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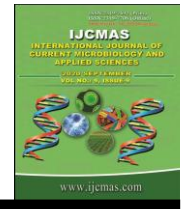

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Effect of Tillage and Weed Management Practices on Growth and Yield of Direct Seeded Rice (*Oryza sativa* L.) under Rainfed Condition

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Field experimentation was conducted during *kharif* season of 2019 at Research Farm, College of Agriculture, Central Agricultural University, Imphal, India to evaluate the "Effect of tillage and weed management practices on growth and yield of direct seeded rice (*Oryza sativa* L.) under rainfed condition". Among the various treatments, the treatment (P_2W_5) conventional tillage with weedicide Pyrazosulfuron ethyl 10% WP + Fenoxaprop-p-ethyl 9.3% EC recorded significantly higher plant height, number of tillers m^{-2}, plant population, yield attributes and yield, higher weed control efficiency with significant reduction in weed dry matter except for test weight and harvest index which was recorded non-significant. Likewise, gross return (`184066.67 $ha^{-1}$), net return (`122407.67 ha^{-1}) and benefit cost ratio (1.99) were recorded significantly higher in (P_2W_5) conventional tillage along with the weedicide Pyrazosulfuron ethyl 10% WP + Fenoxaprop-p-ethyl 9.3% EC whereas the lowest gross return (`116966.66 $ha^{-1}$), net return (`61932.66 ha^{-1}) and benefit cost ratio (1.13) were obtained from the treatment (P_1W_1) which was minimum tillage with weedy check.

Introduction

Rice (*Oryza sativa* L.) belong to the family Poaceae and is one of the most important crop in the world. India accounts for about 21% of the world's total rice production and holds the second position both in production and consumption of rice in the world next to China. Rice is an important crop of the state Manipur with low productivity. The state has 0.18 million ha under rice cultivation, which covers both irrigated and rainfed areas. The area has increased from 0.16 to 0.18 million ha during last seven years. Rice is mainly grown during the *kharif* season covering an area of 1,76,310 hectares, producing 435.93 thousand tonnes with an average productivity of 2413.52 kg/ha (Anon., 2005). Rapid water crisis, water-demanding nature of traditionally cultivated rice and increasing labour costs ramble the search for alternative management methods to increase water productivity, system sustainability and profitability. Direct seeded rice (DSR) technique is becoming popular nowadays because of its low-input demanding nature. It offers a very exciting opportunity to improve water and environmental sustainability.

Production and productivity of rice is influence by various management practices, tillage is one of them playing an important role in influencing soil bulk density, penetration resistance, aggregate mean weight diameter and surface roughness (Carman, 1997). Therefore, the changes created in mechanical characteristics of the seedbed due to tillage can influence the growth of crop and weed emergence. Tillage affects weed seed distribution in soil profile (Yenish *et al.*, 1996) and the differential distribution of the seed in soil profile has the potential to change weed population dynamics (Buhler, 1997).

A major hindrance in successful cultivation of direct seeded rice is heavy infestation of weeds causing drastic reduction in yield. Uncontrolled weeds growth caused 33-45% reduction in rice grain yield (Manhas *et al.*, 2012). The reduction in weed intensity due to herbicide application ranged between 59.38% to 78.12%. After herbicide application paddy yield increased from 31.75 to 78.95% as compared to control. However in absence of proper weed control, rice yield are reduced by 35-100% in DSR (Kumar *et al.*, 2008). The main reasons for high weed pressure in DSR are the absence of a weed-suppressive effect of standing water at the time of crop emergence and the absence of a seedling. Weeds in DSR systems are mainly managed by using herbicides and manual weeding.

Keeping the above points in view the experiment was conducted to find out suitable tillage and weed management practices on growth and yield of direct-seeded rice.

