/ha) over puddled transplanting method. Significantly higher net return and B-C ratio were recorded with unpuddled transplanting method (Rs. 20873/ha, 1.58) over puddled transplanting. Application of Azimsulfuron 20g ai/ha + bispyribac-sodium@ 25 g ai/ha as POE being at par with bispyribac-sodium 25g a.i./ha.+ pyrazosulfuron 20g a.i./ha, were superior to Azimsulfuron 12.5g ai/ha + bispyribac-sodium@ 15 g ai/ha as POE and pretilachlor 500g a.i./ha PRE + one hand weeding at 45 DAT treatments and it resulted into higher grain yield (4728 kg/ha). Net return and B-C ratio were higher in plots treated with Azimsulfuron 20g ai/ha + bispyribac-sodium @ 25 g ai/ha as POE (Rs.21643/ha and 1.61), which being at par with bispyribac-sodium 25g a.i./ha.+ pyrazosulfuron 20g a.i./ha, was superior to Azimsulfuron 12.5g ai/ha + bispyribac-sodium@ 15 g ai/ha as POE, and pretilachlor 500g a.i./ha PRE + one hand weeding at 45 DAT. The highest OC concentration was recorded in unpuddled transplanted rice ($4.8 gkg^{-1}$) and the lowest value in puddled transplanted rice ($4.3 gkg^{-1}$). A similar trend was observed for the three major nutrients (N, P, K. Unpuddled treatments recorded higher nutrient content than puddled treatments.

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