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Effect of crop establishment methods and weed management practices in rice on weed density, weed dry weight and weed control efficiency

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Abstract
A field experiment was conducted at Agronomy Main Research Farm, Department of Agronomy, College of Agriculture, OUAT, Bhubaneswar during *kharif* and *rabi* 2016-17 and 2017-18. The experiment was laid out in a split plot design with three replications by taking 24 treatment combinations in rice with four crop establishment methods in the main plot and six weed management practices in sub plot. Weed problem was more severe in DSR than PTR, WSR and NPTR, respectively. Lowest weed problem was seen in Bensulfuron methyl 0.6% + Pretilachlor 6% (PE) 0.66kgha^{-1} + (HW) at 30 DAS/T. PTR recorded highest WCE (66.6%) with lowest WI (15.8%), while DSR recorded highest WI (26.1%) with lowest WCE (63.5%). Bensulfuron methyl 0.6% + Pretilachlor 6% (PE) 0.66kgha^{-1} + (HW) at 30 DAS/T recorded highest WCE (87.0%) while weedy check recorded the highest WI (66.6%).

Keywords: Establishment, management, practices, control, DSR

Introduction
Rice is the most widely consumed staple food for more than 50% of the world's human population. Ninety percentage of world rice is produced and consumed in Asia (IFPRI, 2010) [19]. In Asia, rice is grown on 143 M ha out of which India accounts for 31% (44Mha) of area, contributing about 107 million tons of grain (GoI, 2016) [5]. The UN/ FAO forecasts that global food production will need to increase by over 40% by 2030 and 70% by 2050 (FAO, 2009) [4]. The one way to meet the requirement is through eliminating the loss caused by the weeds and modifying the crop planting geometry and crop environment by different crop establishment methods. Weeds play a significant role in reducing the yield of crop and are potentially a major constraint on crop production if not controlled (John and Michel, 2010) [12]. They compete with crops for natural and applied resources besides being responsible for reducing quantity and quality of agricultural productivity (Rao *et al.*, 2015) [13]. Of the total annual loss of agricultural produce from various parts in India, weeds account for 45 percent, insect's 30 percent, diseases 20 per cent and other pests 5 per cent (Raja *et al*., 2008) [10]. The extent of yield reduction due to weed infestation varies up to 53% in puddled condition, 91% in non-puddled condition (Mukherjee and Singh 2004) [7, 8]. This has triggered the need to revisit crop establishment methods and formulate weed management strategy.

Material and Methods
A field experiment was conducted at Agronomy Main Research Farm, Department of Agronomy, OUAT, Bhubaneswar during *kharif* and *rabi* of 2016-17 and 2017-18. The field experiment was laid out in a split plot design with three replications by taking 24 treatment combinations with four crop establishment methods in the main plot *viz.* M_1- Direct Seeded Rice (DSR), M_2- Wet Seeded Rice (WSR), M_3-Non-Puddled Transplanted Rice (NPTR), M_4-Puddled Transplanted Rice (PTR) and six weed management practices in the sub-plot *viz.* W_1-Weedy check, W_2- Bensulfuron methyl 0.6% + Pretilachlor 6% (PE) 0.660kgha^{-1} + Hand weeding (HW) at 30 DAS/T, W_3- Bensulfuron methyl 0.6% + Pretilachlor 6% (PE) 0.495kgha^{-1} + HW at 30 DAS/T, W_4- Bensulfuron methyl 0.6% + Pretilachlor 6% (PE) 0.495kgha^{-1} + Bispyribac-Sodium (POE) 0.25 kg ha^{-1} at 15 DAS/T, W_5- Cono weeding at 15 DAS/T + hand weeding 30 DAS/T, W_6- Brown manuring/ Green manuring.

