Madras Agric. J., 99 (1-3): 81-86, March 2012
https://doi.org/10.29321/MAJ.10.100020

Effect of Imazathypr on Weed Control and Yield in Chickpea Under *Kandi* belt of Low Altitude Sub-tropical Zone of Jammu

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Field experiment was conducted at Pulses Research Sub-Station, Samba, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu during *Rabi* 2010-11 to find out effect of post-emergence (POE) herbicide imazathypr along with cultural weed control and weedy check on yield, yield attributes of chickpea under rainfed conditions. Twelve treatments consisting of three doses of the POE herbicide (Imazathypr) at 3 different durations (10, 20 & 30 days after germination-DAG) along with weedy check (control), hand weeding and weed free treatment were tested in randomized block design. The results revealed that significant reduction in total weed density and weed biomass were observed in treatments *viz.* two hand weedings (25-30 and 50-55 DAG) and imazathypr @ 20 g ha^{-1} at 30 DAG which in turn were at par but superior than weedy check treatment and hence resulted in significant improvement in yield attributing characters *viz.* no. of pods plant^{-1}, no. of seeds pod^{-1}, seed index, dry-weight plant^{-1} and seed yield than the other treatment combinations and weedy check treatment during the period under study. The yield and yield attributes were highly negatively correlated with weed infestation.

Keywords: Chickpea, herbicides, imazathypr, weed control efficiency, weed index, yield

Chickpea is the most important pulse crop of India sharing 29.7 and 38 per cent of the total area and production of total pulses, respectively (Chand *et al*., 2010). It is grown as rainfed crop under monocropping system in Jammu and Kashmir State. In the State, it is grown in about 4300 hectares with a production of 2550 tonnes and productivity of 593 kg ha^{-1} (Singh *et al*., 2010). Weed infestation is one of the major constraints for low yield of chickpea. Weeds compete with the crop for the essentials of growth, interfere with the utilization of land and water resources, and thus, adversely affect the grain yield. The losses caused by weeds exceed the losses from any other category of agricultural pests. In India, weeds are responsible for about 33 per cent of total crop loss amounting to Rs. 1980 crore per annum (Kulshrestha and Parmar, 1992). Simultaneous emergence and rapid growth of weeds along with chickpea crop in the fields caused severe weed-crop competition in early stage. Weeds reduce grain yield of chickpea up to 60 per cent (IIPR, 1997).

In *kandi* areas of Jammu region, farmers do not follow chemical weed control in pulses, except for 5-10 per cent farmers who use pre-emergence herbicides followed by one or two hand-weedings. But, to bridge the gap between actual and potential levels of production of pulses, an effective weed control measure has to be found out so as to reduce the drudgery of farmers and also to save time. On small-scale farms, in developing countries more than 50 percent of labour time is devoted to weeding, manually by the women and children in the farmers' family (Ellis-Jones *et al*., 1993 and Akobundu, 1996). Chickpea is not very widely spaced crop, but is more prone to suffer yield loss due to its slow growth during the whole cropping period and limited lateral spread provides opportunity for growth of weeds right from its initial to later stages. The conventional method of weed control in chickpea is time consuming, expensive and labourious. It is more favourable to use herbicides due to non-availability of human labour resource during peak crop season (Dungarwal *et al*., 2002). Farmers are using pre-emergence herbicides only in chickpea, but there is a need of post-emergence herbicide to control weeds in chickpea and to reduce human labour. Pre planting and pre emergence herbicides barely affect the weeds germinated during the late seedling stage in winter sown chickpea. So, farmers need a post-emergence herbicide to control weeds without affecting the crop (Ceylan and Toker, 2006). Therefore, control of the weeds by using herbicides is the only alternative to manage the weeds thereby increasing the yield of chickpea. Therefore, application of post-emergence herbicide along with hand-weeding in combination or in sequence can be more beneficial. Keeping in view these facts, the present investigation was undertaken to test the performance of post-emergence herbicide for providing weed control during critical period of crop-

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weed interference in chickpea under *kandi* belt of Jammu.

