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Effect of tillage and weed control methods on yield of wheat in direct seeded rice-wheat cropping system in plateau region of central India

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Rice-wheat cropping system is one of the main cropping systems and this system is followed in irrigated eco- system of North and Central India. In Madhya Pradesh, this system is followed mainly in Kymore Plateau and Satpura hills zone and some part of the Vindhyan Plateau, Central Narmada Valley and Gird regions in about 1.064 million hectares, contributing nearly 10 percent to the total area under rice - wheat in the country (Anonymous, 2007). Due to rising cost of labour and water crisis, the direct seeding of wheat after conventional tilled rice through ferti-seed drill or zero till sowing through zero till seed drill are gaining importance in many parts of the country. Direct seeded rice matures around 7 -10 days earlier than transplanted rice, enabling timely sowing of subsequent wheat. Hence, it is of utmost importance to decide suitable tillage packages in wheat after direct seeded rice. Weeds are the major problem in irrigated wheat. However, with the use of suitable herbicides or adoption of integrated approach of weed control, the weeds problem in wheat could be managed effectively and economically. Keeping the above facts in view, the present investigation was undertaken to study the effect of tillage and weed control methods on weed dynamics and on growth and yield of wheat.

The present investigation was a part of ongoing project during Rabi season of 2007 – 08 at the National Research Center for Weed Science (NRC–WS), Jabalpur. In the Kharif season, Kranti variety of rice was directly sown in the experimental field and variety GW-273 was taken during *rabi* season. The climate is typical sub tropical with hot dry summers and cool dry winters. Temperature extremes vary between 2^0C in December-January months to maximum of 46^0C in May-June months. The soil of the experimental field was clayey in texture, neutral in reaction and normal in electrical conductivity. It was low in organic carbon (0.57%), and available nitrogen (110kg ha^{-1}), medium in available phosphorus (12.58kg ha^{-1}) and potassium (279 kg ha^{-1}).

After the harvest of direct seeded rice (DSR), twelve treatment combinations consisting of four tillage packages as main-plot treatments and three weed control practices as sub-plot treatments were laid out in split plot design with four replications. Main plot treatments were T_1 – Conventional tilled (Direct Seeded Rice) – Zero tilled (wheat), T_2 – Zero tilled (Direct Seeded Rice) – Conventional tilled (wheat), T_3 - Conventional tilled (Direct Seeded Rice) - Conventional tilled (wheat), T_4 –Zero tilled (Direct Seeded rice) –Zero tilled (wheat) and Sub plot treatments were W_1 -Weedy check, W_2-Chemical control (clodinafop @0.060 followed by 2,4-D @0.50 kg ha^{-1}) and W_3 -Integrated weed management (clodinafop @0.06 fb 2,4 D @0.50 kg ha^{-1} + 1 HW at 40 DAS). For the study, wheat was taken as test crop. Fertilizers were given uniformly to all the plots through urea, single super phosphate and murate of potash at the rate of 120 kg N, 60 kg P_2O_5 and 30 kg K_2O ha^{-1} respectively. The certified seed of wheat having good germination percentage (95%) was sown in all the plots at the rate of 120 kg ha^{-1} on November 14. The quantities of different herbicides for the respective plots were determined according to the active ingredient present in the commercial products. The spraying of herbicides was done by mixing the exact quantity of herbicides in measured quantity of water at the rate of 500 litre ha^{-1}. Herbicides were applied in the plots by Knapsack sprayer using flat fan nozzle. In zero tilled plots, paraquat (1,1'-dimethyl-4,4'-bipyridinium dichloride and 1 kg ha^{-1}) was applied 1 day before sowing (DBS) of wheat crop to kill the emerged weeds and to make the field weed free. The 2,4-D @0.50 kg ha^{-1}and clodinafop @0.06 kg ha^{-1}are antagonistic to each other, therefore, the 2, 4-D was applied 10 days after application of clodinafop. The various observations were made on weeds and crop as well as study requirement. The weed control efficiency (WCE) was calculated by using the following formulae.

$$\text{WCE} = \frac{\text{Dry weight of weed in control plot} - \text{dry weight of weed in treated plot}}{\text{Dry weight of weed in control plot}} \times 100$$

Short Communication

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The data recorded on various observations were tabulated and then subjected to statistical analysis as per the method of analysis of variance for spilt plot design suggested by Snedecor and Cochron (1967). The data on weeds have considerable variation and hence subjected to square root transformation $\sqrt{x \pm 0.5}$ before analysis.