Rice (Naveen) and Green gram (IPM 02-14) was taken as the test crop. The soil of the experimental plot was sandy loam in texture, low in available nitrogen (226.4kg ha^{-1}), high in available phosphorous (32.6 kg ha^{-1}) and medium in available potassium (132.6 kg ha^{-1}), with medium organic carbon content (0.53%), pH (5.9) and Ec (0.134dS m^{-1}). Species wise weed density by quadrate of size 0.50 m2 per plot was taken at periodical intervals and those are categorized into Grasses, Broadleaf and Sedges. Total and group wise population was expressed as individuals per m^2. Species wise weed density was taken by quadrate of size 1.0 m^2 per plot at periodical intervals and those are categorized into Grasses, Sedges and Broadleaf. Total and group wise population was expressed as individuals per m^2. The categorized weed samples were brought in paper bags for air drying, then shade dried initially followed by oven drying at 80 ˚C for 24 hours and its dry matter was determined and expressed in g m^{-2}. Weed control efficiency (WCE) and weed index was calculated based on the weed dry matter and grain yield respectively.

Effect of crop establishment methods on weed population and dry weight

Weed population and dry weight are significantly influenced by crop establishment methods and weed management practices. Weed population per m^2 increased with age up to 50 DAS/T and declined thereafter with age. Weed dry weight increased with age till harvest

Grasses

At all growth stages puddled transplanted rice (PTR) recorded lowest grass density and grass dry weight followed by wet seeded rice (WSR). The highest grass density and dry weight was recorded by DSR which was (57.2 & 60.8%), (45.2 & 45.2%), and (27.6 &15.7) % higher than PTR, WSR and NPTR (Non-puddled transplanted rice), respectively at 25 DAS/T. Heavy weed infestation in DSR than PTR, may be due to methods of land preparation and low puddling that churns the weeds and absence of standing water to suppress weed (Chauhan and Opeˇna, 2012) [3].

Sedges

DSR recorded significantly highest sedge density and dry weight, while PTR recorded the lowest. Sedges count by DSR was 25.4%, 20.4% and 16.7% higher than PTR, NPTR and WSR, respectively at 25 DAS/T. DSR recorded the highest sedge dry weight which was followed by WSR, NPTR and PTR, while PTR and NPTR was at par with each other. This is also supported by Prasad, 2011, who also reported weeds to be serious problems in DSR because dry tillage practices and aerobic soil conditions which are conducive for germination and growth of weeds that can cause loss in grain yield from 50 to 90 per cent.

Broad leave weed

PTR recorded lowest BLW density and dry weight while the highest was recorded by DSR at all the growth stages. DSR recorded 11.7%, 8.0% and 0.3% higher BLW density than PTR, WSR and NPTR, respectively at 25 DAS/T. DSR recorded highest broad leave weed dry weight which was at par with NPTR, while NPTR, WSR and PTR were at par with each other at 25 DAS/T. Subbulakshmi and Pandian (2001) [16] found that adoption of continuous submergence registered lower weed density and weed dry matter production due to reduced weed population caused by possible inhibition of germination of weeds under anaerobic conditions. Weeds were killed in transplanting rice due to puddling effect (Shailendra Singh *et al.* 2005) [14] and intensive puddling with continuous submergence recorded lower weed dry weight (Subramanyam *et al.* 2006) [17].

Total weed density and dry weight

DSR recorded the highest total weed count, while the lowest was recorded by PTR. DSR recorded 29.7%, 22.1% and 13.8% higher total weed count than PTR, WSR and NPTR, respectively at 25 DAS/T. DSR recorded the highest total weed dry weight, which was followed by NPTR, WSR and PTR at all stages of growth. Singh *et al.*, 2005 [14] reported highest total weed dry matter (4.81 m^{-2}) in dry seeding than transplanting (0.98 g m^{-2}), as dry seeding provided favourable aerobic condition for the weeds to grow unlike anaerobic transplanted condition. Aerobic systems are subject to much higher weed pressure than conventional puddled transplanting systems (Rao *et al.*, 2007) [13]. This, results are similar to that of Ramana murthy *et al.*, 2010 [11], who also obtained higher total weed dry matter in direct seeding (3.94 g m^{-2}) than transplanting (1.64 g^{-2}).

