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Effect of Crop Establishment Methods and Weed Management Practices on Productivity, Soil Properties and Economics of Wheat under Rice – Wheat Cropping System

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ABSTRACT

A field experiment was conducted at the Crop Research Centre of GBPUA & T, Pantnagar, Udham Singh Nagar continuous two years to study the productivity, soil properties, and economics of wheat (Triticum aestivum L.) under different wheat establishment methods in main plots and seven weed management practices in sub plots, replicated thrice in a split plot design. Zero tilled wheat exhibited more number of spikes m^{-2} and more number of grains per spike was significantly higher than reduced and conventional tillage. The zero tilled wheat yielded 12.35 and 3.66 per cent higher over reduced and conventional tillage during Ist year and 11.99 and 3.09 per cent during IInd year. The bulk density of soil was higher under zero tillage than that of other tillage. The infiltration rate was significantly greater with ZT than RT and CT. The highest grain yield was obtained in two hand weedings done at 30 and 60 DAS and was at par with Isoproturon 1.0 kg ha^{-1} + Metsulfuron methyl 4 g ha^{-1} at 30 DAS and Clodinafop – Propargyl 60 g ha^{-1} at 30 DAS fb. Metsulfuron methyl 4 g ha^{-1} at 37 DAS.

KEYWORD

Zero tillage, Wheat establishment methods, grain yield, bulk density, infiltration rate

INTRODUCTION

Rice-wheat is the most commonly employed cropping system on around 14 million hectares of land extending across the Indo-Gangetic Plain (IGP). Wheat (*Triticum aestivum* L.) is a predominant *rabi* crop of North- Western Plain Zone and Central Zone of India which occupy about 28.52 million ha area. Wheat production technology has systematically changed with the adoption of high yielding dwarf varieties. The tillage, residue management and nitrogen application were markedly different for tall varieties from the presently grown dwarf ones. The major challenge facing the IGP's rice-wheat cropping system is to sustain long-term productivity. This system has a pivotal role in the food security and livelihoods of millions of farmers and workers of populous countries such as India. The system's productivity and economic gains have been consistently decreasing, mainly because of the delayed sowing of wheat after the rice harvest and the fatigued soil condition. The adoption of resource conservation technologies, such as zero tilled wheat sowing, is considered essential to maintain the productivity of the rice-wheat cropping system (Singh *et al.*, 2010). Zero tillage with previous crop residue retention results in water saving. It also saves the soil from formation of large cracks and also avoids sub-soil compaction (Jat *et al.*, 2008). The zero-tillage technology is widely maintained as an integrated approach that can tackle the problem of wheat yield stagnation in the rice-wheat zone by timely sowing, reducing cost of production, improved input use efficiency and saving irrigation water (15-20%), build-up in SOC due to reduced burning of crop residues. Conventional tillage practices followed by farmers for raising wheat after rice, involve higher use of machines, labour and energy as it is done to change the low permeability soil structure created for rice to well aerated structure for wheat.

Efficient weed management in high yielding dwarf wheat is one of the important inputs required for raising and sustaining its productivity. The introduction of dwarf wheat cultivars appears to have created a greater grassy weed problem like *Phalaris minor* and *Avena* spp. throughout the wheat growing areas in the country (Singh *et al.*, 1996). It is probably due to the fact that the dwarf wheat varieties with short stature and erect leaf orientation, permit more light penetration through the canopy and being highly responsive to fertilizer and irrigation are less competitive against weeds than the traditional tall cultivars. Different herbicides have been tested for controlling weeds. Out of these, isoproturon was introduced as the most effective and economical herbicide for control of *P. minor* and some broad leaf weeds but continuous use of isoproturon has resulted in development of resistance in *P. minor* in Haryana and Punjab. Clodinafop propargyl, sulfosulfuron and fenoxaprop-p-ethyl, post emergence herbicides had been found promising against grassy weeds particularly resistant bio-types of *P. minor*.