Among the different weeds infesting wheat crop, the monocot weed *Avena ludoviciana* was most rampant, constituting major share (94%) relative density of weeds at 60 DAS. Whereas, dicot weeds like *Medicago hispida* (3%), *Chenopodium album* (1%), and monocot weed *Phalaris minor* (2%) were present in lesser numbers. Similar weed flora in wheat in rice-wheat system was also reported by Yadav *et al.* (2001), Yaduraju and Mishra (2002) and Dixit *et al.* (2005) in Jabalpur, M.P.

Among the tillage packages, zero tilled wheat after zero tilled rice had the lowest density and dry weight of *A. ludoviciana* (12.28m^{-2} and 8.83g m^{-2}), *P. minor* (1.65m^{-2} and 0.78g m^{-2}) and *M. hispida* (3.27 m^{-2} and 1.10 g m^{-2}). While the lowest value of *C. album* (1.74 m^{-2} and 1.37 g m$^{-2)}$ was recorded under zero tilled wheat after conventional tilled rice. The lowest value of *P. minor, C. album,* and *M. hispida,* in terms of density and dry weight were recorded in plots receiving IWM practices (0.70 m^{-2} and 0.70 g m^{-2}, 1.67 m^{-2} and 1.28 g m^{-2}, 2.89 m^{-2} and 1.02 g m^{-2}). These results are in close conformity to the findings of Jain *et al.* (2007). Singh *et al.* (2001) also reported more weed emergence in conventional tillage and reduced tillage than zero tillage. Sequential application of selective grass killer (clodinafop @0.06 kg ha^{-1}) followed by selective broad leaved weed killer (2, 4-D @0.50 kg ha^{-1}) lowered the density and dry weight of weeds under chemical weed control. The effective control of post emergent weeds with selective herbicide (clodinafop @0.06 kg ha^{-1}fb 2,4-D @0.5 kg ha^{-1}) coupled with complete elimination of left out weeds with one hand weeding at 40 DAS could be the reason for lowest weed density and dry weight of weeds Jain *et al.* (2007)

Weed control efficiency

The weed control efficiency was almost similar and higher under conventional tilled wheat after conventional tilled rice (88.54 %) and conventional tilled wheat after zero tilled rice (88.43 %) against zero tilled wheat after conventional tilled rice (85.35 %). IWM (clodinafop @0.06kg ha^{-1} fb 2, 4-D @0.5kg ha^{-1}+ 1HW at 40 DAS) gave higher weed control efficiency (89.64 %) than chemical control (76.03 %). Though the combinations of IWM with all the tillage packages had 12 to 16 per cent higher WCE over all the combinations of chemical control under all the tillage packages but magnitude of increase in the WCE was of the higher order in the plots receiving integrated weed management after both conventional tillage packages (95.52%) than remaining interactions.

Yield and yield attributing parameters

The number of effective tiller was between 359 to 377 m^{-2}, but the differences did not touch the level of significance. IWM (clodinafop @0.06kg ha^{-1} fb 2, 4-D @0.5kg ha^{-1}+ 1HW at 40 DAS) had significantly the highest number of effective tillers (409 m^{-2}) followed by chemical weed control. Interaction was found to be significant with higher number of effective tillers in IWM practice than chemical weed control .No significant influence was observed on length of ear head. It varied between 10.07 to 10.23 cm (Table 2). IWM adopted in wheat produced significantly long ear head (11.05cm) than chemical control. Clodinafop @0.06kg ha^{-1} fb 2, 4-D @0.5kg ha^{-1}+ 1 HW at 40 DAS attained the higher values of ear head length than chemical weed control. It is evident from Table1 that no significant variation in number of grains per ear head was recorded due to tillage packages. However, the values varied between 49.47 to 54.24. IWM adopted in wheat had significantly higher number of grains per ear head (57.23) followed by chemical control (clodinafop @0.06kg ha^{-1} fb 2,4-D @0.5kg ha^{-1}). Sequential application of selective grass killer (clodinafop @0.06kg ha^{-1}) followed by selective broad leaved weed killer (2, 4-D @0.5kg ha^{-1}) could be assigned the reason for lower weed density and dry weight of weeds under chemical weed control and complete elimination of left out weeds with one hand weeding which escaped sequential application of (clodinafop @0.06kg ha^{-1} fb 2, 4-D @0.5kg ha^{-1}), could be the reason for the minimal weed growth under IWM adopted in wheat.