Effect of weed management practices on weed population and weed dry weight

Grasses

Pre emergence (PE) application of Bensulfuron methyl + pretilachlor @0.66kg ha^{-1} with hand weeding (HW) at 30 DAS/T recorded lowest grass density and dry weight at all growth stages, followed by PE of Bensulfuron methyl + pretilachlor @0.495kg ha^{-1} with post emergence (POE) Bispyribac-Na @ 0.25kg ha^{-1} while the highest grass density and dry weight was recorded by weedy check which was (77.9 & 77.5%), (74.8 &74.1%). (65.6 & 66.2%), (61.2& 61.8%) and (50.9 & 52.3%) higher than Bensulfuron methyl + pretilachlor (PE) @0.66kg ha^{-1} with HW at 30DAS/T, PE application of Bensulfuron methyl + pretilachlor @0.495kg ha^{-1} with POE Bispyribac-Na @ 0.25kg ha^{-1}, cono weeding (CW) + hand weeding (HW), PE Bensulfuron methyl + pretilachlor @0.495kg ha^{-1} with HW at 30DAS/T and brown/green manuring, respectively at 25 DAS/T. These results are supported by Singh *et al.* (2005) [14] and Sunil *et al.* (2011) [18], who reported lowest weed population, dry weight and WCE by pre-emergence application of Bensulfuron methyl + Pretilachlor (6.6 GR) @ 0.06 +0.60 kg a.i ha^{-1}+ one inters cultivation at 40 DAS which is mainly due better control of weed growth even up to harvest, whereas, un weeded check recorded significantly higher weed population and weed dry weight.

Sedges

Bensulfuron methyl 0.6% + Pretilachlor 6% (PE) 0.66kg ha^{-1} + HW @ 30 DAS/T recorded significantly lowest sedges count while weedy check recorded the highest at all stages of growth. Weedy check plot recorded (91.2 & 85.9%) higher sedge count and dry weight than Bensulfuron methyl 0.6% + Pretilachlor 6% (PE) @0.66kg ha^{-1} + HW @ 30 DAS/T at 25 DAS/T. Bhat *et al.*, 2017 [2] reported a lower sedge density of 5.50 /m2 as compared to weedy check (22.0) at 55 DAT.

Broad leave weeds

At 25 DAS/T weedy check recorded 78.5%, 76.9% 71.8%, 70.7% and 64.4% higher BLW density than Bensulfuron methyl 0.6% + Pretilachlor 6% (PE)@0.495kg ha^{-1} with POE Bispyribac-Na @ 0.25kg ha^{-1}, Bensulfuron methyl 0.6% + Pretilachlor 6% (PE) @0.66kg ha^{-1} + HW @ 30 DAS/T, brown/green manuring, CW+HW, and Bensulfuron methyl 0.6% + Pretilachlor 6% (PE) 0.495kg ha^{-1} with HW,

respectively, while application of Bensulfuron methyl 0.6% + Pretilachlor 6% (PE)@0.495kg ha^{-1} with POE Bispyribac-Na @ 0.25kg ha^{-1} recorded lowest weed dry weight which was at par with Bensulfuron methyl 0.6% + Pretilachlor 6% (PE)@0.66 kg ha^{-1}and CW+HW at 50 DAS/T. Anwar *et al.*, 2017 [1] revealed that application of Pretilachlor + Bensulfuron methyl, caused a reduction of 7.44 and 79 per cent in weed population as compared to Butachlor and weedy check, respectively.

Total weed density and dry weight

Lowest total weed density was recorded by Bensulfuron methyl 0.6% + Pretilachlor 6% (PE)@0.66kg ha^{-1} + HW @ 30 DAS/T followed Bensulfuron methyl 0.6% + Pretilachlor 6% (PE)@0.495kg ha^{-1} with POE Bispyribac-Na @ 0.25kg ha$^{-1,}$ while highest recorded in weedy check at all the growth stages. Weedy check recorded 80.7%, 78.4%, 71.1%, 64.7% and 63.2% higher weed density over Bensulfuron methyl 0.6% + Pretilachlor 6% (PE)@0.66kg ha^{-1} + HW @ 30 DAS/T followed by Bensulfuron methyl 0.6% + Pretilachlor 6% (PE)@0.495kg ha^{-1} with POE Bispyribac-Na @ 0.25kg ha^{-1}, CW+HW, Bensulfuron methyl 0.6% + Pretilachlor 6% (PE)@0.495kg ha^{-1} + HW @ 30 DAS/T and brown/green manuring, respectively at 25 DAS/T. Similar results are also obtained by Singh *et al.* (2005) [14] and Sunil *et al*. (2011) [18].

