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Research Paper

Effect of tillage and tank-mix herbicide application on weed management in soybean (*Glycine max*)

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ABSTRACT

A field experiment was carried out at the Indian Agricultural Research Institute during 2010 and 2011 to investigate the effect of tillage and tank-mix herbicide application on growth, yield, nutrient uptake and protein content of soybean [*Glycine max* (L.) Merrill]. It was observed that conventional (CT) and no (NT) tillage systems resulted in comparable weed density and dry weight and soybean seed yield during both years except 2010, when NT resulted in significantly lower weed density. Tank-mix pre-emergence application of pendimethalin 0.5 kg/ha + imazethapyr 0.075 kg/ha was next to weed-free check and superior to all other weed control treatments on the reduction of weed density in both years, but, with respect to reduction in weed dry weight, it was comparable with pendimethalin 0.5 kg/ha + hand weeding, which resulted in the lowest weed dry weight after weed-free check. Nitrogen, P and K uptake by soybean seed was comparably higher in weed-free check and tank-mix pre-emergence application of pendimethalin 0.5 kg/ha + imazethapyr 0.075 kg/ha in both years. Conversely, N, P and K uptake by weed was significantly higher in weedy check, and the lowest amount of these nutrients after weed-free check was observed in pendimethalin 0.5 kg/ha + imazethapyr 0.075 kg/ha. All weed control measures resulted in significantly higher soybean seed yield compared to weedy check, but the tank-mix pre-emergence application of pendimethalin 0.5 kg/ha + imazethapyr 0.075 kg/ha resulted in considerably higher seed yield over others in both years.

Key words : Nutrients, Soybean, Tank-mix herbicide, Tillage, Weed, Yield

Soybean is an important oilseed crop that is widely grown as a valuable source of protein and oil for human nutrition in the world. Weed infestation is considered a persistent and complex constraint in soybean, as it influences soybean growth and development through competition for nutrients, water, light and space as well as through production of allelopathic compounds (Vollmann *et al*. 2010). Thus, weed control is considered a key factor for successful soybean production. Weed management in soybean is labour-intensive or involves intensive use of herbicides. The efficacy of post-emergence herbicide application is highly dose-sensitive and time/stage-dependent, and, therefore, sometimes may lead to phytotoxic effects on crops. Even selective herbicide poses risk when applied as post-emergence at higher dose. The leaves of crop can be burnt, shriveled or discolored when herbicides are sprayed. This damage can be extensive, and sometimes over 40% of the leaves of crop plants is damaged. In addition to giving crops a poor cosmetic appearance, plants can be weakened, their growth phases retarded and stunted. In contrast, pre-emergence application is less risky (Das, 2008). Mixing two or more compatible partner herbicides together at lower doses in the spray tank and applying that mixture as pre –emergence may result in better and broad-spectrum weed control, and crop can germinate in weed-free situations (Das, 2008). Therefore, this research was designed to evaluate the effect of herbicides applied pre-emergence, alone or as tank-mix, in different tillage conditions on weed management in soybean.

MATERIALS AND METHODS

Field experiments were carried out in 2010 and 2011 at the Indian Agricultural Research Institute, New Delhi to investigate the effect of tillage and tank-mix herbicide applications on weed control, yield, nutrient uptake and protein content of soybean. Soil of the experimental field was alluvium (Typic Ustochrepts; Order Inceptisol) in ori-

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gin and sandy-loam (62.4% sand, 16.8% silt and 19.2% clay) with 0.54% organic C and pH 7.6. The available P (18.5 kg P/ha) and K (191.5 kg K/ha) were medium, but available N (272.5 kg N/ha) was low. The rainfall during *kharif* 2010 and 2011 were 926.6 mm (43% above normal) and 574.3 mm (12% below normal), respectively.