Materials and Methods

The field experiment was conducted during *rabi* 2010-11 at Pulses Research Sub-Station, Samba, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu (32^0 $34^/$ N, 70^0 $83^/$ E, 330 m amsl). Twelve weed control treatments comprising of *viz*., T_1: weedy check (control); T_2: Hand-weeding (HW) at 25-30 and 50-55 days after germination (DAG); T_3: weed free; T_4: imazathypr @ 10 g ha^{-1} at 10 DAG; T_5: imazathypr @ 10 g ha^{-1} at 20 DAG; T_6: imazathypr @ 10 g ha^{-1} at 30 DAG; T_7: imazathypr @ 15 g ha^{-1} at 10 DAG; T_8: imazathypr 15 g ha^{-1} at 20 DAG; T_9: imazathypr 15 g ha^{-1} at 30 DAG; T_{10}: imazathypr 20 g ha^{-1} at 10 DAG; T_{11}: imazathypr 20 g ha^{-1} at 20 DAG and T_{12}: imazathypr 20 g ha^{-1} at 30 DAG were evaluated in randomized block design with three replications. The soil of the experimental site was sandy loam, having 0.32 % organic carbon, 21.2 kg ha^{-1} available P and 286 kg ha^{-1} available K. The chickpea variety *GNG-469* was sown on 1st December, 2010 and harvested on 12nd May, 2011 in *rabi* 2010-11. Recommended dose of fertilizers (20 kg N and 50 kg P ha^{-1}) was applied to the chickpea crop at the time of sowing through diammonium phosphate (DAP). The rainfall received during the cropping season *rabi* 2010-11 was 285.9 mm in 11 rainy days. Weed population and dry-weight were taken at 70 DAG and at maturity stage of chickpea crop using quadrate method. The weed population was then counted into narrow and broad leaved weeds and weighed by transforming into g m^{-2} by using the appropriate formula. Growth, yield parameters and yield of chickpea was recorded. Square root transformation (“x+0.5) was used to analyze the data on weed count and subsequently of weed dry matter. Weed control efficiency was worked out at 70 DAG and at harvest. It was expressed as the percentage reduction in weed density due to weed management practices over control. It was worked by using weed density present in control and treated plots (Mani *et al*., 1973).

$$WCE = \frac{WDC - WDT}{WDC} \times 100$$

Where:

WCE: Weed control efficiency

WDC: Weed dry matter in control

WDT: Weed dry matter in treatment

Weed index (WI) was worked out by using grain yield of weed free check and the treatment (Gill and Vijay Kumar, 1966).

$$WI = \frac{X - Y}{X} \times 100$$

Where:

X = grain yield of weed free check

Y = grain yield of treatment

The other ratios were calculated as per the formulae given below (Devasenapathy *et al.,* 2008)

$$\text{Crop Resistance Index (CRI)} = \frac{\text{Dry matter prod of the crop in the treatment plot}}{\text{Dry matter prod in control}} \times \frac{\text{Dry matter prod of weed in control plot}}{\text{Dry matter prod of weed in treatment plot}}$$

$$\text{Weed Management Index (WMI)} = \frac{\text{Per cent yield over control}}{\text{Per cent control of weed}}$$

Results and Discussion

Effect on weeds

The experimental field was infested with *lolium spp*., *daucas carota*, *anagallis arvensis*, *cynadon dactylon*, *sorghum halepense*, *chenopodium album*, *etc*. The highest density of narrow (NLW) and broad leaved weeds (BLW) (8.33 and 11.33 m^{-2}) and total weed biomass (6.89 and 7.18 g m^{-2}) at 70 days after germination (DAG) and at harvest were recorded in weedy check plots (Table 1), whereas, the lowest total weed density (3.77 and 4.27 m^{-2}) and total weed biomass (2.37 and 2.56 g m^{-2}) were recorded under weed free (T_3) at 70 DAG and harvest, respectively, followed by two HW at 25-30 and 50-55 DAG with weed density and total weed biomass values of 4.15 and 4.73 m^{-2} and 2.37 and 2.56 g m^{-2}, at 70 DAG and harvest, respectively and were comparable. All the treatment combinations of POE application of imazathypr significantly lowered the weed density and dry matter of weeds as compared to weedy check. Among the various weed control treatment combinations; POE application of imazathypr @ 20 g ha^{-1} at 30 DAG registered the lowest total weed density (4.60 and 4.80 m^{-2}) and weed biomass (3.58 and 3.78 g m^{-2}) at 70 DAG and harvest, respectively, followed by two HWs at 25-30 and 50-55 DAG and POE application of imazathypr @ 20 g ha^{-1} at 20 DAG. Higher efficacy and long lasting effects of imazathypr in reducing weed dry matter (upto 85 per cent) might be primarily appeared due to broad-spectrum activity of herbicide particularly on established plants of both narrow and broad leaf weeds. Likewise, Papiernik *et al*. (2003) also recommended use of imazathypr chemical in legumes which inhibit acetohydroxy acid synthase and the synthesis of branched chain amino acids.