Weed control efficiency

PTR (66.6%) recorded highest WCE, which was followed by WSR (66.4%), NPTR (66.3%) and DSR (63.5%). Among weed control practices, Bensulfuron methyl 0.6% + Pretilachlor 6% (PE)@0.66kg ha^{-1} + HW @ 30 DAS/T recorded highest (87.0%) WCE which was followed by Bensulfuron methyl 0.6% + Pretilachlor 6% (PE)@0.495kg ha^{-1} with POE Bispyribac-Na @ 0.25kg ha^{-1} (83.9%), CW+HW (80.8%), Bensulfuron methyl 0.6% + Pretilachlor 6% (PE) @0.495 kg ha^{-1} + HW @ 30 DAS/T (71.9) and Green/brown manuring at 50 DAS/T (70.8%) at 50 DAS/T. Bhat *et al.*, 2017 also reported 79% WCE in Pre emergence application of bensulfuron methyl and pretilachlor.

Weed index

PTR (15.8%) recorded lowest index followed by WSR, NPTR and DSR. DSR recorded 39.4% higher weed index than PTR. PE Bensulfuron methyl + pretilachlor @0.66kg ha^{-1} + HW @ 30 DAS/T recorded lowest weed index which was followed by Bensulfuron methyl 0.6% + Pretilachlor 6% (PE) @0.495kg ha^{-1} with POE Bispyribac-Na @ 0.25kg ha^{-1}, CW+HW, Green/brown manuring and PE Bensulfuron methyl 0.6% + Pretilachlor 6% (PE)@0.495 kg ha^{-1} + HW @ 30 DAS/T.

Table 1: Weed density (Nos. m^{-2}) as influenced by establishment methods and weed management practices in rice (Pooled of two years)

