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ACCETCOMBINED EFFECT OF TILLAGE AND WEED CONTROL METHODS ON WEED DYNAMICS, GROWTH AND YIELD ATTRIBUTES OF CHICKPEA AFTER HARVEST OF SOYBEAN IN C.G. PLAINS

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ABSTRACT

A field experiment was conducted during *rabi* seasons of 2010-11 and 2011-12. Among the tillage management practices, better growth attributes as well as yield attributes were obtained with CT, which was followed by MT and ZT. Among the various weed management practices, growth and yield attributes were maximum under one HW at 20 DAS, followed by the treatments of POE application of imazethapyr @ 90 g ha^{-1}. The PE imazethapyr @ 80, 90, 100 g/ha was inefficient in effective control of weeds but at higher rate of POE application of imazethapyr @ 70, 80, 90 g/ha was effective but phytotoxic on chickpea. The weed density was lowest in conventional tillage during initial period, but, at later stages, weed population was lowest under zero tillage. One HW at 20 DAS, followed by POE application of imazethapyr @ 90 g ha^{-1} and POE imazethapyr @ 80 g ha^{-1} were most effective in reducing weed density, lowest WI and gave highest WCE. The results implied that CT with POE application of imazethapyr was found remunerative in soybean-chickpea cropping sequence. There is need to identify another POE herbicide for better weed control in chickpea.

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INTRODUCTION

Pulses are integral part of the cropping system because these crops fit well in the crop rotation and crop mixture and are most suited diversifying crops in cropping systems. The decreasing per capita availability of pulses from 69.0 g in 1961 to 35.9 g in 2004 has created an alarming situation calling for concerted and expeditious efforts in improving their productivity (*Moorthy and Dubey,* 2004). Chickpea (*Cicer arietinum* L.) ranks as the third most important annual major food grain legume in the world after dry bean and peas (Singh and Saxena, 1999). Global chickpea area is 10.94 M ha with Production of 8.59 M tones and Productivity of 786 kg ha^{-1}. It is also known as gram or chana and belongs to the leguminoceae family and mostly grown in rabi season (Oct-Nov to Feb-March). In India, chickpea is cultivated on 6.93 M ha with production of 5.60 M tonnes (GOI, 2007). In tropical, subtropical, and temperate regions of the country and in recent years, the area, production and productivity is in the increasing trend due to its profitability under rainfed conditions. But its poor productivity makes in non-competitive in comparison to present day high yielding varieties of cereals. In Chhattisgarh, chickpea is cultivated in an area of about 3.20 Lakh ha with an average production of 2.12 Lakh tonnes and productivity of 663 kg ha^{-1}. The average productivity of chickpea is still below one ton per hectare, which is considered low by any standards. Under irrigated conditions weeds are a potential threat to the crop reducing the yield by 40 to 87% under severe infestation (*Moorthy et al.,* 2003). Chickpea is a poor competitor to weeds because of slow growth rate and limited leaf area development at early stages of crop growth and establishment. Weed competition is considered as one of the most important causes of low productivity and inferior quality of chickpea in Chhattisgarh. Considerable yield losses in chickpea recorded to the extent of 88 per cent if weeds are not controlled within critical growth period (*Bhalla et al.,* 1998).

Tillage and/or herbicides are used for weed control, but the degree of control achieved may vary widely depending on weed species present, soil type, climatic condition, crop grown, tillage method and cropping system (*Unger et al.,* 1999). Rice-chickpea and Soybean-chickpea cropping system have been found to be the most remunerative (Chauhan, 2007). There is no registered Post-emergence herbicide with broad spectrum weed control is available at the moment. Imazethapyr 10% seems to be promising as it has been proved to be effective against number of leguminous oilseed and pulse crops.

Hence, it has the potential to control mixed weed flora when applied as Pre and Post-emergence. Performance of Imazethapyr in chickpea as Pre and Post-emergence has yet not been assessed in Chhattisgarh. The paper deals with the combined effect of tillage and weed control methods on weed dynamics, growth and yield attributes of chickpea after harvest of soybean.