The grain yield was numerically higher in zero tilled wheat after conventional tillage in rice (3982 kg ha^{-1}) and *vice–versa* (3924kg ha^{-1}). The weed control practices showed influence on the grain yield of wheat. IWM practice produced significantly higher grain yield (4769kg ha^{-1}) than chemical control practice (4257kg ha^{-1}) but both the weed control treatments produced significantly higher grain yields over weedy check. The grain yield was significantly higher under IWM practice after all the tillage packages in wheat over chemical control and weedy check plots. Saini and Singh (2001) reported significantly lower weed dry weight, superior yield attributes and grain yield due to application of clodinafop. Due to different tillage packages, straw yield ranged between 7035 to 7830 kg ha^{-1}. IWM adopted in wheat yielded significantly higher straw yield (8928 kg ha^{-1}) over weedy check plots (5630 kg ha^{-1}). The straw yield increased identically in the plots receiving IWM practice. However, the impact of increase was significantly more under zero tilled wheat after conventional tilled rice (T_1W_3) and conventional tilled wheat after zero tilled rice (T_2W_3). The IWM (clodinafop @0.06kg ha^{-1} fb 2, 4-D @0.5kg ha^{-1}+ 1HW at 40 DAS) and chemical weed control (clodinafop @0.06kg ha^{-1} fb 2, 4-D @0.5kg ha^{-1}) recorded significantly higher harvest index (34.99 and 34.36%) as compared to weedy check (31.28%) which was lowest.

Table 1: Weed density and weed dry weight as influenced by weed control treatments

Treatments	Density of weeds				Dry weight of weeds (g m^{-2})				
	A. ludovicia	*C. album*	*M. hispida*	*P. minor*	*A. ludovicia*	*C. album*	*M. hispida*	*P. minor*	WCE (%)
T1- CT (Rice)- ZT (wheat)	15.58 (242.23)	1.74 (2.52)	3.84 (14.24)	1.7 (2.39)	9.51 (89.94)	1.37 (1.37)	1.23 (0.44)	0.78 (0.1)	85.35
T_2 - ZT (Rice)-CT(wheat)	16.28 (264.53)	2.28 (4.69)	3.55 (12.1)	1.78 (2.66)	10.14 (102.3)	1.37 (1.37)	1.16 (0.84)	0.78 (0.1)	88.43
T_3 - CT (Rice)-CT (wheat)	16.28 (264.53)	2.38 (5.16)	4.49 (12.53)	1.89 (3.07)	10.22 (10309)	1.37 (1.37)	1.35 (1.32)	0.78 0.78	88.54
T4 - ZT (Rice)-ZT (wheat)	12.28 (150.29)	1.96 (3.34)	3.27 (10.19)	1.65 (2.2)	8.83 (77.46)	1.37 (1.37)	1.1 (0.71)	0.78 (0.1)	69.04
SEm(±)	**0.16**	**0.11**	**0.23**	**0.07**	**0.19**	**0.07**	**0.03**	**0**	-
LSD(0.05)	**0.51**	**NS**	**NS**	**NS**	**0.63**	**NS**	**NS**	**NS**	-
W_1 - Weedy check	26.79 (717.20)	2.72 (6.89)	4.92 (23.7)	3.87 (14.47)	16.75 (280.00)	1.95 (3.3)	1.47 (1.66)	0.97 (0.44)	0
W_2 - Chemical control	11.76 (134.79)	1.88 (3.03)	3.55 (12.1)	0.7 0	7.7 (58.79)	1.4 (1.46)	1.14 (0.79)	0.7 (0.01)	76.03
W_3 – IWM	6.76 (45.19)	1.67 (2.28)	2.89 (7.85)	0.7 0	4.58 (20.47)	1.28 (1.13)	1.02 (0.54)	0.7 (0.01)	89.64
SEm(±)	**0.17**	**0.09**	**0.14**	**0.06**	**0.21**	**0.06**	**0.04**	**0**	-
LSD(0.05)	**0.5**	**0.27**	**0.42**	**0.18**	**0.62**	**0.18**	**0.12**	**0.01**	-
Interaction SEm(±)	**0.34**	**0.18**	**0.29**	**0.12**	**0.43**	**0.12**	**0.08**	**0.01**	-
LSD(0.05)	**1.01**	**0.55**	**0.85**	**0.37**	**1.25**	**0.36**	**0.25**	**0.03**	-