Table 1. Weed density, weed dry weight and weed control efficiency in chickpea under different weed management treatments

Treatment	Weed density (No. m^{-2})						Total weed biomass ($g\ m^{-2}$)		WCE (%)	
	70 DAG			At Harvest						
	NLW	BLW	Total weeds	NLW	BLW	Total weeds	70 DAG	At Harvest	70 DAG	At Harvest
T_1	8.33 (69)	11.33 (128)	14.05 (197)	8.73 (76)	11.67 (136)	14.56 (212)	6.89 (47.2)	7.18 (51.3)	—	—
T_2	2.72 (07)	3.22 (10)	4.15 (17)	3.06 (09)	3.67 (13)	4.73 (22)	3.32 (10.6)	3.62 (12.7)	77.5	76.4
T_3	2.51 (06)	2.89 (08)	3.77 (14)	3.07 (09)	3.07 (09)	4.27 (18)	2.37 (5.2)	2.56 (6.1)	88.9	88.1
T_4	5.68 (32)	5.76 (330	8.06 (650	5.93 (35)	6.40 (41)	8.75 (76)	6.13 (37.4)	6.54 (42.6)	20.8	16.9
T_5	3.67 (13)	4.91 (24)	6.09 (37)	3.34 (11)	5.51 (30)	6.44 (41)	4.99 (24.5)	5.19 (26.5)	48.1	48.3
T_6	3.07 (09)	4.93 (24)	5.76 (33)	3.34 (11)	5.31 (28)	6.25 (39)	4.77 (22.4)	4.86 (23.2)	52.5	54.8
T_7	5.85 (34)	6.41 (41)	8.66 (75)	6.18 (38)	6.71 (45)	9.10 (83)	5.94 (35.2)	6.29 (39.3)	25.4	23.4
T_8	3.66 (13)	3.79 (14)	5.22 (27)	3.93 (150	4.16 (17)	5.68 (32)	4.59 (20.7)	4.81 (22.8)	56.2	55.6
T_9	3.52 (12)	3.66 (13)	5.03 (25)	3.79 (14)	4.01 (16)	5.48 (30)	3.77 (13.9)	4.01 (15.7)	71.8	69.4
T_{10}	3.22 (10)	4.52 (20)	5.50 (30)	3.38 (11)	4.91 (24)	5.95 (35)	4.52 (20.1)	4.79 (22.6)	57.4	55.9
T_{11}	2.34 (05)	4.17 (17)	4.74 (22)	2.73 (07)	4.49 (20)	5.23 (27)	3.69 (13.2)	3.90 (14.8)	72.1	71.2
T_{12}	3.51 (12)	3.06 (09)	4.60 (21)	3.51 (12)	3.36 (11)	4.80 (23)	3.58 (12.4)	3.73 (13.6)	73.7	73.5
Mean	4.01	4.89	6.30	4.25	5.27	6.77	4.55	4.79		
CD (P=0.05)	0.66	0.68	0.81	0.47	1.01	0.79	0.77	0.26		
SE (m)	0.22	0.23	0.27	0.16	0.34	0.27	0.26	0.09		
CV (%)	9.60	8.10	7.50	6.40	11.20	6.80	9.90	3.10		

