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Evaluation of pre and post emergence herbicides in chickpea (*Cicer arietinum* L.)

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Abstract
A field experiment entitled "Evaluation of pre and post emergence herbicides in chickpea (*Cicer arietinum* L.)" was carried out during *rabi* season of 2016 at the Instructional Farm, Department of Agronomy, College of Agriculture, JAU, Junagadh. The experiment comprising 12 treatments was laid out in randomized block design with three replications. The results revealed that next to the weed free treatment, significantly higher values of growth parameters *viz*., plant height, number of branches/plant and leaf SPAD value, yield attributes and yield *viz*. number of pods/plant along with seed yield and stover yield were recorded with application of Oxyfluorfen 0.18 kg ha^{-1} as pre-emergence *fb* Pre-mix (Imazamox + Imazethapyr) 0.03 kg ha^{-1} post-emergence at 40 DAS and Two HW at 20 and 40 DAS. Besides, weed free condition, Oxyfluorfen 0.18 kg ha^{-1} as pre-emergence *fb* Pre-mix (Imazamox + Imazethapyr) 0.03 kg ha^{-1} post-emergence at 40 DAS and Two HW at 20 and 40 DAS were found more effective in reducing the weed population up to harvest and resulted in less dry weight of weeds, lower weed index and higher weed control efficiency and herbicidal efficiency index. The highest net return of ₹ 72040 ha^{-1} was realized with Oxyfluorfen 0.18 kg ha^{-1} as PE *fb* Pre-mix (Imazamox + Imazethapyr) 0.03 kg ha^{-1} PoE at 40 DAS followed by the treatments Weed free and Two HW at 20 and 40 DAS. However, the highest BCR of 3.54 was obtained with the treatment Oxyfluorfen 0.18 kg ha^{-1} as PE *fb* Pre-mix (Imazamox + Imazethapyr) 0.03 kg ha^{-1} PoE at 40 DAS.

Keywords: Chickpea, Herbicide, Hand weeding, Pre and Post emergence herbicides

1. Introduction
India is the largest producer of chickpea in the world. In India, chickpea or gram ranks 5th among grain crops, and is one of the most important pulse crop. In India and Pakistan, a chickpea is consumed locally, and about 56% of the crop is retained by growers. It accounts for 61% of the total area and 66% of total production in the world. In India chickpea represents 32% (6.42 M ha) of total pulse area and 49% (5.47 Mt) of total pulse production. (Nadarajan, 2011). In India, cultivated area of chickpea was 102.2 lakh ha and annul production was 98.8 lakh tones, productivity was 967 kg ha^{-1}. In Gujarat cultivated area 1.36 lakh ha and annul production is 1.33 lakh, productivity of chickpea is 978 kg ha^{-1} (Anon., 2015) [1].

Simultaneous emergence and rapid growth of weed lead to severe weed-crop competition for light, moisture, space and nutrients resulting in drastic reduction in yield. Yield losses varied between 40 to 94 % (Bhan and Kukula, 1987) [2]. Another study shows that weeds cause 40-90 % seed yield losses in chickpea (Solh and Pala, 1990) [2]. Whish *et al.* (2002) [16] narrated that loss in chickpea yield and yield components increased with increasing density of weeds. Even low weed densities of <10 plants m^2 caused large (approx 50%) reduction in yield and more yield losses in wider row spacing.

The field of chemical weed control is practically unexplored, particularly in Gujarat. The cultivators are not aware of proper doses of herbicides, time of application and their economics. Several selective herbicides are available in the market which is considered to be effective for particular crop. The farmers have to make decision about the selection of right type of herbicide.

Judicious use of herbicides in crop land, generally result in:-
(1) Increase in crop yield.
(2) Improvement in crop quality.
(3) Reduction of production costs.

Weed emergence with the *rabi* sown chickpea crop creates a severe competition unless controlled timely and effectively.

Inter-row cultivation is not sufficient and inter-row hand weeding is necessary under most conditions. There is, therefore an urgent need to move from the costly manual mechanical weed control to chemical weed control. The present study was undertaken to see the evaluation of pre and post emergence herbicides and to find out the environment friendly, safe and economical herbicides to control weeds in chickpea.