MATERIALS AND METHODS

A field experiment to study the combined effect of tillage and weed control methods on weed dynamics, growth and yield attributes of chickpea cultivar *JG-226* after

harvest of soybean was carried out at the Research cum Instructional Farm of Indira Gandhi Krishi Vishwavidyalaya, Raipur during two consecutive *rabi seasons* of 2010-11 & 2011-12. The soil of experimental field was *clayey* in texture with neutral pH. The experiment was laid out in Split Plot Design with three replications (Gomez and Gomez 1984). The treatment comprised of Three tillage practices viz. conventional tillage (T_1), minimum tillage (T_2) and zero tillage (T_3) in main plot and nine weed management practices as pendimethalin @ 1000 g ha^{-1} PE (W_1), imazethapyr @ 80 g ha^{-1} PE (W_2), imazethapyr @ 90 g ha^{-1} PE (W_3), imazethapyr @ 100 g ha^{-1} PE (W_4) at 2 DAS, imazethapyr @ 70 g ha^{-1} POE (W_5), imazethapyr @ 80 g ha^{-1} POE (W_6), imazethapyr @ 90 g ha^{-1} POE (W_7) at 20 DAS, one hand weeding at 20 DAS (W_8) and weedy check (W_9), in sub plots. The chickpea seeded @ 80 kg ha^{-1} was sown with the space of 30 × 10 cm. Seeds were treated with Carbendazim @ 2 g kg^{-1} seeds and thereafter again treated with Rhizobium culture @ 5 g kg^{-1} seed before the sowing (Anonymous, 2012). The N, P, K through diamonium phosphate and muriate of potash were applied as basal at sowing of the crop. One protective irrigation gave at the time of sowing for establishment of optimum plant stand (Anonymous, 2012). The chickpea crop was sown in 2nd fortnight of November 2010 and 2011 and harvesting was done in 1st fortnight of March 2011 and 2012, respectively. The rainfall received during the cropping seasons of *rabi* 2010-11 and 2011-12 was 32.1 mm and 15.94 mm, respectively.

RESULTS AND DISCUSSION

Effect on growth attributes

The results revealed that at harvest stage, conventional tillage proved its supremacy over zero tillage and produced significantly taller plants, higher plant dry matter and number of branches/plant. Minimum tillage was also found better over zero tillage during both the years. Tomar and Singh (1991). Chand *et al*. (1993) and Singh *et al*. (1998) have also reported that conventional tillage produced taller plants than zero tillage.

Among weed management treatments at harvest stage, significantly taller plants, higher plant dry matter and number of branches/plant were recorded under the treatment of one hand weeding at 20 DAS (W_8) followed by application of imazethapyr @ 90 g ha^{-1} POE (W_7) over weedy check during both the years. This might be due to severe competition of weeds for growth resources, which made the crop plant inefficient to utilize their sources consequently affecting the growth. The reason for variation in plant height in different treatments may be due to the lower competition of weeds with crop for light, nutrients and space along with availability of water which allow the crop to grow to their potential. These results were in accordance with the findings of Hassan and Khan (2007). The lowest plant height was recorded in control plot at all the time intervals of observations which might be due to smothering effect of weeds.

More number of branches under this treatment might be due to less weed density, providing adequate space for horizontal spread of crop leading to higher number of branches and dry matter accumulation $plant^{-1}$. These results are in tune with Singh and Tripathi (2004). The horizontal spread in plants was more pronounced where imazethapyr was applied as post-emergence in higher doses i.e. 90, 80 and 70 g ha^{-1}, respectively, might be due to some hormonal effect of imazethapyr.

Effect on yield attributes

The various tillage and weed management practices showed significant impact in enhancing the number of pods/plant, seed yield, stover yield and harvest index during both the years. Among the various tillage practices, conventional tillage, proved to be more pronounced in increasing the yield significantly over zero tillage, but it was comparable with minimum tillage, which was next in order. different tillage and

Table 1: Growth and growth attributing characters of chickpea after harvest of soybean as influenced by different tillage and weed management practices (2010-11 and 2011-12)