DAG- Days after germination, NLW- Narrow leaved weeds; BLW- Broad leaved weeds, WCE- Weed Control Efficiency,
Figures in parentheses are original values and outside are transformed (“x+0.5) values

Weed control efficiency

The highest value of weed control efficiency (Table 1 and Fig 1) was recorded under weed free (88.9 and 88.1 per cent), followed by two HW at 25-30 and 50-55 DAG (77.5 and 76.4 per cent) and

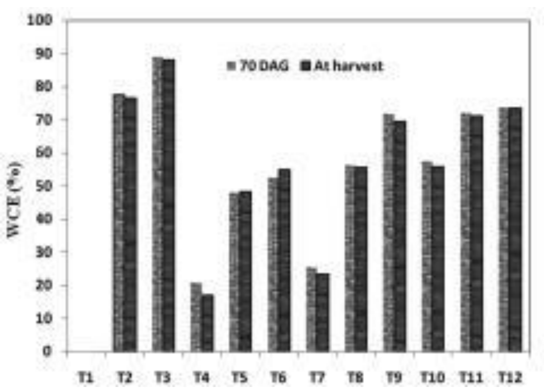

Fig 1. Effect of post emergence and cultural weed management practices on weed control efficiency (%) at 70 DAG and at harvest in chickpea in *rabi* 2010-11

POE application of imazathypr @ 20 g ha^{-1} at 30 DAG (73.7 and 73.5 per cent), at 70 DAG and harvest, respectively which were statistically on par. Singh and Chandel (1995) also reported higher WCE with 2 hand weedings. Likewise, Vyas and Jain (2003) also observed greater values of WCE with the application of imazathypr in soybean crop. The results were confirmed by the findings of Kantar *et al*. (1999) where 84.6 per cent weed biomass was controlled with application of imazathypr.

Growth parameters

Manual and herbicidal weed control methods significantly influenced the periodic dry matter accumulation (Table 2) in chickpea crop at an interval of 30 DAG. The maximum dry matter (30.2, 63.5, 109.4, 146.5 and 190.3 g m^{-2}) was accumulated under weed free (T_3) at 30, 60, 90, 120 DAG and at harvest and was followed by statistically similar treatments; *viz.,* two HW at 25-30 and 50-55 DAG and POE application of imazathypr @ 20 g ha^{-1} at 30 DAG. The minimum accumulation of dry matter was observed in weedy check treatments.

Table 2. Effect of post-emergence herbicidal and manual weed management treatments on growth parameters of chickpea during *Rabi* 2010-11

Treatment	Dry-weight (g m^{-2}) DAG					Crop growth rate (g m^{-2} day^{-1}) DAG				
	30	60	90	120	At Harvest	30	60	90	120	At Harvest
T_1	18.92	39.75	65.23	92.36	119.02	0.63	0.69	0.85	1.24	0.89
T_2	29.29	61.53	106.58	141.84	184.21	0.98	1.07	1.50	1.84	1.41
T_3	30.27	63.58	109.47	146.58	190.36	1.01	1.11	1.53	1.90	1.46
T_4	20.52	43.09	70.63	99.34	129.01	0.68	0.75	0.92	1.29	0.99
T_5	21.59	45.35	73.82	104.55	135.78	0.72	0.79	0.95	1.36	1.04
T_6	22.73	47.76	77.21	110.10	142.99	0.76	0.83	0.98	1.43	1.10
T_7	21.10	44.32	72.36	102.16	132.68	0.70	0.77	0.93	1.33	1.02
T_8	25.12	52.77	84.26	121.65	157.99	0.84	0.92	1.05	1.58	1.21
T_9	26.30	55.24	87.73	127.34	165.38	0.88	0.96	1.08	1.65	1.27
T_{10}	23.80	50.12	80.36	115.27	149.70	0.79	0.88	1.01	1.50	1.15
T_{11}	27.17	57.06	90.30	131.55	170.85	0.91	1.00	1.11	1.71	1.31
T_{12}	28.32	54.50	93.72	137.16	178.13	0.94	1.07	1.31	1.78	1.37
Mean	24.60	51.26	84.31	119.53	154.68	0.82	0.89	1.10	1.55	1.18
CD (P= 0.05)	6.47	5.57	7.34	9.06	9.01	0.22	0.22	0.20	0.38	0.36
SE (m)\	2.19	1.89	2.50	3.07	2.37	0.07	0.07	0.08	0.13	0.12