Materials and Methods

A Field experiment was conducted during *kharif* season of 2019 at Research Farm, College of Agriculture, Central Agricultural University, Imphal to study the effect of tillage and weed management practices on growth and yield of direct seeded rice. The soil of the experimental site was acidic with pH 4.93, available nitrogen 261.3 kg ha^{-1}, available phosphorous 12.56 kg ha^{-1}, available potash 289.2 kg ha^{-1} and organic carbon 1.2 %. The experiment was laid out in Factorial Randomized Block Design (FRBD) with three replications consisting of two tillage treatments viz. minimum tillage and conventional tillage and five weed management treatments viz. weedy check, Pretilachlor 50% EC @ 1.5L/ha, Pyrazosulfuron ethyl 10% WP @ 0.25kg/ha, Pretilachlor 50% EC @ 1.5L/ha fbFenoxaprop-p-ethyl 9.3% EC @ 625ml/ha and Pyrazosulfuron ethyl 10% WP @ 0.25kg/ha fbFenoxaprop-p-ethyl 9.3% EC @ 625ml/ha. The total rainfall received during the crop season was 717.7 mm. The variety was CAU R1 (Tamphaphou). The conventional plots were ploughed twice with power tiller without disturbing the minimum tillage plots. Pre-emergence application of Pretilachlor and Pyrazosulfuron ethyl after 2 DAS followed by post emergence application of Fenoxaprop-p-ethyl after 25 DAS was done according to the treatments to different experimental plots using knapsack sprayer. In case of weedy check treatments, neither herbicides application nor any hand weeding was done. The crop was line sown with seed rate of 100 kg/ha on 7th July, 2019.A common fertilizer dose of 60, 40 and 30 kg of N, P and K per ha, respectively was applied. Full dose of P_2O_5, K_2O and 50% N were applied one day prior to sowing and the rest 50% N was applied as top dressing in two equal splits, i.e. at tillering and panicle initiation stage of crop respectively. Plant protection measures were provided as and when required. The crop was harvested on 22nd November, 2019. All the data obtained were statistically analysed by the method of analysis of variance to test the significance of the treatment effects as well as result interpretation as given by Gomez and Gomez (1984). F-test at 5% level of probability was used to test the significance of treatment effect and wherever the 'F' test was significant critical difference (CD) values were given at 5 % level of significance. The data on weed dry weight were recorded at 30 and 60 DAS and were subjected to square root transformation √ x+0.5 before statistical analysis to normalize their distribution and to make the analysis of variance valid (Gomez and Gomez, 1984).

Results and Discussion

Effect of tillage on growth and yield

The execution of the direct seeded rice estimated in terms of plant height, number of tillers m^{-2} and plant population m^{-2} are presented in Table 1. The highest plant height (109.79 cm), number of tillers m^{-2} (91.73) and plant population m^{-2} (48.33) were recorded in conventional tillage (P_2) while the lowest was recorded in minimum tillage (P_1). It might be due to the reason that plants sown under conventional tillage, loosen up the compact soil layer improving the physical condition of the soil with respect to better tilth, enhanced infiltration, water movement, increased crop nutrition, less crop-weed competition thus enhancing subsequent plant growth leading to higher plant height, number of effective tillers m^{-2} and plant population m^{-2}. This observation was in consistent to the findings of Gangwar *et al.,* (2004); Zein El-Din *et al.,* (2008).

The effect of tillage and weed management in direct seeded rice estimated in terms of yield attributes and yield are presented in Table 1 and Table 2. Among the tillage treatments, they had significant difference among all the parameters except for test weight and harvest index which were found to be non-significant. Highest data were recorded in conventional tillage (P_2) with number of effective tillers m^{-2} (88.13), panicle length (25.38 cm), number of filled grains panicle^{-1} (137.93), test weight (27.57 g), grain yield (5373.33 kg/ha), straw yield (7700 kg/ha) and harvest index (41.44%) while the least were recorded in minimum tillage (P_1). It might be due to good soil tilth, better aeration, less crop-weed competition providing better nourishment to the crop, enabling uniform distribution of photo assimilates throughout the panicle enabling the crops to partition dry matter towards grains, higher root growth and increased nutrient uptake might be the reason for greater biomass production of the crop thus enhancing subsequent plant growth leading to higher number of effective tillers $m^{-2,}$ increase panicle length, higher number of filled grains panicle^{-1} and test weight resulting in higher grain, straw yield and harvest index respectively. The result was concurrent to the findings of Gangwar *et al.,* (2004); Sharif and Chauhan (2014).

Effect of weedicide on growth and yield

In weed management practices, highest plant height (112 cm), number of tillers m^{-2} (96) and plant population m^{-2} (52.67) were observed under Pyrazosulfuron ethyl 10% WP fb Fenoxaprop-p-ethyl 9.3% EC (W_5) while the least was observed in weedy check (W_1). This was due to effective weed control by pre and post emergence herbicides which allowed individual plants to have proper space, providing favourable environmental condition for improved utilisation of plant nutrients, moisture and solar radiation which resulted in better photosynthesis and in turned showed increased growth parameters while in weedy check there was no such control which led to severe crop-weed competition. This result is in agreement with those reported by Dixit and Varshney (2008); Narolia *et al.,* (2014). As for treatment interaction, all growth parameter differed significantly.