MATERIALS AND METHODS

An investigation was conducted at the Crop Research Centre of Govind Ballabh Pant University of Agriculture and Technology Pantnagar, Udham Singh Nagar during continuous two years. The Crop Research Center is located at 29^0 N latitude, 79.3^{0}E longitude and at an altitude of 243.8 meters above mean sea level and lies in the *tarai* belt of Shivalik range of Himalayan foot hills. *The experimental site was*

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sandy loam in texture having alkaline reaction (7.9 pH). The soils was low in available N (265 kg N/ha) and rich in available P (37.5 kg/ha) and medium in K (264.45 kg/ha). The field experiments was consisted of 21 treatments combinations imposed to wheat crop, comprising three wheat establishment methods *i.e.* Zero tillage (sowing with zero till ferti-seed drill), Reduced tillage (3 harrowing fb planking) and Conventional tillage (6-7 harrowing fb planking) in main plots and seven Weed management practices (i.) Isoproturon 1.0 kg ha^{-1} at 30 DAS (ii.) Clodinafop – propargyl 60 g ha^{-1} at 30 DAS (iii). Metsulfuron methyl 4 g ha^{-1} at 30 DAS (iv). Isoproturon 1.0 kg ha^{-1} + Metsulfuron methyl 4 g ha^{-1} at 30 DAS (v). Clodinafop – Propargyl 60 g ha^{-1} at 30 DAS fb. Metsulfuron methyl 4 g ha^{-1} at 37 DAS (vi). Hand weedings at 30 & 50 DAS (vii). Weedy (control) in sub plots, replicated thrice in a split plot design. Recommended levels of 150 kg N; 60 kg P_2O_5, 40 kg K_2O and 25 kg $ZnSO_4$/ha will be applied in wheat crop. Field was prepared as per the given in the treatment i.e. reduced tillage (3 harrowing) and conventional tillage (6 harrowing) followed by one roller and then finally field was leveled. But in case of zero tillage, wheat was sown directly without any tillage operation. Wheat variety "PBW 343" with 100 kg ha^{-1} seed rate was sown in the rows, 20 cm apart. In the zero tillage treatment the seeds were sown by Pant zero-till ferti-seed drill and in reduced and conventional system the seeds were sown manually. The isoproturon and clodinafop-propargyl were applied at 30 days after sowing (DAS), while metsulfuron methyl at 7 days after spray of clodinafop propargyl in wheat crop. Data on various yield attributes, grain and straw yields of wheat and economic return were calculated as per the standard procedures. The nutrient uptake (NPK) were estimated from both seed and stover separately during both the years and its uptake were calculated with the help of total seed and stover yield multiply with respective nutrient content.

Bulk density determination was made with the help of a core sampler. Soil samples were taken from 0-7 and 7-14 cm soil depth in the plots after harvest of wheat. Samples of soil were dried in an electric oven at 105 ^{0}C till a constant weight was attained and bulk density was determined by the following formula:

$$\text{Bulk density} = \frac{\text{Dry wt. of soil (Mg)}}{\text{Total volume of soil (m}^3\text{)}}$$

Where, volume of soil is inner volume of the core sampler.
Infiltration rate was determined after harvests of wheat crop (i.e. after completion of cycle) by using methods. The measured groundcover, infiltration using ring infiltrometers and runoff and soil erosion from natural weather events. The experimental data were analysed statistically by applying the technique of analysis of variance (ANOVA) prescribed for the design to test and conclusions were drawn at 5% probability levels.

RESULTS AND DISCUSSION

i. Growth and Development

Wheat establishment method significantly effects on number of shoot m^{-2} dry matter and plant height during both the year of experimentation. However, days taken to anthesis as well as maturity does not influenced at statistical level of significance due to method of wheat establishment. Sowing of wheat with zero tillage proved significantly superior in respect number of shoots, dry matter production as well as