2. Materials and methods

The field experiment entitled "Evaluation of pre and post emergence herbicides in chickpea (*Cicer arietinum* L.)" was conducted during *rabi* season of the year 2015-16. The soil of the experimental plot was clayey in texture and slightly alkaline in reaction with pH 8.0 and EC 0.56 dS m^{-1}. The soil was low in available nitrogen (248 kg ha^{-1}), high in available phosphorus (37 kg ha^{-1}) and medium in available potash (272 kg ha^{-1}). Twelve weed management treatments comprising of T_1(Pendimethalin 0.90 kg ha^{-1} as pre-emergence *fb*1 HW at 40 DAS), T_2 (Oxyfluorfen 0.18 kg ha^{-1} as pre-emergence *fb*1 HW at 40 DAS), T_3 (Quizalofop-ethyl 0.040 kg ha^{-1} as post-emergence at 20 DAS *fb* 1 HW at 40 DAS), T_4 (Pre-mix (Imazamox + Imazethapyr) 0.03 kg ha^{-1} post-emergence at 20 DAS *fb* 1 HW at 40 DAS), T_5 (Pendimethalin 0.90 kg ha^{-1} as pre-emergence *fb* Quizalofop-ethyl 0.040 kg ha^{-1} as post-emergence at 40 DAS), T_6 (Pendimethailin 0.90 kg ha^{-1} as pre-emergence *fb* Pre-mix (Imazamox + Imazethapyr) 0.03 kg ha^{-1} post-emergence at 40 DAS), T_7 (Oxyfluorfen 0.18 kg ha^{-1} as pre-emergence *fb* Quizalofop-ethyl 0.040 kg ha^{-1} as post-emergence at 40 DAS), T_8 (Oxyfluorfen 0.18 kg ha^{-1} as pre-emergence *fb* Pre-mix (Imazamox + Imazethapyr) 0.03 kg ha^{-1} post-emergence at 40 DAS), T_9 (HW at 20 DAS), T_{10} (Two HW at 20 and 40 DAS), T_{11} (Weed free) and T_{12} (Unweeded check) were tried under randomized block design with three replications. The pre-emergence applications of herbicides were applied after sowing and post-emergence at 20 and 40 DAS using water 500 l ha^{-1}. The improved variety 'Chickpea GG-5' was sown at 45 cm row spacing by bullock drawn seed drill at third week of November. The fertilizer dose of 20-40 kg N-P_2O_5/ha in form of Urea and Diammonium Phosphate was applied to the crop just before sowing. Gap filling were carried out at 25-30 DAS to maintain intra-row spacing of 10 cm.

3. Results and discussion

1. Growth parameters

The data pertaining to the effect of different treatments on Growth parameters are presented in Table 1.At 30, 60 DAS and at harvest, maximum plant height was recorded under weed free (T_{11}), but it was found statistically at par with treatments T_8 (Oxyfluorfen 0.18 kg ha^{-1} as PE *fb* Pre-mix (Imazamox + Imazethapyr) 0.03 kg ha^{-1} PoE at 40 DAS) and T_{10} (Two HW at 20 and 40 DAS). Minimum plant height was recorded under treatment T_{12} (Unweeded control). At 60 DAS and at harvest, maximum number of branches per plant was recorded under weed free (T_{11}), but it was found statistically at par with treatments T_8 (Oxyfluorfen 0.18 kg ha^{-1} as PE *fb* Pre-mix (Imazamox + Imazethapyr) 0.03 kg ha^{-1} PoE at 40 DAS) and T_{10} (Two HW at 20 and 40 DAS). Maximum SPAD meter value at 15 and 30 days after spray was recorded under weed free (T_{11}), but it was found statistically at par with treatments T_8 (Oxyfluorfen 0.18 kg ha^{-1} as PE *fb* Pre-mix (Imazamox + Imazethapyr) 0.03 kg ha^{-1} PoE at 40 DAS) and T_{10} (Two HW at 20 and 40 DAS), while, Minimum plant height, number of branches and SPAD meter reading were recorded under treatment T_{12} (Unweeded control).

The higher values of growth parameters viz., plant height and number of branches per plant registered under treatments T_{11} (weed free), T_{10} (2 HW at 20 and 40 DAS) and T_8 (Oxyfluorfen 0.18 kg ha^{-1} as PE *fb* Pre-mix (Imazamox + Imazethapyr) 0.03 kg ha^{-1} PoE at 40 DAS) and maximum SPAD meter reading mainly ascribed to better control of weeds through application of pre and post emergence herbicide and hand weeding thus, increase water and nutrient uptake, which might have accelerated photosynthetic rate, thereby increasing the supply of carbohydrates, resulted in increased cell division, multiplication and elongation leading to increased plant height and number of branches. These findings are in agreement with those of Singh *et al.* (2003) [11], Vyas and Jain (2003) [15], Kachhadia *et al.* (2009) [6], Mishra *et al*. (2013) [8] and Poonia *et al*. (2013) [9].