Treatments	Growth attributing characters								
	Plant height			Plant dry matter			Number of branches/plant		
	2010-2011	2011-2012	Mean	2010-2011	2011-2012	Mean	2010-2011	2011-2012	Mean
Main Plot: Tillage management									
T_1 : Conventional	45.48	44.48	44.98	26.13	23.78	24.96	15.68	15.42	15.55
T_2 : Minimum	43.99	43.15	43.57	24.7	20.16	22.43	14.67	14.59	14.63
T_3 : Zero	40.27	39.98	40.13	22.11	18.09	20.1	13.22	13.22	13.22
S Em +	0.85	1.04		0.46	0.51		0.36	0.41	
CD (P = 0.05)	3.34	4.1		1.8	1.98		1.42	1.6	
Sub Plot: Weed management									
W_1 : Pendimethalin @ 1000 g/ha PE	40.45	40.76	40.61	22.19	19.22	20.71	12.82	11.8	12.31
W_2 : Imazethapyr @ 80 g/ha PE	39.73	37.89	38.81	21.28	17.97	19.63	11.82	11.51	11.67
W_3 : Imazethapyr @ 90 g/ha PE	42.49	40.66	41.58	22.54	20.18	21.36	13.22	13.51	13.37
W_4 : Imazethapyr @ 100 g/ha PE	43.1	42.26	42.68	23.67	20.68	22.18	14.16	14	14.08
W_5 : Imazethapyr @ 70 g/ha POE	44.66	45.28	44.97	26.16	22.47	24.32	15.87	15.82	15.85
W_6 : Imazethapyr @ 80 g/ha POE	46.09	46.09	46.09	27.89	22.88	25.39	17.33	16.36	16.85
W_7 : Imazethapyr @ 90 g/ha POE	47.76	47.41	47.59	28.33	23.67	26	17.9	17.98	17.94
W_8 : One hand weeding at 20 DAS	48.66	48.63	48.65	28.77	25.09	26.93	18.8	18.02	18.41
W_9 : Weedy Check	36.27	33.86	35.07	18.01	13.94	15.98	8.78	10.69	9.74
S Em +	1.19	1.61		0.49	0.72		0.56	0.61	
CD (P = 0.05)	3.39	4.59		1.39	2.04		1.59	1.73	

Table 2: Yield and yield attributing characters of chickpea after harvest of soybean as influenced by different tillage and weed management practices (2010-11 and 2011-12)

Treatments	Yield and yield attributing characters											
	Number of pods plant^{-1}			Test weight (g)			Grain yield (Kg ha^{-1})			Stover yield (Kg ha^{-1})		
	2010-2011	2011-2012	Mean	2010-2011	2011-2012	Mean	2010-2011	2011-2012	Mean	2010-2011	2011-2012	Mean
Main Plot: Tillage management												
T_1 : Conventional	42.26	40.15	41.21	15.65	15.33	15.49	1552.87	1406.78	1479.83	2115.77	1858.26	1987.02
T_2 : Minimum	39.22	37.26	38.24	15.56	15.25	15.41	1387.76	1264.47	1326.12	1842.03	1740.30	1791.17
T_3 : Zero	30.56	29.03	29.80	15.35	15.04	15.20	1280.06	1127.18	1203.62	1631.29	1521.38	1576.34
S Em +	0.93	0.87		0.20	0.19		42.30	39.73		51.59	48.16	
CD (P = 0.05)												
Sub Plot: Weed management	3.66	3.41		NS	NS		166.10	156.01		202.55	189.11	
W_1 : Pendimethalin @ 1000 g/ha PE	33.89	32.19	33.04	15.41	15.10	15.26	1363.22	1192.90	1278.06	1700.73	1520.62	1610.68
W_2 : Imazethapyr @ 80 g/ha PE	32.00	30.40	31.20	15.39	15.08	15.24	1262.48	1136.23	1199.36	1519.21	1387.77	1453.49
W_3 : Imazethapyr @ 90 g/ha PE	33.22	31.56	32.39	15.42	15.11	15.27	1371.74	1233.57	1302.66	1809.79	1604.43	1707.11
W_4 : Imazethapyr @ 100 g/ha PE	36.11	34.31	35.21	15.48	15.17	15.33	1419.89	1312.90	1366.40	1908.32	1781.09	1844.71
W_5 : Imazethapyr @ 70 g/ha POE	40.44	38.42	39.43	15.51	15.20	15.36	1494.33	1344.90	1419.62	2054.98	1840.62	1947.80
W_6 : Imazethapyr @ 80 g/ha POE	43.44	41.27	42.36	15.60	15.28	15.44	1559.81	1403.83	1481.82	2161.92	2031.58	2096.75
W_7 : Imazethapyr @ 90 g/ha POE	46.00	43.70	44.85	15.72	15.40	15.56	1604.70	1444.23	1524.47	2253.77	2126.71	2190.24
W_8 : One hand weeding at 20 DAS	50.56	48.03	49.30	15.86	15.54	15.70	1696.19	1526.57	1611.38	2403.12	2317.01	2360.07
W_9 : Weedy Check	20.44	19.42	19.93	15.29	14.98	15.14	889.70	800.13	844.92	955.45	749.97	852.71
S Em +	0.83	0.79		0.26	0.25		36.61	33.45		42.22	52.16	
CD (P = 0.05)	2.37	2.27		NS	NS		104.09	95.11		120.05	148.30	