The highest interaction was observed in the treatment combination of conventional tillage and Pyrazosulfuron ethyl 10% WP fb Fenoxaprop-p-ethyl 9.3% EC (P_2W_5) with plant height (115 cm), number of effective tillers m^{-2} (98.67) and plant population m^{-2} (53.67) while the least was observed in treatment combination of minimum tillage with weedy check (P_1W_1).

Table.1 Effect of tillage and weed management on growth and yield attributes of direct seeded rice

Treatment	Plant height (cm)	No. of tillers m^{-2}	Plant population m^{-2}	No. of effective tillers m^{-2}	Panicle length (cm)	No. of filled grains panicle^{-1}
Tillage						
Minimum Tillage (P_1)	107.35	88.67	44.47	81.13	23.05	131.66
Conventional Tillage (P_2)	109.79	91.33	48.33	88.13	25.38	137.93
S. Em (±)	0.62	0.84	1.05	0.768	0.36	1.867
C.D. (P = 0.05)	1.31	1.76	2.21	1.614	0.78	3.924
Weed Management						
Weedy check (W_1)	104.07	80.17	40.33	75.66	22.13	118.16
Pretilachlor 50% EC (W_2)	107.8	87.83	42.5	81.66	23.93	134.83
Pyrazosulfuron ethyl 10% WP (W_3)	108.2	92.67	49.17	83.5	24.38	136.66
Pretilachlor 50% EC + Fenoxaprop-p-ethyl 9.3% EC (W_4)	110.79	93.33	47.33	89.83	25.00	139.83
Pyrazosulfuron ethyl 10% WP + Fenoxaprop-p-ethyl 9.3% EC (W_5)	112	96	52.67	92.5	25.66	144.5
S.Ed. (±)	0.99	1.32	1.65	1.215	0.58	2.953
C.D. (P = 0.05)	2.07	2.77	3.47	2.552	1.22	6.20
Interaction						
P_1 W_1	102.83	77.33	40	71.66	19.73	109
P_1 W_2	107.96	87	42.67	80	23.26	134.33
P_1 W_3	107.7	94	45.33	81.33	23.49	136.33
P_1 W_4	109.25	91.67	42.67	84.66	23.83	137.33
P_1 W_5	109	93.33	51.67	88	24.96	141.33
P_2 W_1	105.3	83	40.67	79.66	24.53	127.33
P_2 W_2	107.63	88.67	42.33	83.33	24.61	135.33
P_2 W_3	108.7	91.33	53	85.66	25.27	137
P_2 W_4	112.33	95	52	95	26.16	142.33
P_2 W5	115	98.67	53.67	97	26.36	147.66
S.Ed. (±)	1.39	1.87	2.34	1.718	0.82	4.176
C.D. (P = 0.05)	2.93	3.92	4.91	3.61	1.73	8.774

Table.2 Effect of tillage and weed management on yield of direct seeded rice

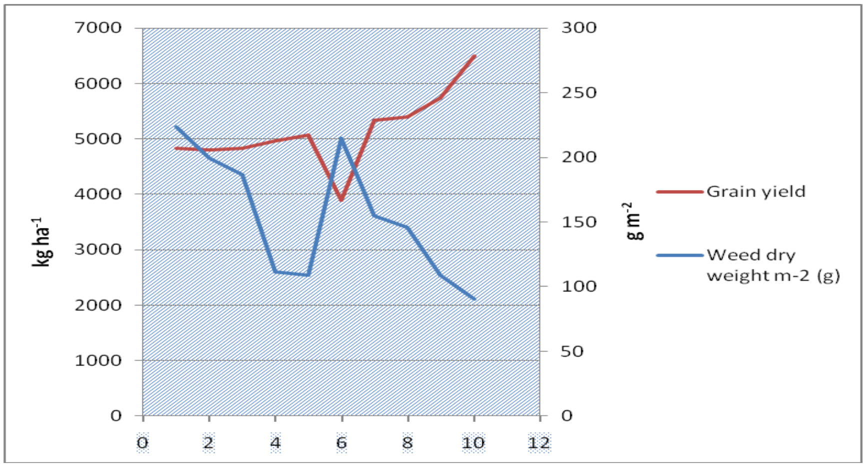
Treatment	Test weight (g)	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest index (%)
Tillage				
Minimum Tillage (P_1)	27.36	4900	6906.66	40.83
Conventional Tillage (P_2)	27.57	5373.33	7700	41.44
S. Ed. (±)	0.159	223.95	122.58	1.12
C.D. (P = 0.05)	NS	470.539	257.55	NS
Weed Management				
Weedy check (W_1)	27.26	4366.66	6950	38.48
Pretilachlor 50% EC (W_2)	27.27	5066.66	6966.6	42.05
Pyrazosulfuron ethyl 10% WP (W_3)	27.29	5116.66	7083.3	41.72
Pretilachlor 50% EC + Fenoxaprop-p-ethyl 9.3% EC (W_4)	27.68	5350	7983.33	40.06
Pyrazosulfuron ethyl 10% WP + Fenoxaprop-p-ethyl 9.3% EC (W_5)	27.84	5783.33	7533.33	43.35
S.Ed. (±)	0.252	354.11	193.82	1.77
C.D. (P = 0.05)	NS	743.98	407.22	NS
Interaction				
P_1 W_1	27.25	4833.33	6733.3	41.74
P_1 W_2	27.24	4800	6633.3	41.92
P_1 W_3	27.046	4833.33	6933.3	40.79
P_1 W_4	27.46	4966.66	7500	39.83
P_1 W_5	27.83	5066.66	6733.3	42.91
P_2 W_1	27.27	3900	7166.6	35.21
P_2 W_2	27.3	5333.33	7300	42.18
P_2 W_3	27.54	5400	7233.3	42.64
P_2 W_4	27.90	5733.33	8466.6	40.30
P_2 W_5	27.85	6500	7533.3	43.80
S.Ed. (±)	0.357	500.78	274.10	2.50
C.D. (P = 0.05)	NS	1052.16	575.9	NS