The experiment, comprising of two levels of tillage, *viz*, conventional tillage (CT) and no-tillage (NT) in main plots, and 8 weed control measures (mentioned in Tables 1-5) in sub-plots, was laid out in split plot design with 3 replications. Pre-emergence applications of herbicide alone or as tank-mix combinations were made one day after sowing. A knapsack sprayer (200 kPa pressure) fitted with a flat fan nozzle (Sukun Agencies India, Mumbai, Maharashtra) was used with 400 L water/ha for herbicide application. Pendimethalin [N-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine] is a selective pre-emergence herbicide of the dinitroanilines, which controls most annual grasses and certain broad-leaved weeds in 60 different crops (Das, 2008). It prevents plant cell division and elongation in susceptible species. Metribuzin [4-amino-6-(1,1-dimethylethyl)-3-(methylthio)-1,2,4-triazin-5(4h)-one] belongs to triazinones and controls a wide spectrum of broad-leaved weeds and grasses in corn, soybean and potato. It is a soil and foliar herbicide, applied as pre- and post-emergence. It inhibits photosynthesis at photosystem II. Imazethapyr [2-[4, 5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1 H-imidazol -2-yl]-5-ethyl-3-pyridinecarboxylic acid] is a systemic herbicide of the imidazolinones, absorbed by the roots and foliage, and translocated through xylem and phloem, and accumulated in the meristematic regions. It controls annual grass and broad-leaved weeds and sedges in crops like soybean, groundnut. Chlorimuron-p-ethyl [2-(4-chloro-6-methoxypyrimidin-2-ylcarbamoylsulfamoyl) benzoic acid] is a herbicide of the pyrimidinylsulfonylureas, highly active for pre- and post-emergence use in soybean, inhibiting acetolactate synthase (ALS). Weed-free check was kept free from weeds all through the growing season by manual weeding.

A pre-sowing irrigation was given to facilitate land preparation/sowing. One disking and two harrowing followed by planking were done in the conventional tillage strips, while no-tillage strips were untilled during both years. Soybean 'Pusa 9712' was sown using 75 kg seed/ha at 40 cm row-space and 4 cm depth with the help of a manually-operated hand plough. Plant to plant distance in a row was 10 cm. N, P and K, respectively through urea (46% N), single supper phosphate (SSP, 16% P_2O_5) and muriate of potash (MOP, 60% K_2O) at N: P_2O_5: K_2O:: 30:60:40 kg/ha were uniformly applied as basal by broadcasting and mixed with soil before sowing. Chlorpyriphos at 10 ml/L was applied to soil before crop sowing to protect crop plants from termites.

Weed population and dry weight were recorded at 60 DAS by placing a quadrat of 50 cm ×50 cm randomly in each plot. At harvest, soybean yield components such as number of pods/plant, number of seeds/pod, 1000-seed weight (g) were estimated from 5 randomly selected plants, and seed yield was recorded from the net plots (4.0 m × 3.2 m). At harvest, N concentration in soybean seed and stover and weeds by modified Kjeldahl method; P concentration by vanadomolybdophosphoric acid yellow colour method using spectrophotometer; and K concentration by flame photometry method (Prasad *et al*. 2006) were determined. Data on weed population and dry weight were transformed through square-root [$\sqrt{(x + 0.5)}$] method before statistical analysis. All data on weed and soybean were subjected to analysis of variance (ANOVA) using the PROC GLM procedure of SAS (SAS Institute, 2003) to evaluate differences among treatments, and interactions between the main and sub-plot treatments. The significance was tested by variance ratio (i.e. F value) at *p*d" 0.05 (Gomez and Gomez 1984). Standard error (S.E.) and least significant difference (LSD) were worked out for each parameter of weed and soybean studied for comparing the treatment means.