Table: Harvest index (%) of chickpea after harvest of soybean as influenced by different tillage and weed management practices

Treatments	Harvest index (%)		
	2010-2011	2011-2012	Mean
Main Plot: Tillage management			
T_1 : Conventional	44.89	43.47	44.18
T_2 : Minimum	43.94	42.28	43.11
T_3 : Zero	43.10	41.54	42.32
S Em +	0.94	0.99	
CD (P = 0.05)			
Sub Plot: Weed management	3.71	3.88	
W_1 : Pendimethalin @ 1000 g/ha PE	42.12	40.08	41.10
W_2 : Imazethapyr @ 80 g/ha PE	41.93	39.99	40.96
W_3 : Imazethapyr @ 90 g/ha PE	42.51	41.39	41.95
W_4 : Imazethapyr @ 100 g/ha PE	43.82	42.29	43.06
W_5 : Imazethapyr @ 70 g/ha POE	45.22	43.53	44.38
W_6 : Imazethapyr @ 80 g/ha POE	46.22	44.36	45.29
W_7 : Imazethapyr @ 90 g/ha POE	47.15	45.57	46.36
W_8 : One hand weeding at 20 DAS	49.72	48.05	48.89
W_9 : Weedy Check	37.10	36.59	36.85
S Em +	1.54	1.60	
CD (P = 0.05)	4.37	4.56	

weed management practices did not show any significant impact on test weight during both the years. However, maximum test weight among various tillage practices was obtained with conventional tillage followed by minimum and zero tillage, respectively, during both the years.

Khattak and Khan (2005) stated that the type of ploughs had significant effect on seed yield per unit area of chickpea. Chisel plough once and tine cultivator three times surpassed mould board and disc harrow and gave 18.9% yield higher than no tillage treatment and this might be due to better control of weeds. Conventional tillage (one ploughing + 2 harrowings) produced significantly higher values of yield attributes and yield than zero tillage, might be due to improved rooting condition, better soil structure and aeration and more nutrient extraction which might have increase the values of yield attributes. Since crop yield is a function of number of pods/plant, grains/pod and 1000-grain weight, the higher values of these under conventional tillage might have an edge in manifestation of grain yield over zero tillage. More mobilization of photosynthates to grain under conventional tillage as a result of higher harvest index might have also led to increase of yield. Lopez-Bellido *et al.* (2003) and Izaurralde *et al.* (1993) also reported similar results. Tillage practices had no significant effect on seed yield of chickpea, though; the seed yield was slightly higher under conventional tillage than zero tillage was also reported by Singh *et al.* (2014).

The number of pods/plant, seed yield, stover yield, harvest index and test weight under non herbicidal treatments i.e. one hand weeding at 20 DAS (W_8) was found to be significantly higher over weedy check (W_9) and all other herbicidal treatments. Among different weed management treatments, the significantly highest pod yield was obtained under imazethapyr @ 90 g ha^{-1} POE (W_7), which was significantly superior over rest of the herbicidal treatments during both the

Table 3: Total weed population (m^{-2}) at different growth stages of chickpea crop after harvest of soybean as influenced by different tillage and weed management practices