Table 1: Growth and development in wheat as influenced by various treatments

Treatments	Number of shoots m^{-2} at 120 days		Dry matter accumulation g/m^2 at 120 days		Plant height cm at 120 days		Days to anthesis		Days of Maturity	
	Ist year	IInd year	Ist year	IInd year	Ist year	IInd year	Ist year	IInd year	Ist year	IInd year
Wheat establishments methods										
Zero tillage	165.6	168.3	1175.5	1189.3	87.62	89.46	93.1	93.5	140.7	142.5
Reduced tillage	158.9	160.3	1072.3	1085.9	83.33	85.96	93.8	94.5	141.4	143.4
Conventional tillage	157.3	158.4	1057.5	1072.4	81.26	83.79	93.2	93.8	141.3	143.5
S.Em. ±	0.94	0.87	7.07	8.04	0.963	0.982	0.49	0.30	0.158	0.69
CD at 5%	3.24	2.99	24.35	27.69	3.317	3.382	NS	NS	NS	NS
Weed management practices in wheat										
Isoproturon 1.0 kg ha^{-1} at 30 DAS	157.0	158.7	1076.8	1087.1	82.67	84.27	93.3	91.6	140.0	141.4
Clodinafop – propargyl 60 g ha^{-1} at 30 DAS	154.3	155.7	1081.5	1094.0	83.33	85.43	93.7	94.2	139.8	142.8
Metsulfuron methyl 4 g ha^{-1} at 30 DAS	157.0	159.0	1085.9	1099.3	81.37	83.83	92.2	92.7	140.5	142.0
Isoproturon 1.0 kg ha^{-1} + Metsulfuron methyl 4 g ha^{-1} at 30 DAS	166.3	168.3	1159.2	1175.8	87.67	90.13	94.9	95.9	144.2	146.0
Clodinafop – Propargyl 60 g ha^{-1} at 30 DAS fb. Metsulfuron methyl 4 g ha^{-1} at 37 DAS	168.0	171.0	1108.0	1123.0	85.40	87.57	93.6	94.4	140.8	141.6
Hand weeding at 30 & 50 DAS	175.7	175.7	1189.2	1202.7	90.83	93.43	95.2	95.7	145.8	147.9
Weedy (control)	145.7	148.0	1011.9	1029.1	77.30	80.13	92.5	93.2	136.7	140.2
S.Em. ±	2.07	2.35	14.90	12.52	1.216	1.167	1.19	1.29	1.97	2.07
CD at 5%	5.87	6.67	42.26	35.51	3.448	3.309	NS	NS	NS	NS

plant height over reduced and conventional method of tillage during both the year. All the growth and development parameters given in the Table 1 were affected remarkably by used management practices during both years. The significant highest number of shoot of tallest height was recorded under the treatment of chlodinafop-propargyl 60g ha^{-1}, metsulfuron methyl 14gha^{-1} during both years over there treatments. However, the lowest value in this regards were noticed in weedy parts, where none of the methods to control the weeds were followed.

ii. Yield performance

Data recorded on yield attributes, viz. number of spike/m^2, number of grains/spike, grain weight per spike and 1000 seed weight of wheat crop (Table 2) exhibited significant differences under different wheat establishments methods. Zero tilled wheat exhibited more number of spikes m^{-2} and more number of grains per spike was significantly higher under zero tillage than reduced and conventional tillage during both the years. There were 8.48 and 5.66 per cent increase in number of grains per spike under zero tillage over reduced and conventional tillage in the first year and 8.04 and 6.22 per cent increase during second year. The grain weight per ear was also affected significantly by wheat establishment methods during both the years. It was 8.97 and 7.26 per cent higher under zero tillage than that of reduced and conventional tillage during first year and 13.89 and 13.10 per cent during second year. Wheat establishment methods caused significant effect on the grain yield during both the years. The zero tilled wheat yielded 12.35 and 3.66 per cent higher over reduced and conventional tillage during Ist year, respectively. The respective increase during IInd year was 11.99 and 3.09 per cent. The marked increase in grain yield in above treatments might be due to overall improvement on yield attributes. The straw yield was higher under zero tillage during both the years. There was an increase of 9.7 and 9.95 per cent over reduced tillage and 2.52 and 2.69 per cent over conventional tillage during Ist year and IInd year, respectively.

Table 2: Yield attributes of wheat as influenced by different treatments

Treatments	No of spikes/ m^2		No of grains/spike		Grain wt/spike (g)		1000 grain wt (g)	
	Ist year	IInd year	Ist year	IInd year	Ist year	IInd year	Ist year	IInd year
Wheat establishments methods								
Zero tillage(ZT)	155.8	159.2	45.39	46.17	2.34	2.52	39.78	40.05
Reduced tillage(RT)	145.6	148.5	41.54	42.46	2.13	2.17	38.28	38.50
Conventional tillage(CT)	149.1	152.3	42.82	43.30	2.17	2.19	38.86	39.33
S.Em. ±	0.47	0.08	0.271	0.248	0.001	0.002	0.206	0.204
CD at 5%	1.61	0.28	0.936	0.406	0.003	0.006	0.193	0.703
Weed management practices in wheat								
Isoproturon 1.0 kg ha^{-1} at 30 DAS	150.5	153.5	42.39	42.85	2.07	2.08	38.06	38.52
Clodinafop – propargyl 60 g ha^{-1} at 30 DAS	152.9	156.2	42.85	43.87	2.15	2.19	39.65	39.77
Metsulfuron methyl 4 g ha^{-1} at 30 DAS	151.5	154.5	41.50	41.89	2.15	2.17	38.75	38.97
Isoproturon 1.0 kg ha^{-1} + Metsulfuron methyl 4 g ha^{-1} at 30 DAS	158.8	161.5	46.78	47.41	2.46	2.50	41.51	41.92
Clodinafop – Propargyl 60 g ha^{-1} at 30 DAS fb. Metsulfuron methyl 4 g ha^{-1} at 37 DAS	154.8	157.0	42.84	43.80	2.25	2.29	38.88	39.09
Hand weedings at 30 & 50 DAS	162.7	165.9	49.15	50.17	2.60	2.63	42.50	42.99
Weedy (control)	119.9	124.6	37.27	37.85	1.80	2.18	33.46	33.80
S.Em. ±	2.28	2.11	0.563	0.587	0.030	0.035	0.556	0.574
CD at 5%	6.47	5.97	1.597	1.664	0.085	0.101	1.578	1.627