RESULTS AND DISCUSSION

Weed growth

Ten weed species, five monocotyledons (monocots) and five dicotyledons (dicots) belonging to seven botanical families were present in soybean. Monocots were more predominant over dicots during both years. The most important monocots were: *Acrachne racemosa* (Heyne ex Roem and Schult) Ohwi (poaceae); *Dactyloctenium aegyptium* (L.) P. Beauv. Willd; and *Cyperus rotundus* L. (cyperaceae). The most important dicots weeds were: *Digera arvensis* (L.) Forsk. (amaranthaceae) and *Phyllanthus niruri* (phyllanthaceae). Results indicated that weed density in no-tillage (NT) was significantly lower than conventional tillage (CT) in 2010 (Table 1), but weed density in 2011 and weed dry weight in both years were not significantly affected by tillage treatments. This showed that both CT and NT were more or less similar in their effect s on weeds in soybean. Significant difference was observed between herbicidal treatments with respect to weed population in 2010 and 2011. Lowest weed density after weed-free check was in tank-mix pre-emergence application of pendimethalin 0.5 kg/ha + imazethapyr 0.075 kg/ha. This herbicide treatment was superior to all other treatments with respect to weed control during both years. Arnold *et al*. (1993) observed an efficient broad-leaved weed control by imazethapyr applied as pre-plant incorporation or post-emergence. They highlighted that barnyardgrass (*Echinochloa crus-galli* (L.) Beauv.) control by imazethapyr ranged from 58 to 96%, and was increased to 98% when imazethapyr was combined with metolachlor, pendimethalin, trifluralin or EPTC. Weed dry matter was decreased significantly due to all herbicide treatments during both years (Table 1). After weed-free check, pendimethalin 0.75 kg/ha PE + HW at 30 DAS resulted in the lowest weed dry weight, but pendimethalin 0.5 kg/ha + imazethapyr 0.075 kg/ha PE was at par with it. The results are in conformity with Monsefi *et al.* (2011). Bhan and Kewat (2002) reported that pendimethalin was the most potent herbicide for effective weed control in soybean at 1.0 kg/ha, but its efficacy against weeds was reduced in heavy soils applied at the same dose. The dose played a role in this experiment, too. The dose of pendimethalin was reduced to 0.5 kg/ha in the tank-mixture compared to 0.75 or 1.0 kg/ha as usually recommended. This affected weed control slightly, but its mixture with imazethapyr 0.075 kg/ha could compensate this, might be due to synergistic action. Weed dry weight was the second highest in pendimethalin 0.75 kg/ha alone in both years. This necessitated the tank-mix application of pendimethalin and imazethapyr for better weed control in soybean. Chlorimuron-p-ethyl is recommended as an effective pre- or post-emergence herbicide in soybean (Behera *et al*., 2005; Das, 2008). But, its effect was less in this study, probably, due to mixture incompatibility.

Soybean yield attributes and yield

Number of pod/plant, seed/pod, 1000-seed weight and seed yield were not significantly affected by tillage treatments during both years (Table 2). This indicated that NT was as good as CT in producing these yield attributes and yield of soybean. The seed/pod of soybean was not significantly influenced by weed control treatments in either year, but weed free-check resulted in higher values. In 2011, metribuzin 0.3 kg/ha + imazethapyr 0.075 kg/ha resulted in significantly greater number of pod/plant, but pendimethalin 0.75 kg/ha + HW at 30 DAS, and pendimethalin 0.5 kg/ha + imazethapyr 0.075 kg/ha were comparable with it. Weedy check gave lowest number of pod/ plant followed by pendimethalin 0.75 kg/ha alone, and metribuzin 0.3 kg/ha + chlorimuron-p-ethyl 0.009 kg/ ha. Soybean 1000-seed weight was influenced by weed control treatments only in 2011, and all weed control measures exhibited higher seed weight than weedy check (Table 2). Pendimethalin 0.5 kg/ha + imazethapyr 0.075 kg/ha being comparable with weed-free check resulted in higher seed yield in both years. The results are in conformity with Monsefi *et al*. (2011). In this study, metribuzin applied with imazethapyr or chlorimuron-p-ethyl, and

Table 1. Weed density, weed dry weight, phytotoxicity score, weed control efficiency and weed index in soybean

Treatment	Phytotoxicity score at 15 DAS		Weed density (no./m^2) (60 DAS)		Weed dry weight (g/m^2) (60DAS)		Weed control efficiency (WCE)		Weed index (WI)	
	Weeds	Soybean	2010	2011	2010	2011	2010	2011	2010	2011
Tillage level										
Conventional tillage (CT)	6.67	1.21	5.9(36.7)*	7.4 (62.3)	7.0(68.1)	11.2(157.8)	67.15	53.87	16.40	31.98
No-Tillage (NT)	5.80	0.19	4.9(35.9)	6.3 (46.6)	6.5(61.5)	11.5(158.9)	41.43	64.21	17.53	25.97
SEm±	0.18	0.11	0.15	0.36	0.14	1.3	0.33	4.04	4.76	3.21
CD(P=0.05)	0.50	0.30	0.9	NS	NS	NS	1.98	NS	NS	NS
Weed Management										
Pendimethalin 0.75 kg/ha	5.13	0.0	4.6(20.7)	7.2(51.0)	9.7(95.3)	16.7(283.3)	46.1	56.0	26.60	44.55
Pendimethalin 0.5 kg/ha + imazethapyr 0.075 kg/ha	8.95	0.79	3.0(12.0)	6.0(37.0)	3.2(10.1)	9.9(108.45)	76.60	73.52	5.55	16.23
Pendimethalin 0.5 kg/ha + chlorimuron-p-ethyl 0.009 kg/ha	7.47	2.04	5.0(24.7)	7.0(50.0)	6.1(39.7)	11.4(141.9)	61.55	67.73	13.65	20.87
Metribuzin 0.3 kg/ha + imazethapyr 0.075 kg/ha	8.1	0.67	4.6(22.2)	7.6(60.7)	9.3(101.6)	11.4(186.1)	60.54	59.70	17.97	37.20
Metribuzin 0.3 kg/ha + chlorimuron-p-ethyl 0.009 kg/ha	6.58	1.83	6.7(47.3)	7.0(51.7)	7.9(63.7)	11.6(139.3)	42.62	72.17	16.83	23.92
Pendimethalin 0.75 kg/ha + hand weeding at 30 DAS	4.44	0.0	5.7(34.7)	8.9(79.3)	2.3(6.2)	9.3(87.9)	46.16	43.20	11.70	23.88
Weedy check	0.0	0.0 c	10.6(116.7)	10.3(106.0)	14.1(200.7)	17.9(320.0)	0.0	0.0	42.65	65.13
Weed-free check	9.53	0.0 c	0.7(0.0)	0.7(0.0)	0.7(0.0)	0.7(0.0)	100.0	100.0	0.0	0.0
SEm±	0.35	0.38	0.21	0.28	0.28	0.85	2.38	2.46	4.48	5.86
CD(P=0.05)	0.97	0.54	0.7	0.9	0.9	2.5	6.87	7.11	12.95	16.94