DAG- Days after germination

All weed management practices had a significant role in CGR at all the developmental stages; *viz.,* 30, 60, 90, 120 DAG and at harvest. CGR increased from the initial stage towards reproductive stage (90-120 DAG) and thereafter it decreased. The maximum values of CGR were

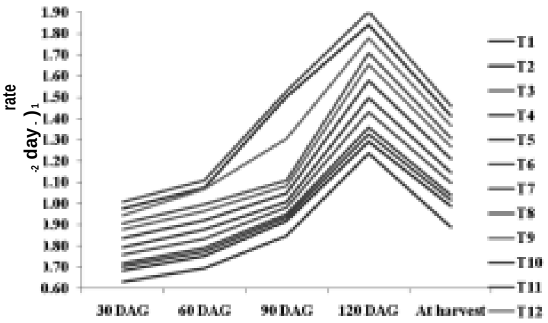

Fig. 2. Crop growth rate (g m^{-2} day^{-1}) as affected by different weed management treatments in chickpea during *rabi* 2010-11

found under weed free, two HWs at 25-30 and 50-55 DAG and POE application of imazathypr @ 20 g ha^{-1} at 30 DAG with the corresponding values of 1.90, 1.84 and 1.78 g m^{-2} day^{-1}, respectively at 120 DAG (Table 2 and Fig 2).

Effect on Crop

Weed control treatments in chickpea crop had significant positive impact on yield and all yield attributing characters (Table 3). Significantly lower values of plant height (27.3 cm), no. of pods $plant^{-1}$ (5.3), no. of seeds pod^{-1} (1.10), seed-index (23.6 g), dry-weight $plant^{-1}$, grain & straw yield (440.70 & 749.50 kg ha^{-1}) were recorded under weedy check and the highest values for these parameters were observed in weed free which was followed by

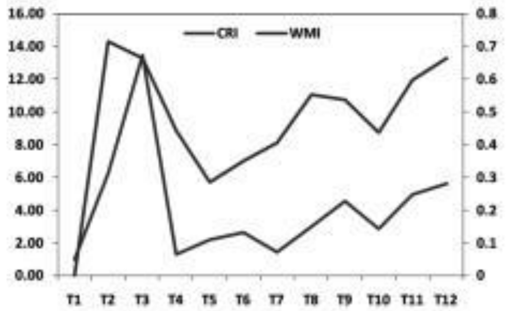

Fig 3. Effect of various weed management treatments on crop resistance index (CRI) and weed management index (WMI) in chickpea during *rabi* 2010-11

statistically similar treatments; *viz.,* two hand weedings (HW) at 25-30 and 50-55 DAG and the treatment POE application of imazathypr @ 20 g ha^{-1} at 30 DAG and was superior to all other treatment combinations of imazathypr herbicide with lower doses at different intervals of time. Values of yield and yield attributes obtained under different treatments with the application of imazathypr @ 10 and 15 g ha^{-1} at 10, 20 and 30 DAG were statistically significant over the weedy check, but the values were not on par with the values obtained with imazathypr @ 20 g ha^{-1} at 30 DAG. Nelson and Renner (1999) reported that imazathypr gave grain yield statistically equal to the hand-weeded plots in soybean crop.

Grain yield recorded with imazathypr @ 20 g ha^{-1} when applied at 10, 20 and 30 DAG was 24.4, 42.6 and 48.9 per cent higher over weedy check and 27.5, 11.2 and 6.5 and 24.3, 8.4 and 3.8 per cent lower than weed free and two HW at 25-30 and 50-55 DAG treatments, respectively. Nelson *et al*. (1999) also observed that the effective control of both monocot and dicot weeds could be well done with the application of imazathypr. Kay and McMillan

Table 3. Yield and yield attributing parameters of chickpea as affected by post-emergence herbicidal and manual weed management treatments during *Rabi* 2010-11