Treatments	Total weed population m^{-2}											
	20 DAS			40 DAS			60 DAS			At Harvest		
	2010-11	2011-12	Mean	2010-11	2011-12	Mean	2010-11	2011-12	Mean	2010-11	2011-12	Mean
Main Plot: Tillage management												
T_1 : Conventional	13.42	11.28	12.35	12.86	11.41	12.14	13.96	12.59	13.28	14.69	13.65	14.17
T_2 : Minimum	14.01	11.93	12.97	11.95	10.83	11.39	13.10	11.84	12.47	14.28	13.00	13.64
T_3 : Zero	14.74	12.56	13.65	11.61	10.43	11.02	12.72	11.39	12.06	13.54	12.25	12.90
S Em +	0.23	0.26	-	0.19	0.19	-	0.24	0.26	-	0.26	0.31	-
CD (P = 0.05)												
Sub Plot: Weed management	NS	NS	-	NS	NS	-	NS	NS	-	NS	NS	-
W_1 : Pendimethalin @ 1000 g/ha PE	11.81	10.31	11.06	12.71	11.17	11.94	13.73	12.29	13.01	14.53	13.45	13.99
W_2 : Imazethapyr @ 80 g/ha PE	12.54	10.78	11.66	13.69	12.23	12.96	14.44	13.26	13.85	15.52	14.32	14.92
W_3 : Imazethapyr @ 90 g/ha PE	12.25	10.49	11.37	13.25	11.73	12.49	14.11	12.74	13.43	14.79	14.07	14.43
W_4 : Imazethapyr @ 100 g/ha PE	12.00	10.26	11.13	12.69	11.21	11.95	13.83	12.20	13.02	14.32	13.65	13.99
W_5 : Imazethapyr @ 70 g/ha POE	15.56	12.94	14.25	11.39	10.42	10.91	12.68	11.49	12.09	13.75	12.04	12.90
W_6 : Imazethapyr @ 80 g/ha POE	15.51	12.86	14.19	10.38	9.45	9.92	11.83	10.63	11.23	12.78	11.42	12.10
W_7 : Imazethapyr @ 90 g/ha POE	15.47	12.79	14.13	10.04	9.14	9.59	11.36	10.28	10.82	12.46	11.02	11.74
W_8 : One hand weeding at 20 DAS	15.64	13.37	14.51	7.75	7.18	7.47	9.02	7.92	8.47	10.11	8.71	9.41
W_9 : Weedy Check	15.74	13.51	14.63	17.38	15.49	16.44	18.35	16.62	17.49	19.24	18.03	18.64
S Em +	0.30	0.29	-	0.18	0.25	-	0.28	0.23	-	0.26	0.19	-
CD (P = 0.05)	0.85	0.81	-	0.52	0.70	-	0.79	0.65	-	0.74	0.55	-

Table 4: Total dry weight of weeds (m^{-2}) of chickpea crop after harvest of soybean at different growth stages as influenced by different tillage and weed management practices

Treatments	Total weed dry matter m^{-2}											
	20 DAS			40 DAS			60 DAS			At Harvest		
	2010-11	2011-12	Mean	2010-11	2011-12	Mean	2010-11	2011-12	Mean	2010-11	2011-12	Mean
Main Plot: Tillage management												
T_1 : Conventional	7.48	6.53	7.01	8.41	7.8	8.11	10.28	9.12	9.70	13.55	11.78	12.67
T_2 : Minimum	7.73	6.83	7.28	8.1	7.52	7.81	9.82	8.84	9.33	13.12	11.52	12.32
T_3 : Zero	7.96	7.04	7.50	7.86	7.22	7.54	9.45	8.31	8.88	12.35	11.12	11.74
S Em +	0.14	0.14	-	0.15	0.11	-	0.22	0.09	-	0.21	0.25	-
CD (P = 0.05)												
Sub Plot: Weed management	NS	NS	-	NS	NS	-	NS	NS	-	NS	NS	-
W_1 : Pendimethalin @ 1000 g/ha PE	6.49	5.49	5.99	8.34	7.81	8.08	10.21	8.98	9.60	13.85	12.13	12.99
W_2 : Imazethapyr @ 80 g/ha PE	6.91	5.91	6.41	8.93	8.32	8.63	10.89	9.57	10.23	14.48	12.78	13.63
W_3 : Imazethapyr @ 90 g/ha PE	6.73	5.73	6.23	8.69	8.09	8.39	10.69	9.39	10.04	13.98	12.53	13.26
W_4 : Imazethapyr @ 100 g/ha PE	6.49	5.52	6.01	8.48	7.92	8.20	10.49	9.09	9.79	13.74	12.32	13.03
W_5 : Imazethapyr @ 70 g/ha POE	8.57	7.67	8.12	7.82	7.17	7.50	9.64	8.38	9.01	13.16	11.05	12.11
W_6 : Imazethapyr @ 80 g/ha POE	8.53	7.62	8.08	7.53	6.74	7.14	8.96	8.01	8.49	12.47	10.72	11.60
W_7 : Imazethapyr @ 90 g/ha POE	8.49	7.58	8.04	7.24	6.47	6.86	8.57	7.72	8.15	11.76	10.28	11.02
W_8 : One hand weeding at 20 DAS	8.62	7.81	8.22	5.44	5.02	5.23	6.41	5.88	6.15	7.98	7.31	7.65
W_9 : Weedy Check	8.69	7.85	8.27	10.63	10.08	10.36	12.78	11.78	12.28	15.66	14.16	14.91
S Em +	0.12	0.1	-	0.12	0.12	-	0.16	0.13	-	0.18	0.17	-
CD (P = 0.05)	0.34	0.29	-	0.34	0.35	-	0.45	0.38	-	0.5	0.49	-

years.