Table 2. Yield and yield attributes of soybean as influenced by tillage and tank-mix herbicide

Treatment	Plant/m²		Seeds/pod		Pods/plant		Test weight (g)		Seed yield (t/ha)	
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
Tillage level										
Conventional tillage (CT)	57.1	44.79	1.9	1.3	59.5	55.7	98.5	90.06	1.68	1.60
No-Tillage (NT)	53.3	43.75	1.8	1.3	57.4	61.6	93.75	88.21	1.74	1.61
SEm±	2.2	5.1	0.03	0.04	2.10	3.67	1.10	0.47	0.05	0.10
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Weed management										
Pendimethalin 0.75 kg/ha	59.17	39.6	1.9	1.3	58.7	54.4	95.57	80.94	1.50	1.25
Pendimethalin 0.5 kg/ha + imazethapyr 0.075 kg/ha	55.83	46.9	1.8	1.3	60.0	64.1	95.78	94.41	1.95	1.91
Pendimethalin 0.5 kg/ha + chlorimuron-p-ethyl 0.009 kg/ha	40.83	50.0	1.8	1.3	54.2	56.4	95.53	97.64	1.77	1.78
Metribuzin 0.3 kg/ha + imazethapyr 0.075 kg/ha	65.0	40.6	1.9	1.3	56.2	72.8	94.48	92.49	1.67	1.42
Metribuzin 0.3 kg/ha + chlorimuron-p-ethyl 0.009 kg/ha	70.0	49.0	1.9	1.3	58.7	53.2	94.68	83.0	1.70	1.71
Pendimethalin 0.75 kg/ha + hand weeding at 30 DAS	43.3	43.8	1.9	1.4	58.4	64.8	97.63	91.81	1.85	1.74
Weedy check	55.0	34.4	1.7	1.3	53.8	44.8	97.97	78.28	1.18	0.77
Weed-free check	52.5	50.0	1.9	1.4	67.5	59.0	97.30	94.53	2.05	2.26
SEm±	7.0	3.9	0.07	0.05	4.24	4.03	2.14	5.74	0.09	0.14
CD(P=0.05)	20.2	11.2	NS	NS	12.3	11.7	NS	16.62	0.26	0.40

pendimethalin with chlorimuron-p-ethyl proved slightly phytotoxic to soybean, although soybean recovered from this toxicity after 30 DAS. Antagonistic effect of metribuzin with sulfonylurea herbicides like chlorimuron-*p*-ethyl has been reported (Johnson *et al*., 2002). Poston *et al*. (2008) observed that metribuzin when applied at 694 g/ha reduced yield by 8 and 13%. In this study, the dose of metribuzin, therefore, was reduced to 0.3 kg/ha in mixtures.