Treatment	Plant Height (cm)	No. of pods plant^{-1}	No. of seeds pod^{-1}	Seed index (g)	Dry-wt. plant^{-1}	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	% increase over control	Weed index
T_1	27.3	5.3	1.10	23.6	6.57	440.70	749.50	—	36.94
T_2	36.4	14.5	1.56	40.1	8.53	681.30	1160.80	54.6	2.52
T_3	37.8	15.7	1.63	40.7	8.71	698.90	1204.70	58.6	—
T_4	28.2	8.1	1.23	26.7	6.87	473.90	816.20	7.5	32.19
T_5	29.8	9.9	1.25	28.5	7.07	501.60	856.20	13.8	28.23
T_6	30.6	10.7	1.26	29.1	7.29	525.30	904.60	19.2	24.84
T_7	29.2	8.5	1.25	27.9	6.98	482.60	844.20	9.5	30.95
T_8	32.4	12.5	1.36	33.7	7.74	576.50	1003.40	30.8	17.51
T_9	33.6	13.4	1.44	35.9	7.96	604.90	1048.90	37.3	13.45
T_{10}	31.3	11.5	1.27	31.9	7.49	548.30	948.70	24.4	21.55
T_{11}	34.8	13.9	1.44	36.7	8.13	628.30	1080.20	42.6	10.10
T_{12}	35.3	14.2	1.48	37.9	8.34	656.40	1124.90	48.9	6.08
Mean	32.2	11.52	1.36	36.11	7.64	568.23	978.53		
CD (P=0.05)	4.1	1.2	NS	2.7	0.21	49.43	69.44		
SE(m)	1.4	0.4	0.1	0.9	0.07	16.70	23.52		

(1990) also reported higher seed yield with Imazathypr application in chickpea; whereas, Kantar *et al*. (1999) observed 63.6 per cent higher seed yield over unweeded check with application of imazathypr.

The lowest value of weed index (Table 3) was observed in two HWs at 25-30 and 50-55 DAG to the tune of 2.52 and was followed by POE application of imazathypr @ 20 g ha^{-1} at 30 and 20 DAG (6.08 and 10.10), respectively. The highest weed index (36.94) was recorded under weedy check.

Table 4. Correlation matrix between weed population, total weed biomass with growth, yield and yield attributing characters

	Plant Height (cm)	No. of pods plant^{-1}	No. of seeds pod^{-1}	Seed index (g)	Dry-wt. plant^{-1}	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})
Weed population (70 DAG)	-0.22	-0.92**	-0.80**	-0.83**	-0.81**	-0.81**	-0.81**
Weed population (at harvest)	-0.22	-0.91**	-0.79**	-0.83**	-0.81**	-0.81**	-0.81**
Weed biomass (70 DAG)	-0.25	-0.98**	-0.95**	-0.96**	-0.97**	-0.96**	-0.97**
Weed biomass (at harvest)	-0.25	-0.98**	-0.94**	-0.95**	-0.96**	-0.95**	-0.96**

The highest Crop Resistance Index (CRI) was obtained under weed free treatment with the corresponding value of 13.45 and was followed by 2 HWs at 25-30 and 50-55 DAG (6.25) and POE application of imazathypr @ 20 g ha^{-1} at 30 and 20 DAG with the corresponding values of 5.65 and 4.98, respectively (Fig. 3). Maximum Weed Management Index (WMI) was recorded with two HW at 25-30 and 50-55 DAG (0.71), which was followed by weed free treatment and POE application of imazathypr @ 20 g ha^{-1} at 30 DAG having the similar value (0.67).