Table.3 Effect of tillage and weed management on weed analysis and economics of rice

Treatment	Weed dry matter (g m^{-2})		Weed control Efficiency (%)		Gross income (Rs./ha)	Net return (Rs./ha)	B:C ratio
	30 DAS	60 DAS	30 DAS	60 DAS			
$P_1 W_1$	7.71 (50.41)	14.95 (223.33)	00.00	00.00	116966.66	61932.66	1.13
$P_1 W_2$	5.34 (28.57)	14.14 (199.33)	17.03	5.37	147366.68	91192.68	1.62
$P_1 W_3$	5.24 (27.57)	13.67 (186.66)	18.98	8.56	144366.66	86207.66	1.48
$P_1 W_4$	4.49 (20.23)	10.57 (111.33)	31.56	29.22	151800.09	94126.09	1.63
$P_1 W_5$	4.26 (18.20)	10.44 (108.66)	36.11	30.08	158366.68	98707.68	1.65
$P_2 W_1$	6.12 (37.50)	14.65 (214.66)	00.00	00.00	125033.33	67999.33	1.19
$P_2 W_2$	5.05 (25.60)	12.45 (154.66)	22.77	14.63	158599.99	100425.99	1.73
$P_2 W_3$	4.93 (24.40)	12.10 (146)	24.06	17.12	160266.67	100107.67	1.66
$P_2 W_4$	4.14 (17.23)	10.45 (108.66)	34.67	28.44	171733.33	112059.33	1.88
$P_2 W_5$	3.85 (14.97)	9.54 (90.66)	37.91	34.44	184066.67	122407.67	1.99
S.Ed. (±)	0.16	0.38	2.40	2.64	-	-	-
C.D.(P = 0.05)	0.33	0.81	5.06	5.55	-	-	-

***The data were transformed to √ x + 0.5. The figures in the parenthesis are original values.**

Fig.1 Grain yield v/s weeds dry weight



There was significant difference among all parameters except for test weight and harvest index. Higher data were recorded in Pyrazosulfuron ethyl 10% WP fbFenoxaprop-p-ethyl 9.3% EC (W_5) with number of effective tillers m^{-2} (92.5), panicle length (25.66 cm), number of filled grains panicle^{-1} (144.5), test weight (27.84 g), grain yield (5783.33 kg/ha), straw yield (7533.33 kg/ha) and harvest index (43.35%) while the least were recorded in weedy check (W_1). It might be due to effective control of mixed weed flora by sequential application of pre and post emergence herbicides which significantly minimized the accumulation of weed flora providing better nourishment to the crop, sufficient availability of moisture, light, space leading to better grain development. Increased number of effective tillers m^{-2}, panicle length, higher number of filled grains panicle^{-1}and test weight. Similar findings were reported by Chitale *et al.,* (2007); Longkumar and Singh (2013); Mandal *et al.,* (2011); Narolia *et al.,* (2014) and Sharif and Chauhan (2014).As a result of increased yield attributes greater sink capacity was developed in reproductive stage resulting in higher grain yield. Similar finding was reported by Kailkhura *et al.,* (2015). Reduction in depletion of nutrients by the weeds enhances better uptake of nutrients by the crop resulting in increased production of biomass resulting in higher straw yield as supported by the findings of Mishra and Singh (2008)**.** As of treatment combination, there was significant interaction among all the parameters except for test weight and harvest index. The highest data were pertained in conventional tillage and Pyrazosulfuron ethyl 10% WP fbFenoxaprop-p-ethyl 9.3% EC (P_2W_5) while the least were obtained in minimum tillage with weedy check (P_1W_1). Among the herbicidal treatments, all the herbicidal control produced greater yield than weedy check which is due to significant reduction in weed population and weed biomass under these treatments as supported from the findings of Sharif and Chauhan (2014).