Treatments	Grass density (Nos. m^{-2})					Sedges density (Nos. m^{-2})					BLW cdesity (Nos. m^{-2})				
Establishment methods	**25**	**50**	**75**	**100**	**Harvest**	**25**	**50**	**75**	**100**	**Harvest**	**25**	**50**	**75**	**100**	**Harvest**
M_1-DSR	4.8 (22.5)	4.7 (21.4)	4.6 (20.2)	4.3 (18.2)	4.0 (15.7)	4.0 (15.8)	5.0 (24.5)	4.9 (23.7)	4.7 (21.5)	4.5 (20.1)	5.6 (30.7)	5.3 (27.6)	5.2 (26.9)	4.7 (21.3)	4.5 (19.3)
M_2-WSR	3.6 (12.3)	3.7 (12.9)	3.4 (11.3)	3.3 (10.2)	3.0 (8.4)	3.7 (13.1)	4.8 (22.6)	4.7 (21.5)	4.5 (20.0)	4.3 (18.0)	5.4 (28.2)	4.8 (22.7)	4.5 (19.8)	4.2 (17.2)	3.9 (14.9)
M_3-NPTR	4.1 (16.3)	4.3 (17.9)	4.1 (16.6)	3.8 (14.1)	3.6 (12.3)	3.6 (12.6)	4.4 (18.7)	4.2 (17.4)	4.1 (16.0)	3.9 (14.3)	5.6 (30.6)	4.9 (23.6)	4.7 (21.8)	4.4 (18.7)	4.2 (17.2)
M_4-PTR	3.2 (9.6)	3.5 (12.0)	3.4 (10.7)	3.2 (9.6)	2.9 (8.2)	3.5 (11.8)	4.3 (18.4)	4.2 (16.9)	4.0 (15.9)	3.8 (14.2)	5.3 (27.1)	4.6 (20.6)	4.5 (19.3)	4.3 (17.7)	3.9 (14.7)
SEm (+)	0.08	0.01	0.012	0.011	0.006	0.006	0.003	0.01	0.011	0.104	0.019	0.021	0.016	0.011	0.008
CD (0.05)	0.27	0.04	0.04	0.03	0.02	0.02	0.01	0.03	0.04	0.33	0.06	0.07	0.05	0.03	0.03
Weed management practices															
W_1-Weedy check	5.9 (33.9)	6.9 (47.5)	6.8 (45.1)	6.5 (41.9)	6.0 (35.7)	6.0 (35.6)	6.8 (46.3)	6.7 (44.6)	6.5 (42.0)	6.3 (39.0)	8.6 (73.6)	9.0 (80.2)	8.8 (76.8)	8.3 (68.3)	8.1 (64.9)
W_2- Bensul +Pretila (PE) @0.660g ha^{-1} +HW@30DAS/T	2.8 (7.5)	2.1 (4.1)	2.0 (3.5)	1.8 (2.9)	1.7 (2.4)	1.9 (3.1)	2.7 (7.0)	2.6 (6.4)	2.4 (5.3)	2.2 (4.1)	4.2 (17.0)	3.2 (9.5)	3.1 (9.0)	2.8 (7.3)	2.2 (4.5)
W_3- Bensul +Pretila (PE) @0.495g ha^{-1} HW@30DAS/T	3.7 (13.2)	3.5 (12.0)	3.4 (11.1)	3.1 (9.0)	2.9 (7.7)	3.4 (11.2)	4.4 (18.6)	4.2 (17.4)	4.1 (16.3)	3.9 (14.9)	5.2 (26.2)	4.7 (21.6)	4.4 (19.0)	3.9 (15.1)	3.6 (12.3)
W_4- Bensul +Pretila (PE) @ 0.495g ha^{-1} +Bisp-Na @0.25 kg ha^{-1} POE	3.0 (8.5)	2.7 (7.0)	2.6 (6.2)	2.5 (5.6)	2.4 (5.2)	2.7 (6.6)	4.0 (15.5)	3.9 (14.4)	3.7 (13.1)	3.5 (11.9)	4.0 (15.8)	2.6 (6.5)	2.5 (6.0)	2.3 (4.7)	2.0 (3.6)
W_5-Cw@ 15 DAS/T + HW@30 DAS/T	3.5 (11.7)	3.2 (9.7)	3.0 (8.3)	2.8 (7.4)	2.6 (6.3)	2.9 (8.1)	4.3 (17.7)	4.1 (16.5)	4.0 (15.4)	3.8 (14.3)	4.7 (21.5)	3.3 (10.2)	3.1 (9.0)	2.5 (5.8)	2.5 (5.9)
W_6-Green/Brown manuring	4.1 (16.7)	4.1 (16.1)	3.8 (14.1)	3.5 (11.4)	3.2 (9.6)	4.0 (15.2)	4.7 (21.2)	4.5 (19.8)	4.3 (18.0)	4.0 (15.8)	4.6 (20.7)	3.8 (13.6)	3.5 (12.0)	3.4 (11.0)	3.0 (8.3)
Treatment mean	3.8 (15.2)	3.8 (16)	3.6 (14.7)	3.4 (13.0)	3.1 (11.1)	3.5 (13.3)	4.5 (21.0)	4.3 (19.9)	4.2 (18.4)	4.0 (16.7)	5.2 (29.1)	4.4 (23.6)	4.2 (22.0)	3.9 (18.7)	3.6 (16.6)
SEm (+)	0.11	0.04	0.04	0.04	0.03	0.03	0.039	0.04	0.04	0.13	0.06	0.06	0.05	0.05	0.04
CD (0.05)	0.3	0.11	0.1	0.1	0.09	0.09	0.11	0.11	0.11	0.36	0.16	0.16	0.14	0.13	0.17

Table 2: Total weed density (nos. m^{-2}) as influenced by establishment methods and weed management practices in rice (Pooled of two years)