Nutrients uptake

N, P and K uptake by soybean (Table 3) and weed (Table 4) were not affected by tillage treatments, indicating that NT and CT were at par with each other. In both years, pendimethalin 0.5 kg/ha + imazethapyr 0.075 kg/ha was comparable with weed-free check and resulted in higher N uptake by soybean. Similarly, P and K uptake in soybean was higher in this treatment than other weed control treatments in both years. Weeds had higher K uptake, but lower N and P uptake than that of soybean (Tables 3 and 4). Highest N, P and K uptake by weeds was observed in weedy check, and the lowest uptake, excluding weed-free check, in the tank-mix pre-emergence application of pendimethalin 0.5 kg/ha + imazethapyr 0.075 kg/ha in both years (Table 4). The results are in conformity with Kaur *et al*. (2010).

Protein yield

Results showed that both CT and NT did not differ significantly on protein content (%) as well as protein yield (kg/ha) of soybean seed in both years (Table 5). But, weed control treatments significantly influenced protein content (%) and protein yield (kg/ha) in both years. Among them, pendimethalin 0.5 kg/ha + imazethapyr 0.075 kg/ha in first year, while pendimethalin 0.5 kg/ha + chlorimuron-p-ethyl 0.009 kg/ha in second year resulted in higher protein content in soybean seed. Tank-mix pre-emergence application of pendimethalin 0.5 kg/ha + imazethapyr 0.075 kg/ha resulted in lower but comparable protein yield with weed-free check. It gave significantly higher protein yield compared to most other treatments in both years. This indicated that herbicides, particularly pendimethalin influenced protein content, although not significantly. The effect of pendimethalin on increasing protein content in green alga *Protosiphon botryoides* has been reported (Shabana *et al*., 2001).

Economics

Both NT and CT were comparable with each other on the yield attributes, yield and nutrient uptake of soybean crop. But, NT is less costly than CT. Therefore, it resulted in higher gross returns, net returns and net B:C than CT

Table 3. N, P and K uptake by soybean crop as influenced by tillage and tank-mix herbicide

Treatment	Total N, P and K uptake by soybean (kg/ha)					
	2010			2011		
	N	P	K	N	P	K
Tillage level						
Conventional tillage (CT)	138.1	17.9	59.4	136.6	19.0	55.7
No-Tillage (NT)	136.6	21.1	64.9	129.5	20.0	56.0
MSEm±	2.44	1.06	2.58	6.36	1.62	3.73
CD (P=0.05)	NS	NS	NS	NS	NS	NS
Weed management						
Pendimethalin 0.75 kg/ha	127.6	15.7	60.9	119.1	16.9	44.3
Pendimethalin 0.5 kg/ha + imazethapyr 0.075 kg/ha	169.0	25.0	72.4	150.1	22.2	62.2
Pendimethalin 0.5 kg/ha + chlorimuron-p-ethyl 0.009 kg/ha	145.9	18.6	58.1	155.4	21.9	66.9
Metribuzin 0.3 kg/ha + imazethapyr 0.075 kg/ha	139.3	16.9	66.7	123.7	18.5	55.8
Metribuzin 0.3 kg/ha + chlorimuron-p-ethyl 0.009 kg/ha	125.3	22.6	63.8	144.6	19.1	60.9
Pendimethalin 0.75 kg/ha + hand weeding at 30 DAS	137.8	18.3	63.7	132.5	20.7	57.5
Weedy check	95.75	14.3	48.3	71.1	11.5	26.9
Weed-free check	158.2	24.5	63.2	168.1	25.1	72.2
SEm±	8.17	1.44	4.36	9.88	1.42	3.54
CD(P=0.05)	24.52	4.19	12.62	28.63	4.11	10.24

Table 4. Nitrogen, P and K uptake by weed as influenced by tillage and tank-mix herbicide

Treatment	N, P and K uptake by weeds (kg/ha)					
	2010			2011		
	N	P	K	N	P	K
Tillage level						
Conventional tillage (CT)	15.23	1.65	12.37	20.11	2.32	17.00
No-Tillage (NT)	13.45	1.25	14.03	22.91	3.12	15.45
SEm±	2.30	0.15	2.96	2.36	0.33	3.05
CD (P=0.05)	NS	NS	NS	NS	NS	NS
Weed management						
Pendimethalin 0.75 kg/ha	38.37	2.47	23.62	32.95	3.28	28.38
Pendimethalin 0.5 kg/ha + imazethapyr 0.075 kg/ha	0.28	0.03	5.47	12.35	1.45	10.72
Pendimethalin 0.5 kg/ha + chlorimuron-p-ethyl 0.009 kg/ha	15.82	1.42	14.73	22.48	2.24	14.72
Metribuzin 0.3 kg/ha + imazethapyr 0.075 kg/ha	7.77	1.00	6.23	26.55	1.69	13.55
Metribuzin 0.3 kg/ha + chlorimuron-p-ethyl 0.009 kg/ha	11.10	1.00	15.0	14.47	1.69	11.08
Pendimethalin 0.75 kg/ha + hand weeding at 30 DAS	7.87	1.02	1.65	17.96	3.23	14.05
Weedy check	33.48	4.67	38.87	45.35	8.18	37.28
Weed-free check	0.0	0.0	0.0	0.0	0.0	0.0
SEm±	4.31	0.27	3.89	2.60	0.61	3.46
CD (P=0.05)	12.48	0.77	11.27	7.52	1.77	10.03