Interaction effect of tillage and weedicide on growth and yield

The interaction of tillage and weedicide found to be significantly influenced to most of the growth and yield of rice. It might be due to less population of weed occurrence by conventional tillage and application of pre and post application of weedicides. Due to less weed population there was a condition for rice to utilize almost all available nutrients, light and moisture thereby giving more final grain yield as compare to other treatments. Figure 1 shows the interaction between weed dry matter and grain yield. As the increased in weed dry matter there was a decreased in grain yield. In contrast, grain yield increased as the weed dry matter increases.

Weed parameters

The experimental area was comprised of various weed floras like *Echinochloa colona, Echinochloa crus-galli, Dactyloctenium aegyptium, Digitaria sanguinalis, Eleusine indica, Leptochloa chinensis* among grasses*; Digera arvensis, Eclipta alba, Trianthema portulacastrum* among broad leaf weeds and *Cyperusiria, C. rotundus, C. difformis* among sedges. The effects of tillage and weed management in direct seeded rice estimated in terms of weed analysis are presented in Table 3. Among the tillage treatments, maximum weed dry matter was observed under minimum tillage while the lowest weed dry matter was recorded in conventional tillage both at 30 and 60 DAS. This might be due to burial of the weed seeds by intermittent turning of surface soil under conventional tillage and greater deposition of weed seeds at the soil surface in minimum tillage. Highest weed control efficiency was recorded in conventional tillage due to lower accumulation of weed dry matter as they are inversely correlated. The result was in agreement to the finding of Chauhan and Johnson (2009); Clements *et al.,* (1996).

Among weed management treatments, lowest weed dry matter was observed in Pyrazosulfuron ethyl 10% WP fb Fenoxaprop-p-ethyl 9.3% EC (W_5) due to the broad-spectrum activity of these pre and post emergence herbicides application in DSR hence responsible for higher weed control efficiency. Similar finding was also reported by Moorthy and Saha (2002).As of treatment combination there was significant difference both in weed dry matter and WCE. Lowest weed dry matter m^{-2} and highest WCE were observed in the treatment combination of conventional tillage and Pyrazosulfuron ethyl 10% WP fb Fenoxaprop-p-ethyl 9.3% EC (P_2W_5) while the highest weed dry matter m^{-2} was observed in minimum tillage with weedy check (P_1W_1). However, among the herbicidal treatments the lowest WCE was seen in the treatment Pretilachlor 50% EC @ 1.5L/ha.

Economics

The effect of tillage and weed management in direct seeded rice estimated in terms of economics is presented in Table 3. Among the various treatments the highest gross return (Rs.184066.67 ha^{-1}), net return (Rs.122407.67 ha^{-1}) and benefit cost ratio (1.99) were recorded from the treatment (P_2W_5) which was conventional tillage with Pyrazosulfuron ethyl 10% WP + Fenoxaprop-p-ethyl 9.3% EC, whereas the lowest gross return (Rs.116966.66 ha^{-1}), net return (Rs.1932.66 ha^{-1}) and benefit cost ratio (1.13) were obtained from the treatment (P_1W_1) which was minimum tillage with weedy check. Conventional tillage gave higher yield with increased B: C ratio over minimum tillage. Bhurer *et al.,* (2013); Mahajan and Chauhan (2015) reported that any treatments in combination with weed management measures were more effective than weedy check in terms of monetary returns. Similar findings were reported by Mandal *et al.,* (2011) who observed that chemical mode of controlling weeds proved more economical and beneficial with respect to net return and benefit cost ratio.

From the above experiment it can be concluded that conventional tillage along with Pyrazosulfuron ethyl 10% WP at 2 DAS fbFenoxaprop-p-ethyl 9.3% EC at 25 DAS found to be best profitable treatment under direct seeded rice that can be adopted effectively and economically without notable reduction in yield from the rest of the treatments.

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