This result may be due to the less competition at critical periods of crop growth and better suppression of weeds, which allowed the crop to grow to their potential by absorbing sufficient nutrients, light, moisture and space which facilitate more translocation of photosynthates towards the reproductive parts as well as presence of favourable agro-climatic conditions due to removal of weeds, led to more number of pods $plant^{-1}$. Similar results have been reported by Patel *et al*. (2006). The treatment of hand weeding at 20 DAS recorded significantly higher number of pods per plant followed by post-emergence application of imazethapyr 90 and 80 g ha^{-1} recorded significantly higher number of pods per plant respectively, might be due to effective control of weeds at critical crop-weed competition stages which have helped in increasing nutrient uptake and there by the crop growth and formation of bold seeds and consequently increase in the weight of 100 seeds. Results are in accordance with the findings of Ahalawat *et al*. (1978) and Vaishya *et al*. (1996). These results are in close conformity with those reported by Singh *et al*. (2003) and Azad *et al*. (2003). Kayan and Adak (2005) stated that hand hoeing was more effective than herbicide application in terms of reducing weed population and increasing chickpea yield. Similar findings were reported by Patel *et al*. (2006). The lowest stover yield was recorded under weedy check plot (W_9). It may be due to the fact that weeds if allowed to grow freely may reduce the growth of crop by sharing with the plant for moisture, nutrient and radiation which ultimately result in the low dry matter production of the crop. It was also partly due to relatively higher growth of weeds in this treatment among the other treatments.

Effect on weed dynamics

In the soybean-chickpea experimental field, at harvest stage, infestation percentage of different weed species i.e. *Chenopodium album* (11%), *Medicago denticulata* (22%), *Brachiaria ramosa* (16%), *Echinochloa colona* (16%), *Euphorbia geniculata* (18%) and some other weeds (17%)

Plate 1: General view of experiment-1 Soybean-Chickpea

and in a rice-chickpea experimental field, at harvest, weed infestation percentage of weeds i.e. *Chenopodium album* (17%), *Medicago denticulata* (40%), *Echinochloa colona* (23%) *and* other weed species (20%) was noted and dominance of above weed species was observed throughout the crop growth period. Rao, A.S. (2008) noticed that the experimental field of black gram grown as relay crop was dominated by natural infestation of *Echinochloa colonum* which constituted 80% of total weed population. Singh *et al.* (2014) found that *Medicago denticulata, Chenopodium album, Melilotus indica,* were the predominant weeds in the experimental field of IGKV, Raipur in chickpea crop.

Various tillage practices did not affect the total weed population and dry matter of weeds significantly at all the growing periods during both the years. At harvest stage, the lower total weed population and dry matter was observed under zero tillage, which was narrowly followed by minimum and conventional tillage in ascending order, during both the years. Vaishaya *et al.* (1995) stated that conventional tillage produced minimum weeds biomass than zero tillage system. This might be due to the fact that weeds were not left for germination or were destroyed after germination due to repeated ploughing. Tillage practices also had no significant effect on dry matter production of weeds at any stage. Dry matter was marginally lower under zero tillage than conventional tillage. Similar findings were reported by Singh *et al.* (2014).

Various herbicidal and non herbicidal treatments significantly affected the total weed population and dry matter of weeds at all the growth stages. At harvest stage, one hand weeding at 20 DAS was significantly superior over weedy check (W_9) and other treatments and gave lowest total weed dry matter of weeds. Among different herbicidal treatments, imazethapyr @ 90 g ha^{-1} POE (W_7) was effective in reducing the total weed dry matter of weeds as compared to weedy check (W_9) and other herbicidal treatments except imazethapyr @ 80 g ha^{-1} POE (W_6), which was comparable to imazethapyr @ 90 g ha^{-1} POE (W_7), during both the years. Production of dry matter by total species and other weed species was observed significantly higher under untreated control (W_9), which was due to absence of suitable weed management, which leads to accumulation of more dry matter in weeds upto harvest and significantly minimum production of dry matter under treatment one hand weeding twice at 20, throughout the period of investigation. Similar results were observed by Aslam *et al.* (2007), Butlar *et al.* (2008), Chaudhary *et al.* (2011), who reported that the highest weed density and dry weight of weeds was recorded in control plot. Chaudhary *et al.* (2005) found the lowest number and dry weight of total weeds was due to weeding at 20 and 40 days after sowing.

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