Treatments	Total weed count (Nos. m^{-2})				
Establishment methods	**25 DAS/T**	**50 DAS/T**	**75 DAS/T**	**100 DAS/T**	**Harvest**
M_1-DSR	8.3 (68.9)	8.6 (73.4)	8.4 (70.8)	7.8 (61.0)	7.5 (55.2)
M_2-WSR	7.4 (53.7)	7.7 (58.2)	7.3 (52.6)	6.9 (47.4)	6.5 (41.4)
M_3-NPTR	7.7 (59.4)	7.8 (60.2)	7.5 (55.8)	7.0 (48.8)	6.7 (43.8)
M_4-PTR	7.0 (57.6)	7.2 (51.0)	6.9 (47.0)	6.6 (43.1)	6.1 (37.1)
SEm (+)	0.04	0.011	0.012	0.016	0.009
CD (0.05)	0.13	0.04	0.04	0.03	0.03
Weed management Practices					
W_1-Weedy check	12.0 (143.1)	13.2 (174.0)	12.9 (166.5)	12.4 (152.3)	11.8 (139.6)
W_2- Bensul +Pretila (PE) @ 0.660kg ha^{-1} +HW@30DAS/T	5.3 (27.6)	4.6 (20.6)	4.4 (18.9)	4.0 (15.4)	3.4 (11.0)

W_3- Bensul +Pretila (PE) @0.495kg ha^{-1} HW@30DAS/T	7.1 (50.5)	7.3 (52.3)	6.9 (47.5)	6.4 (40.3)	5.9 (34.8)
W_4- Bensul +Pretila (PE) @ 0.495kg ha^{-1} +Bisp-Na @0.25 kg ha^{-1} POE	5.6 (31.0)	5.4 (28.9)	5.2 (26.6)	4.9 (23.5)	4.6 (20.7)
W_5-Cw@ 15 DAS/T + HW@30 DAS/T	6.5 (41.3)	6.2 (37.6)	5.9 (33.8)	5.4 (28.6)	5.2 (26.4)
W_6-Green/Brown manuring	7.3 (52.6)	7.2 (50.8)	6.8 (46.0)	6.4 (40.4)	5.8 (33.7)
Treatment mean	7.3 (57.7)	7.3 (60.7)	7.0 (56.6)	6.6 (50.1)	6.1 (44.4)
S.Em (+)	0.078	0.059	0.057	0.055	0.051
CD (0.05)	0.22	0.17	0.16	0.16	0.14

Table 3: Weed dry weight (g m^{-2}) as influenced by establishment methods and weed management practices in rice (Pooled of two years)