All the weed control practices recorded significantly higher number of spikes m^{-2}, number of grains per spike and 1000 grain weight than weedy check during both the years. Two hand weedingss exhibited significantly higher number of grains per spike than Isoproturon 1.0 kg ha^{-1} + Metsulfuron methyl 4 g ha^{-1} at 30 DAS and Clodinafop – Propargyl 60 g ha^{-1} at 30 DAS fb. Metsulfuron methyl 4 g ha^{-1} at 37 DAS, but in case of number of spikes and 1000-grain weight, two hand weedingss did not prove superior to both of herbicidal treatments except that of 1000-grain weight during first year. Wheat yield was affected remarkably by the weeds and recorded 62.0 and 65.7 per cent reduction in the yield in uncontrolled weeds during Ist year and IInd year, respectively as compared to crop given two hand weedingss at 30 and 50 DAS (Table 3). All the weed management practices produced significantly higher grain yield than weedy check. The highest grain yield was obtained in two hand weedings done at 30 and 60 DAS and was at par with Isoproturon 1.0 kg ha^{-1} + Metsulfuron methyl 4 g ha^{-1} at 30 DAS and Clodinafop – Propargyl 60 g ha^{-1} at 30 DAS fb. Metsulfuron methyl 4 g ha^{-1} at 37 DAS. Bharat and Karchroo (2007) also reported superiority of tank mixing of clodinafop + metsulfuron methyl over isoproturon alone in broadening the spectrum of weed control and increasing yield. The

herbicide application significantly increased the grain and biomass yield due to reduction in weed density and weed dry weight. That's why there would be less crop weed competition for space, light, moisture and nutrient etc which resulted in better crop establishment, reduced tiller mortality and ultimately increase in the grain and biomass yield. The straw yield was highest under hand weedings twice followed by Isoproturon 1.0 kg ha^{-1} + Metsulfuron methyl 4 g ha^{-1} at 30 DAS and Clodinafop – Propargyl 60 g ha^{-1} at 30 DAS fb. Metsulfuron methyl 4 g ha^{-1} at 37 DAS during both the years, but, these are significantly higher over the weedy condition during both the years. Grain: straw ratio did not differ significantly among different establishment methods. On the other hand, straw yield was significantly higher than weedy check under all the weed management practices.

ii Soil properties

The bulk density of soil was higher under zero tillage than that of reduced and conventional tillage. Higher bulk density in zero tilled plots might be due to the repeated movement of heavy implements that compressed the soil, however the same soil was loosened when harrowings were done in reduced and conventional tillage. Pandey *et al.* (2005), Gangwar *et al.* (2004) and Parihar (2004), who, reported higher bulk density in zero tilled plots as compared to deep tilled plots. Significantly higher bulk density of zero tilled plots than that of conventionally tilled plots could be due to natural consolidation and compaction of soil. Continuous use of zero tillage resulted in reduced yield due to soil compaction and poor aeration Hobbs and Gupta (2002). The bulk density of the soil was not affected by different weed management practices in wheat during both the years. The infiltration rate was significantly greater with ZT than RT and CT in present investigation. According to Stone and Schlegel (2013) the significantly better conditions of aggregate stability and water infiltration with ZT management and the lack of development of poor infiltration properties during the wheat season that would need to be alleviated by tillage after harvest reinforce the appropriateness of ZT management in crop production system of the region.