2. Yield and Yield Attributes

The yield and yield attributes as influenced by different weed control treatments recorded at harvest is obtainable in Table 1. The enhanced yield and yield attributes under treatments T_{11} (weed free), but it was found significantly at par with T_8 (Oxyfluorfen 0.18 kg ha^{-1} as PE *fb* Pre-mix (Imazamox + Imazethapyr) 0.03 kg ha^{-1} PoE at 40 DAS) and T_{10} (2 HW at 20 and 40 DAS) might be due to early season control of weeds by application of pre emergence herbicides and at later stage by post emergence herbicide as evidenced by less number of weed (Table 4.8 to 4.13) and dry weight of weeds (Table 4.14), which might have maintained high soil fertility status and moisture content by means of less removal of plant nutrients and water through weeds. This might have increased nutrients and water uptake by the crop leading to increased rate of photosynthesis. Supply of photosynthates to various metabolic sinks might have favoured yield and yield attributes. The superiority of these treatments could be explained on the basis of better growth and higher uptake of nutrients under these practices might have produced more photosynthates and converted into numerous metabolites needed for such yield and yield attributes. The lowest value of yield and yield attributes viz., number of pods per plant, seed yield and stover yield under treatment T_{12} (unweeded control). These findings are in close conformity with those reported by Vyas and Jain (2003) [15], Kachhadia *et al.* (2009) [6], Upadhyay *et al*. (2012) [12], Mishra *et al*. (2013) [8], Rajib *et al*. (2014) [10] and Mamta *et al*. (2016) [7].

3. Weed parameters

A perusal of data (Table 2.) showed that the Dry weight of weeds, Weed index, Weed control efficiency and Herbicidal efficiency index was significantly influenced by different treatments. Except weed free (T_{11}), significantly the lowest dry weight of weeds and weed index was observed under the treatment T_8 (Oxyfluorfen 0.18 kg ha^{-1} as PE *fb* Pre-mix (Imazamox + Imazethapyr) 0.03 kg ha^{-1} PoE at 40 DAS) followed by T_{10} (2 HW at 20 and 40 DAS). Next to weed free (T_{11}), significantly higher weed control efficiency and herbicidal efficiency index was obtained under treatment T_8 (Oxyfluorfen 0.18 kg ha^{-1} as PE *fb* Pre-mix (Imazamox + Imazethapyr) 0.03 kg ha^{-1} PoE at 40 DAS) followed by T_{10} (2 HW at 20 and 40 DAS). The lowest weed population observed under this treatment due to weed free condition maintained by hand weeding as when needed and early season control of weeds by application of pre emergence herbicides and at later stage by post emergence herbicide. In addition to

this, dense crop canopy might have suppressed weed growth and ultimately less weed population. The findings are in conformity with those reported by Vyas and Jain (2003) [15], Kachhadia *et al.* (2009) [6], Upadhyay *et al*. (2012) [13], Goud *et al*. (2013) and Rajib *et al*. (2014) [10].

4. Economics

The effect of different weed management treatments was found significant on gross returns, net returns and B: C ratio of chickpea (Table 2.)Economics point of view, significantly highest gross returns, net returns was obtained under the weed free treatment (T_{11}) followed by T_8 (Oxyfluorfen 0.18 kg ha^{-1} as PE *fb* Pre-mix (Imazamox + Imazethapyr) 0.03 kg ha^{-1} PoE at 40 DAS) and T_{10} (Two HW at 20 and 40 DAS). Whereas, significantly higher B: C ratio was obtained under T_8 (Oxyfluorfen 0.18 kg ha^{-1}as PE *fb* Pre-mix (Imazamox + Imazethapyr) 0.03 kg ha^{-1} PoE at 40 DAS).The findings are in conformity with those reported by Upadhyaya and Bhalla (2002) [14], Chaudhary *et al*. (2011) [4], Upadhyay *et al*. (2012) [13] and Bhutada and Bhale (2015) [3].

Table 1: Effect of different treatments on growth, yield attributes and yield of chickpea.