Treatments	Grasses dry weight (g m^{-2})					Sedges dry weight (g m^{-2})					BLW dry weight (g m^{-2})				
Establishment methods	**25 DAS/T**	**50 DAS/T**	**75 DAS/T**	**100 DAS/T**	**Harvest**	**25 DAS/T**	**50 DAS/T**	**75 DAS/T**	**100 DAS/T**	**Harvest**	**25 DAS/T**	**50 DAS/T**	**75 DAS/T**	**100 DAS/T**	**Harvest**
M_1-DSR	2.8 (7.6)	3.8 (13.6)	4.5 (19.5)	4.5 (20.2)	5.4 (28.3)	1.8 (2.8)	3.4 (10.8)	4.6 (20.9)	5.8 (33.4)	6.1 (36.6)	3.5 (11.7)	5.7 (32.5)	7.5 (56.1)	8.0 (63.7)	8.4 (69.6)
M_2-WSR	2.2 (4.1)	2.8 (7.1)	3.4 (11.1)	3.5 (11.7)	4.2 (17.5)	1.7 (2.4)	3.2 (9.7)	4.1 (16.4)	5.3 (27.2)	5.8 (33.3)	2.7 (6.6)	5.0 (24.8)	6.4 (40.3)	6.8 (46.1)	7.0 (48.1)
M_3-NPTR	2.6 (6.4)	3.3 (10.5)	4.1 (16.3)	4.1 (16.5	4.7 (22.0)	1.6 (2.1)	3.1 (9.2)	3.9 (14.8)	5.1 (25.8)	5.1 (25.2)	3.3 (10.1)	5.2 (26.5)	6.8 (45.1)	7.0 (47.8)	7.4 (54.0)
M_4-PTR	1.9 (3.0)	2.7 (6.7)	3.2 (9.9)	3.3 (10.5)	3.9 (14.8)	1.6 (2.0)	2.9 (8.1)	3.8 (14.0)	4.8 (22.8)	5.1 (25.1)	2.5 (6.0)	4.7 (21.4)	6.1 (36.6)	6.2 (38.4)	6.8 (46.1)
S.Em (+)	0.026	0.041	0.021	0.018	0.024	0.009	0.02	0.015	0.022	0.015	0.02	0.163	0.015	0.016	0.119
CD (0.05)	0.08	0.13	0.07	0.06	0.08	0.03	0.06	0.05	0.07	0.05	0.06	0.52	0.05	0.055	0.06
Weed management practices															
W_1-Weedy check	3.5 (11.8)	5.4 (29.0)	6.5 (42.2)	6.7 (44.0)	7.7 (59.3)	2.3 (5.0)	4.2 (17.3)	5.5 (29.3)	7.3 (52.1)	8.2 (66.7)	4.8 (22.5)	9.2 (84.9)	12.0 (144.4)	12.7 (160.7)	13.3 (175.7)
W_2- Bensul +Pretila (PE) @0. 660kg ha^{-1} +HW@30DAS/T	1.8 (2.7)	1.9 (3.0)	2.3 (4.6)	2.4 (5.1)	2.7 (7.0)	1.1 (0.7)	2.2 (4.3)	2.9 (8.1)	3.4 (10.9)	2.9 (8.0)	2.4 (5.3)	3.3 (10.2)	4.1 (16.7)	4.1 (16.4)	4.4 (19.3)
W_3- Bensul +Pretila (PE) @0.495kg ha^{-1} HW@30DAS/T	2.2 (4.5)	2.8 (7.5)	3.3 (10.4)	3.3 (10.7)	4.1 (16.1)	1.6 (2.0)	3.0 (8.7)	4.1 (15.9)	5.2 (26.4)	5.5 (29.2)	2.8 (7.5)	4.7 (21.5)	6.6 (43.5)	6.6 (42.6)	7.1 (50.1)
W_4- Bensul +Pretila (PE) @ 0.495kg ha^{-1} +Bisp-Na @0.25 kg ha^{-1} POE	1.9 (3.0)	2.3 (4.9)	2.9 (7.7)	2.9 (7.9)	3.3 (10.6)	1.3 (1.1)	2.8 (7.3)	3.8 (13.9)	4.7 (21.9)	4.7 (21.9)	2.1 (3.8)	3.1 (9.3)	4.0 (15.5)	4.3 (18.3)	4.3 (18.0)
W_5-Cw@ 15 DAS/T + HW@30 DAS/T	2.1 (4.0)	2.5 (5.9)	3.1 (9.0)	3.2 (9.5)	3.7 (12.8)	1.4 (1.6)	2.9 (8.1)	3.9 (14.8)	4.9 (24.2)	4.9 (23.9)	2.5 (6.0)	3.5 (11.6)	4.6 (20.8)	5.0 (24.2)	5.3 (28.0)
W_6-Green/Brown manuring	2.5 (5.6)	2.7 (6.7)	3.4 (11.3)	3.5 (11.4)	4.3 (18.2)	1.9 (3.4)	3.4 (11.0)	4.2 (17.0)	5.4 (28.3)	5.6 (30.7)	2.7 (6.5)	4.6 (20.4)	5.2 (26.5)	5.7 (32.0)	6.0 (35.6)
Treatment mean	2.3 (5.3)	2.9 (9.5)	3.6 (14.2)	3.7 (14.7)	4.3 (20.7)	1.6 (2.3)	3.1 (9.4)	4.1 (16.5)	5.1 (27.3)	5.3 (30.1)	2.9 (8.6)	4.7 (26.3)	6.1 (44.6)	6.4 (49.0)	6.7 (54.5)
S.Em (+)	0.048	0.062	0.051	0.48	0.053	0.036	0.049	0.051	0.057	0.05	0.048	0.172	0.066	0.051	0.065
CD (0.05)	0.13	0.18	0.14	0.13	0.15	0.09	0.14	0.14	0.16	0.19	0.14	0.49	0.17	0.149	0.19