* *Figures in parentheses are original values*

Table 2: Yield and yield attributing characteristics influenced by weed control treatments

Treatments	Effective tillers (m^{-2})	Earhead length (cm)	No. of grains earhead^{-1}	1000 grain wt (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	HI	B:C ratio	Cost of cultivation (₹ha^{-1})
T1- CT (Rice)- ZT (wheat)	372	10.15	49.47	41.31	3982	7830	31.77	3.75	11524
T_2 - ZT (Rice)- CT(wheat)	359	10.12	51.85	42.5	3924	7576	34.75	3.04	13924
T_3 - CT (Rice)- CT (wheat)	372	10.23	54.24	41.51	3798	7035	33.71	2.93	13924
T4 - ZT (Rice)- ZT (wheat)	377	10.07	49.8	42.39	3719	7802	33.95	3.5	11524
SEm(±)	**7.32**	**0.09**	**1**	**0.33**	**73.78**	**134.45**	**0.48**	-	-
LSD(0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	-	-
W_1 - Weedy check	313	8.88	44.53	39.03	2540	5630	31.28	2.62	10899
W_2 - Chemical control	388	10.5	52.25	42.32	4257	8125	34.36	3.72	12625
W_3 – IWM	409	11.05	57.23	44.43	4769	8928	34.99	3.58	14650
SEm(±)	**3.46**	**0.12**	**1.23**	**0.35**	**66.83**	**169.94**	**0.66**	-	-
LSD(0.05)	**10.38**	**0.37**	**3.69**	**1.02**	**195.06**	**496.02**	**1.94**	-	-
Interaction SEm(±)	**6.92**	**0.25**	**2.46**	**0.7**	**133.66**	**339.88**	**1.33**	-	-
LSD(0.05)	**20.76**	**0.74**	**NS**	**NS**	**390.13**	**992.04**	**NS**	-	-

Benefit – cost ratio

The cost of cultivation was the highest (Rs.13,924 ha^{-1}) under conventionally tilled wheat after zero tilled rice or conventional tilled rice. Among weed control practices, the cost of cultivation was the highest (₹14,650 ha^{-1}) under IWM followed by chemical control (₹12,625 ha^{-1}) due to more expenditure on herbicides and manual labour for weed control in IWM and on herbicides in chemical control as compared to weedy check (₹10,899 ha^{-1}). Hence the unit price of particulars under the study of variable cost cultivation is comparatively low (Appendix I). The net monetary returns and benefit per rupee of investment were higher in the plots receiving clodinafop fb 2,4-D in zero tilled wheat after conventional tilled rice as well as IWM in wheat under zero tilled wheat after zero tilled rice. The higher B:C ratio under zero tillage than conventional tillage was also reported by Rautary (2002) and Khuhro *et al.* (2002).

A field experiment was conducted during *rabi* 2007-08 at NRC – Weed Science, Jabalpur (M.P.) to assess the effect of tillage and weed control methods on yield, and weed dynamic of wheat in direct seeded rice – wheat cropping system. It is evident from the data that crop growth, yield attributes and yields were not influenced by any of the tillage packages adopted in wheat. But chemical weed control or IWM (clodinafop fb 2,4-D along with 1 HW) after all the tillage packages increased the growth parameters, yield attributes, grain and straw yields of wheat compared to weedy check plots. weed control efficiency was almost higher under conventional tilled wheat after conventional tillage in rice (88.54 %) and conventional tilled wheat after zero tillage in rice (88.43 %) against zero tilled wheat after conventional tillage in rice and zero tilled wheat after zero tillage in rice (85.35 % and 69.04%). IWM practice (clodinafop @0.06kg ha^{-1} fb 2, 4-D @0.5kg ha^{-1}+ 1HW at 40 DAS) gave higher weed control efficiency (89.64 %) than chemical control (76.03 %) and also produced significantly higher grain yield of wheat than chemical control practice (clodinafop @0.06kg ha^{-1} fb 2, 4-D @0.5kg ha^{-1}).The net monetary returns and benefit per rupee of investment were higher in plots receiving clodinafop fb 2, 4-D in zero tilled wheat after conventional tillage in rice as well as IWM in wheat under zero tilled wheat after zero tillage in rice.

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