Relationship between weed population and growth and yield parameters

Weed population under *kandi* belt also affected biological yield and grain yield in chickpea crop. The weed population at 70 DAG and at harvest reduced biological yield of chick pea crop with the rate of -

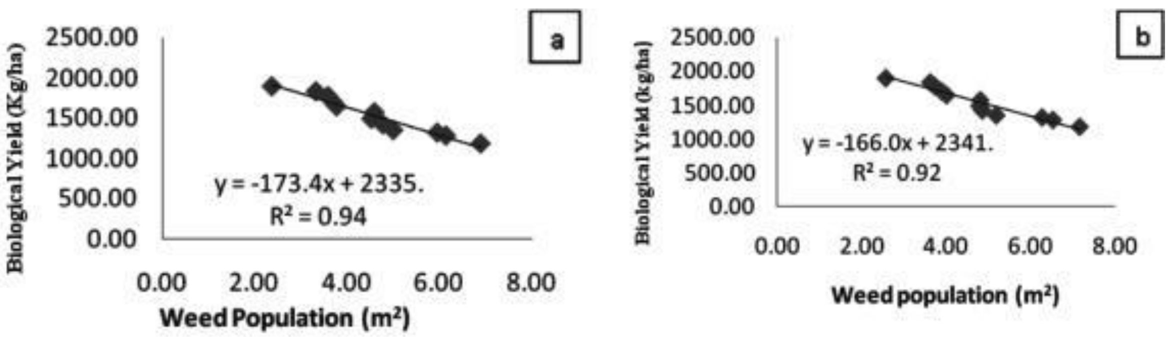

Fig 4. Relationship between weed population and Biological Yield (kg/ha) at (a) 70 DAG and (b) at Harvest

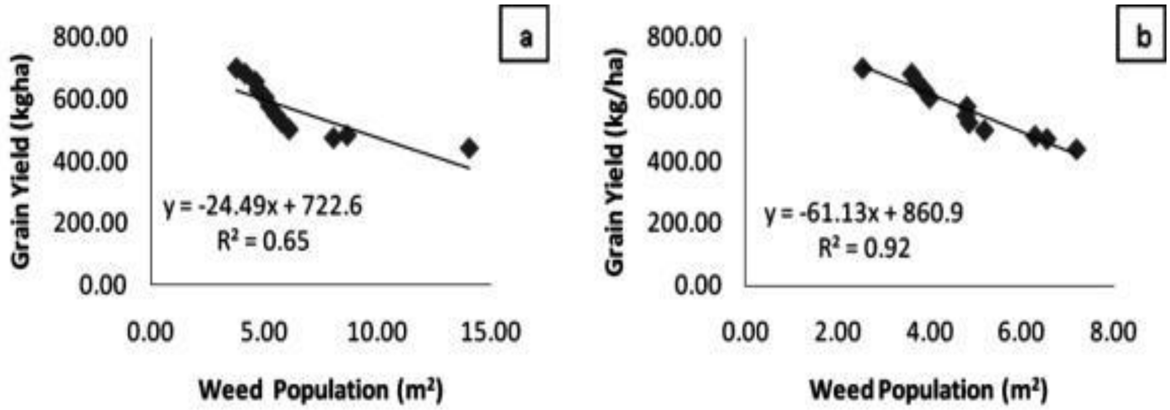

Fig 5. Relationship between weed population and Grain Yield (kg/ha) at (a) 70 DAG and (b) at Harvest

173.4 and -166.0 kg ha^{-1} with an accuracy of 94 and 92 percent, respectively (Fig 4 a and b). The weed population at 70 days after germination in chickpea crop affected more as compared to weed population at harvest due to competition of water and other nutrients between chickpea plants. But in case of grain yield, it is vice versa; *i.e.* the weed population at harvest (-61.13 kg ha^{-1}) was affected more as compared to weed population at 70 days after germination (-24.49 kg ha^{-1}) with an accuracy of 92 and 65 percent, respectively (Fig 5 a and b) due to less accumulation of assimilates in grain and hence taken by weeds.

Correlation matrix

Weed population and weed biomass are negatively correlated with growth, yield and yield attributes (Table 4). Plant height of chickpea crop is not significantly correlated with weed population and weed biomass at 70 DAG and harvest. Various yield attributing characters like no. of pods plant^{-1}, no. of seeds pod^{-1}, seed index and dry weight (g plant^{-1}) were highly negatively correlated with weed infestation. The grain and biological yield were also highly negatively correlated with weed population and weed biomass both at 70 DAG and harvest. The weed biomass was much more correlated with yield and yield attributes.

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Received: September 19, 2011; Accepted: February 20, 2012