Table 3: Seed yield, straw yield, bulk density and infiltration rate in wheat as influenced by different treatments

Treatments	Seed yield (q/ha)		Straw yield (q/ha)		Bulk density (Mg^{-3})		Infiltration rate (mm hr^{-1})	
	Ist year	IInd year	Ist year	IInd year	Ist year	IInd year	Ist year	IInd year
Wheat establishments methods								
Zero tillage (ZT)	46.13	46.55	68.14	68.74	1.54	1.55	31.69	32.77
Reduced tillage (RT)	40.44	40.97	61.48	61.90	1.48	1.49	15.73	16.16
Conventional tillage (CT)	44.44	45.11	66.42	66.89	1.46	1.47	12.12	12.21
S. Em. ±	0.132	0.137	0.382	0.353	0.010	0.009	0.25	0.14
CD at 5%	0.456	0.472	1.317	1.215	0.040	0.035	0.96	0.54
Weed management practices in wheat								
Isoproturon 1.0 kg ha^{-1} at 30 DAS	43.88	44.45	65.09	65.88	1.48	1.49	18.81	18.94
Clodinafop – propargyl 60 g ha^{-1} at 30 DAS	45.77	46.37	69.11	69.40	1.51	1.52	18.97	19.54
Metsulfuron methyl 4 g ha^{-1} at 30 DAS	43.98	44.45	65.98	66.62	1.52	1.53	19.87	20.01
Isoproturon 1.0 kg ha^{-1} + Metsulfuron methyl 4 g ha^{-1} at 30 DAS	47.54	48.31	71.80	72.36	1.50	1.51	20.34	20.84
Clodinafop – Propargyl 60 g ha^{-1} at 30 DAS fb. Metsulfuron methyl 4 g ha^{-1} at 37 DAS	46.72	47.39	71.17	71.26	1.47	1.48	20.41	21.37
Hand weedings at 30 & 50 DAS	48.10	48.94	72.71	73.23	1.48	1.49	21.87	22.67
Weedy (control)	29.70	29.54	41.55	42.17	1.48	1.51	18.64	19.27
S.Em. ±	0.660	0.674	0.990	0.916	0.028	0.025	0.45	0.49
CD at 5%	1.871	1.954	2.807	2.599	N.S.	N.S.	1.29	1.40

III. *Economics*

Economic analysis of different treatments adopted in wheat and farmer practice of raising rice crop indicated that maximum cost of cultivation was recorded under conventional tillage followed by reduced tillage and found lowest under zero tillage. Under different weed management practices, cost requirement was highest under two hand weedingss, which was followed by Clodinafop – Propargyl 60 g ha^{-1} at 30 DAS fb. + Metsulfuron methyl 4 g ha^{-1} at 37 DAS and Isoproturon 1.0 kg ha^{-1} + Metsulfuron methyl 4 g ha^{-1} at 30 DAS. Treatment combination of zero tillage with Clodinafop – Propargyl 60 g ha^{-1} at 30 DAS fb. + Metsulfuron methyl 4 g ha^{-1} at 37 DAS followed by two hand weedingss at 30 and 50 DAS stages during both the years Benefit: cost ratio obtained highest under zero tillage in combination with Clodinafop – Propargyl 60 g ha^{-1} at 30 DAS fb. + Metsulfuron methyl 4 g ha^{-1} at 37 DAS in wheat and farmer practices of rice (1.40 and 1.52) which was closely followed by the treatment combination of zero tillage along with Isoproturon 1.0 kg ha^{-1} at 30 DAS and two hand weedingss at 30 and 50 DAS.

Table 4: Gross return, net return and benefit cost (B:C) ratio as influenced by different treatment combination