(Table 6). Similarly, tank-mix pre-emergence application of pendimethalin 0.5 kg/ha+ imazethapyr 0.075 kg/ha resulted in higher gross returns, net returns and net B:C than other weed control treatments.

It is concluded that the tank-mix pre-emergence application of pendimethalin 0.5 kg/ha+ imazethapyr 0.075 kg/ha was comparable with weed-free check on soybean seed yield and most of the yield attributes of soybean. The uptake of N, P and K by soybean was higher, whereas the uptake of N, P and K by weed was lower in this treatment among weed control treatments. Thus, a combination of no-tillage and tank-mix pre-emergence application of pendimethalin 0.05 kg/ha + imazethapyr 0.075 kg/ha may be recommended for better weed control and higher soybean yield.

Table 5. Seed protein percentage and protein yield in soybean as influenced by tillage and tank-mix herbicide

Treatment	Protein (%)		Protein yield (kg/ha)	
	2010	2011	2010	2011
Tillage level				
Conventional tillage (CT)	41.43	37.82	636.7	535.7
No-Tillage (NT)	39.68	37.12	634.8	549.6
SEm±	0.35	0.89	20.44	14.92
CD(P=0.05)	NS	NS	NS	NS
Weed management				
Pendimethalin 0.75 kg/ha	41.86	37.18	575.6	441.9
Pendimethalin 0.5 kg/ha + imazethapyr 0.075 kg/ha	42.64	35.88	762.6	641.5
Pendimethalin 0.5 kg/ha + chlorimuron-p-ethyl 0.009 kg/ha	41.80	39.82	671.4	639.7
Metribuzin 0.3 kg/ha + imazethapyr 0.075 kg/ha	42.15	38.44	648.3	474.7
Metribuzin 0.3 kg/ha + chlorimuron-p-ethyl 0.009 kg/ha	36.87	38.95	560.8	581.3
Pendimethalin 0.75 kg/ha + hand weeding at 30 DAS	39.49	34.70	667.6	494.0
Weedy check	38.12	37.27	419.0	301.3
Weed–free check	41.86	37.54	780.9	767.1
SEm±	1.53	1.57	45.5	46.0
CD (P=0.05)	NS	NS	132.1	133.2

Table 6. Cost of cultivation, gross returns, net returns and net benefit-cost ratio in soybean

Treatment	Total cost of cultivation ($\times 10^3$ ₹/ha)		Net returns ($\times 10^3$ ₹/ha)		Net B:C ratio	
	2010	2011	2010	2011	2010	2011
Tillage level						
Conventional tillage (CT)	15.5	17.1	11.5	13.6	0.74	0.80
No-Tillage (NT)	13.7	15.1	14.5	15.8	1.05	1.05
Weed management						
Pendimethalin 0.75 kg/ha	14.9	16.4	9.7	7.7	0.65	0.47
Pendimethalin 0.5 kg/ha + imazethapyr 0.075 kg/ha	16.2	17.8	15.3	18.5	0.94	1.04
Pendimethalin 0.5 kg/ha + chlorimuron-p-ethyl 0.009 kg/ha	17.1	18.8	11.2	15.6	0.65	0.83
Metribuzin 0.3 kg/ha + imazethapyr 0.075 kg/ha	16.3	17.9	11.0	9.7	0.68	0.54
Metribuzin 0.3 kg/ha + chlorimuron-p-ethyl 0.009 kg/ha	17.2	18.9	10.3	13.9	0.60	0.73
Pendimethalin 0.75 kg/ha + hand weeding at 30 DAS	16.8	18.5	12.6	14.8	0.75	0.80
Weedy check	13.7	15.1	5.7	-0.2	0.41	-0.01
Weed-free check	18.2	21.7	14.3	21.0	0.78	0.97

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