Table 4: Total weed dry weight (g m^{-2}) as influenced by establishment methods and weed management practices in rice (Pooled of two years)

Treatments	Total weed dry weight (g m^{-2})				
Establishment methods	**25 DAS/T**	**50 DAS/T**	**75 DAS/T**	**100 DAS/T**	**Harvest**
M_1-DSR	4.8 (22.1)	7.6 (57.0)	9.9 (96.6)	10.9 (117.3)	11.6 (134.6)
M_2-WSR	3.7 (13.1)	6.5 (41.6)	8.3 (67.8)	9.2 (85.0)	10.0 (98.9)
M_3-NPTR	4.4 (18.5)	6.8 (46.2)	8.8 (76.2)	9.5 (90.1)	10.1 (101.2)
M_4-PTR	3.4 (10.9)	6.1 (36.2)	7.8 (60.5)	8.5 (71.7)	9.3 (85.9)
SEm (+)	0.023	0.104	0.014	0.015	0.017
CD (0.05)	0.07	0.33	0.05	0.05	0.05
Weed management Practices					
W_1-Weedy check	6.3 (39.3)	11.5 (131.2)	14.7 (215.9)	16.0 (256.6)	17.4 (301.7)
W_2- Bensul +Pretila (PE) @ 0.660kg ha^{-1} +HW@30DAS/T	3.0 (8.6)	4.2 (17.5)	5.5 (29.5)	5.7 (32.4)	5.9 (34.2)
W_3- Bensul +Pretila (PE) @0.495kg ha^{-1} HW@30DAS/T	3.8 (14.0)	6.2 (37.7)	8.4 (69.8)	9.0 (79.6)	9.8 (95.3)
W_4- Bensul +Pretila (PE) @ 0.495kg ha^{-1} +Bisp-Na @0.25 kg ha^{-1} POE	2.9 (8.0)	4.7 (21.4)	6.1 (37.1)	7.0 (48.1)	7.1 (50.5)
W_5-Cw@ 15 DAS/T + HW@30 DAS/T	3.5 (11.6)	5.1 (25.6)	6.7 (44.6)	7.6 (57.8)	8.1 (64.8)
W_6-Green/Brown manuring	4.0 (15.6)	6.2 (38.2)	7.4 (54.8)	8.5 (71.8)	9.2 (84.5)
Treatment mean	3.9 (16.2)	6.3 (45.2)	8.1 (75.3)	9.0 (91.0)	9.6 (105.2)
S.Em (+)	0.042	0.053	0.057	0.06	0.06
CD (0.05)	0.12	0.15	0.16	0.017	0.17

Table 5: Weed control efficiency and weed index as influenced by establishment methods and weed management practices in rice

Treatments	WCE at 50 DAS (%)			WI (%)		
Establishment methods	**2016**	**2017**	**Pooled**	**2016**	**2017**	**Pooled**
M_1-DSR	63.7	63.4	63.5	26.0	26.2	26.1
M_2-WSR	67.9	65.0	66.4	18.5	17.6	18.1

M_3-NPTR	67.0	65.6	66.3	19.5	18.8	19.2
M_4-PTR	67.1	66.1	66.6	15.9	15.6	15.8
Weed management Practices						
W_1-Weedy check	-	-	-	64.0	69.1	66.6
W_2- Bensul +Pretila (PE) @ 660g ha^{-1} +HW@30DAS/T	88.2	85.7	87.0	0.5	0.2	0.4
W_3- Bensul +Pretila (PE) @495g ha^{-1} HW@30DAS/T	71.4	72.3	71.9	21.9	20.6	21.2
W_4- Bensul +Pretila (PE) @ 495g ha^{-1} +Bisp-Na @0.25 kg ha^{-1} POE	85.8	82.0	83.9	2.0	2.0	2.0
W_5-Cw@ 15 DAS/T + HW@30 DAS/T	82.4	79.2	80.8	12.8	10.1	11.4
W_6-Green/Brown manuring	70.8	70.8	70.8	18.6	15.4	17.0
Treatment mean	66.4	65.0	65.7	20.0	19.6	19.8

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