Treatments	Gross return (ha^{-1})		Net return (ha^{-1})		B:C Ratio	
	Ist year	IInd year	Ist year	IInd year	Ist year	IInd year
ZT x Isoproturon 1.0 kg ha^{-1} at 30 DAS	110199	116775	63803	70267	1.38	1.51
ZT x Clodinafop – propargyl 60 g ha^{-1} at 30 DAS	112026	118866	64117	70817	1.34	1.47
ZT x Metsulfuron methyl 4 g ha^{-1} at 30 DAS	108431	114855	60679	66994	1.27	1.40
ZT x Isoproturon 1.0 kg ha^{-1} + Metsulfuron methyl 4 g ha^{-1} at 30 DAS	116146	122446	67735	73923	1.40	1.52
ZT x Clodinafop – Propargyl 60 g ha^{-1} at 30 DAS fb. Metsulfuron methyl 4 g ha^{-1} at 37 DAS	114779	120322	64241	69682	1.27	1.38
ZT x Hand weedings at 30 & 50 DAS	117543	124527	66452	73367	1.30	1.43
ZT x Weedy (control)	87475	91260	47351	51136	1.18	1.27
RT x Isoproturon 1.0 kg ha^{-1} at 30 DAS	102724	108335	54304	60073	1.12	1.24
RT x Clodinafop – propargyl 60 g ha^{-1} at 30 DAS	105318	110930	55385	61127	1.11	1.23
RT x Metsulfuron methyl 4 g ha^{-1} at 30 DAS	103435	108984	53659	59369	1.08	1.20
RT x Isoproturon 1.0 kg ha^{-1} + Metsulfuron methyl 4 g ha^{-1} at 30 DAS	108221	114143	57786	63866	1.15	1.27
RT x Clodinafop – Propargyl 60 g ha^{-1} at 30 DAS fb. Metsulfuron methyl 4 g ha^{-1} at 37 DAS	108217	114095	55655	61701	1.06	1.18
RT x Hand weedings at 30 & 50 DAS	109535	115241	56420	62327	1.06	1.18
RT x Weedy (control)	80830	84500	38682	42622	0.92	1.02
CT x Isoproturon 1.0 kg ha^{-1} at 30 DAS	106420	111726	56003	60937	1.11	1.20
CT x Clodinafop – propargyl 60 g ha^{-1} at 30 DAS	108266	114110	56336	61780	1.08	1.18
CT x Metsulfuron methyl 4 g ha^{-1} at 30 DAS	106861	111906	55088	59764	1.06	1.15
CT x Isoproturon 1.0 kg ha^{-1} + Metsulfuron methyl 4 g ha^{-1} at 30 DAS	110845	116996	58413	64192	1.11	1.22
CT x Clodinafop – Propargyl 60 g ha^{-1} at 30 DAS fb. Metsulfuron methyl 4 g ha^{-1} at 37 DAS	110556	117067	55997	62146	1.03	1.13
CT x Hand weedings at 30 & 50 DAS	113406	119398	58294	63957	1.06	1.15
CT x Weedy (control)	84205	89299	40060	44894	0.91	1.01

CONCLUSION

Based on above study it may be concluded that wheat grown with zero tillage in combination with Clodinafop- Propargyl 60 g ha^{-1} at 30 DAS fb., Metsulfuron methyl 4 g ha^{-1} at 37 DAS gave the highest benefit: cost ratio during both the years, Hence this treatment combination is a viable option for enhancing the growth, yield as well as net monetary income of wheat crop under rice- wheat system.

REFERENCES

Bharat R and Kachroo D. 2007. Bio-efficacy of various herbicides and their mixtures on weeds and yield of heat under sub tropical agro ecosystem. *Indian Journal of Agronomy* **50** (1): 53-59.

Gangwar KS, Singh KK and Sharma SK.2004. Effect of tillage on growth, yield and nutrient uptake in wheat after rice in the Indo-Gangatic Plains of India. *J. Agril. Sci.* **142**: 453-459.

Hobbs PR and Gupta RK. 2002. Rice- wheat cropping system in the Indo-Gangatic plains: issues of water productivity in relation to new resource conserving technologies. (In) *Proceedings of the water productivity workshop*, 12-14 Nov., 2001. International Water Management Institute, Sri Lanka.

Jat ML, Gathala MK, Singh KK, Ladha JK, Gupta RK, Singh S, Sharma SK, Saharawat YS and Tetarwal JP. 2008. Experiences with permanent beds in the rice-wheat systems of the western Indo-Gangetic Plain. *ACIAR Proc. Series*. **127**: 98-107.

Pandey IB, Sharma SL, Tiwari S and Mishra SS.2005. Economics of tillage and weed management system for wheat (*Triticum aestivum*) after lowland rice (*Oryza sativa*). *Indian J. Agron*. **50** (1): 44-47.

Parihar SS. 2004. Effect of crop establishment methods tillage irrigation and nitrogen on production potential of rice (*Oryza sativa*) – wheat (*Triticum aestivum*) cropping system. *Indian J. Agron*. **49** (1): 1-5.

Singh G, Singh OP, Singh S. 2010. Weed management in late sown wheat (*Triticum aestivum*) after rice (*Oryza sativa*) in rice-wheat system in rainfed lowland. *Indian J. Agronomy*. **55** (2): 83-88.

Stone LR and Schlegel AL.2006. Yield - water supply relationships of grain sorghum and winter wheat. *Agron. J*. **98**:1359-1366.

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