Treatments	Plant height (cm)			No. of branches per plant		Leaf SPAD meter value at			Pods per plant	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})
	At 30 DAS	At 60 DAS	At harvest	At 60 DAS	At harvest	Before spray	15 days after spray	30 days after spray			
T_1	21.33	28.67	32.33	5.33	6.33	54.00	62.67	67.00	55.33	2268	2638
T_2	23.00	30.00	34.33	6.00	7.00	54.67	63.00	68.33	61.67	2361	2646
T_3	22.22	30.33	34.85	6.33	8.00	52.67	59.67	63.33	61.00	2175	2500
T_4	16.22	28.19	30.33	4.33	6.00	53.67	61.67	62.67	58.67	2037	2361
T_5	19.67	29.53	33.33	5.00	7.67	56.00	63.00	64.33	52.67	2083	2453
T_6	23.67	28.54	34.37	6.67	8.00	56.00	61.67	65.33	61.33	2453	2690
T_7	21.78	30.33	35.00	5.67	7.67	54.67	63.00	66.00	55.33	2175	2592
T_8	27.05	33.33	38.33	7.00	9.33	56.67	67.00	73.00	66.00	2731	3194
T_9	14.33	30.04	34.00	5.33	7.67	54.00	62.33	65.33	58.00	1990	2407
T_{10}	26.63	33.27	37.71	7.33	9.67	55.33	65.33	72.33	66.33	2546	2916
T_{11}	28.31	34.33	40.00	7.67	10.33	57.67	69.00	75.33	69.67	2916	3240
T_{12}	11.11	27.67	29.67	4.00	5.33	53.33	54.00	55.00	46.00	1851	2175
S.Em. ±	1.20	1.22	1.43	0.29	0.42	1.12	1.79	2.06	2.21	137	181
CD at 5 %	3.52	3.59	4.20	0.86	1.25	NS	5.26	6.05	6.51	404	532
CV %	9.78	7.00	7.2	8.7	9.6	3.56	4.95	5.38	6.48	10.39	11.85

Table 2: Effect of different treatments on weed parameters and economics.

Treatments	Dry weight of weed (kg ha^{-1})	Weed Index (%)	Weed control efficiency (%)	Herbicidal efficiency index	Gross return (₹ ha^{-1})	Cost of cultivation (₹ ha^{-1})	Net return (₹ ha^{-1})	BCR
T_1	190	22.03	82.19	1.26	83337	30079	53258	2.77
T_2	194	18.77	81.78	1.51	86604	29330	57274	2.95
T_3	223	25.27	78.90	0.83	79875	29260	50615	2.72
T_4	526	29.83	50.77	0.20	74836	27889	46947	2.68
T_5	276	28.23	74.16	0.48	76584	28915	47669	2.65
T_6	206	15.97	80.70	1.68	89890	28744	61146	3.12
T_7	253	25.36	76.52	0.75	80013	28681	51332	2.78
T_8	83	6.67	92.23	6.11	100376	28336	72040	3.54
T_9	271	31.57	74.46	-	73260	27688	45572	2.65
T_{10}	84	12.57	92.20	-	93484	30762	62722	3.03
T_{11}	00	-	100.00	-	106920	38447	68473	2.78
T_{12}	1073	59.19	-	-	68047	25707	42340	2.64
S.Em. ±	28.94	-	-	-	-	-	-	-
CD at 5 %	84.89	-	-	-	-	-	-	-
CV %	17.79	-	-	-	-	-	-	-

Treatment details

T_1 = Pendimethalin 0.90 kg ha^{-1} as pre-emergence *fb*1 HW at 40 DAS, T_2 = Oxyfluorfen 0.18 kg ha^{-1} as pre-emergence *fb*1 HW at 40 DAS, T_3 = Quizalofop-ethyl 0.040 kg ha^{-1} as post-emergence at 20 DAS *fb* 1 HW at 40 DAS, T_4 = Pre-mix (Imazamox + Imazethapyr) 0.03 kg ha^{-1} post-emergence at 20 DAS *fb* 1 HW at 40 DAS, T_5 = Pendimethalin 0.90 kg ha^{-1} as pre-emergence *fb* Quizalofop-ethyl 0.040 kg ha^{-1} as post-emergence at 40 DAS, T_6 = Pendimethailin 0.90 kg ha^{-1} as pre-emergence *fb* Pre-mix (Imazamox + Imazethapyr) 0.03 kg ha^{-1} post-emergence at 40 DAS, T_7 = Oxyfluorfen 0.18 kg ha^{-1} as pre-emergence *fb* Quizalofop-ethyl 0.040 kg ha^{-1} as post-emergence at 40 DAS, T_8 = Oxyfluorfen 0.18 kg ha^{-1} as pre-emergence *fb* Pre-mix (Imazamox + Imazethapyr) 0.03 kg ha^{-1} post-emergence at 40 DAS, T_9 = HW at 20 DAS, T_{10} = Two HW at 20 and 40 DAS, T_{11} = Weed free and T_{12} = Unweeded check.

4. Conclusion

On the basis of the results of the present one year field study, it can be concluded that effective and economically viable weed management ongrowth**,** yield attributes, yield and quality of chickpea under South Saurashtra Agro-climatic Zone can be achieved by application of Oxyfluorfen 0.18 kg ha^{-1} as pre-emergence *fb* Pre-mix (Imazamox + Imazethapyr) 0.03 kg ha^{-1} post-emergence at 40 DAS. Alternatively,

maintaining the crop weed free throughout crop growth period OR adopting Two HW at 20 and 40 DAS days after sowing can be employed according to availability of labourers.

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