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Grassy weed management through suitable post-emergence herbicides in Clusterbean [*Cyamopsis tetragonoloba* (L.) Taub.]

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Abstract
The field experiment was conducted during *kharif,* 2015 at Research farm, College of Agriculture, Gwalior (M.P.) to test the effect of different post emergence herbicides against grassy weeds mainly *Cyperus rotundus, Dactyloctenium aeyptium*, *Leptochloa chinensis,* and *Eragrostis minor sp.* in clusterbean. The experiment was laid out in "RBD" with ten treatments, replicated thrice. The treatments comprised of post–emergence grass weed killer; cycloxydim at 75, 100 and 125 g/ha with adjuvant and without adjuvant, Quizalofop-ethyl @ 37.5 g and Fenoxoprop-ethyl @ 100 g, these treatments were compared with two hand weeding at 20 and 40 DAS and weedy check. All herbicides applied at 3–4 leaf stage (around 20 DAS). Treatment T_9 Weed Free check was found best by recording highest values of yield attributes, seed (2.097 tonne/ha), stover (6.568 tonne/ha) with maximum weed control efficiency at successive stages. Among different herbicides treatments, T_7 Quizalofop-ethyl @ 37.5 g recorded lowest weed population/m^2, weed biomass and dry weight of grassy weeds with maximum weed control efficiency at 60 DAS (85.52 %) and minimum WI (19.56) and showed highest values of yield attributes i.e 43.30 pods/plant, 8.04 seed/pods followed by T_8 Fenoxoprop-ethyl @ 100 g and T_4 Cycloxydim @ 75 g a.i./ha + MSO Adjuvent @ 2ml/l of water. While Treatment T_6 Cycloxydim @ 125 g a.i./ha + MSO Adjuvent @ 2ml/l of water which is at par with T_4 Cycloxydim @ 75 g a.i./ha + MSO Adjuvent @ 2ml/l showed minimum population of *Leptochloa chinensis* as compared to other treatments. In monetary terms, it may be concluded that, among different post emergence herbicides T_7 Quizalofop-ethyl @ 37.5 g a.i./ha (PoE) gave significantly highest net return and B:C ratio (70597.5 Rs/ha and 5.40).

Keywords: Cluster bean, Cycloxydim, Quizalofop-ethyl, Post emergence herbicide

1. Introduction
Guar (*Cyamopsis tetragonoloba*) is an important cash crop in rainfed, especially in semi arid and arid regions of India. It is annual arid and semi-arid legume crop grown during *Kharif* season in India. The term guar has been evolved from the common use of the crop and its residue as cattle feed "Gowahaar (Gow means cow and Ahaar mean feed). Guar plant produces a cluster of flower and pods, therefore, it is also known as cluster bean. Guar is a drought resistant plant which belongs to the family leguminaceae and subfamily Papilionaceae and is known to improve soil fertility. Root nodules contain nitrogen-fixing bacteria and incorporation of crop residues improves soil fertility and productivity. Its well-developed tap root system make it drought hardy plant.

India alone contributes more than 80% of global guar production. Its cultivation in India is concentrated in northwestern states namely Rajasthan, Haryana, Gujarat and Madhya Pradesh. Guar is a natural source of nano-particles of hydrocolloids (substance that forms thick solution at low concentration with water). Guar beans have a large endosperm that contains galactomannon gum, a substance which forms a gel in water and is known as guar gum having main commercial value.

Weeds pose most serious problem in legume crops because of the liberal use of farm yard manure, chemical fertilizers and frequent irrigations that help the weeds to grow vigorously. It has been well established that losses from weeds accounts for 45 per cent more than when compared to insect pests and diseases of about 30 and 20 per cent, respectively (Rao, 1983) [5]. Cluster bean has low productivity of 380 kg/ha on account of variety of production constraints. Being a rainy season crop, it suffers badly due to severe competition by mixed weed flora. Yield reduction due to weed infestation is to the tune of 53.7% has been observed

(Saxena *et al*. 2004) [6]. Season long competition with weeds in clusterbean causes severe yield reduction ranging from 29-48 per cent and severity may even be higher (70-98%) depending on the weed infestation. Reports indicate that in the absence of any other inputs, weed control alone is responsible to increase the seed yield by 68 per cent (Yadav *et al.*, 1993) [12] at Bawal and 61 per cent (Yadav *et al.*, 1991a) [10] at Hisar. Therefore, weed control needs to be restored to exploit the yield potential of this crop. In the last four decades, considerable development have been made in chemical weed control. Adoption of chemical weed control is increasing crop return by reducing the cost of production. However, information is lacking on the kind of herbicide, time, rate and method of application. Residual effects on the succeeding crop are asking in our country.

In view of the above facts, the present study entitled, "Grassy weed management through suitable post-emergence herbicides in Clusterbean [*Cyamopsis tetragonoloba* (L.) Taub.]" was undertaken.

Materials and Methods

A field experiment was conducted during the *kharif* season of 2015, was conducted under AICRP on Arid legumes at the Research Farm, of College of Agriculture Gwalior. Geographical conditions of experimental field, Gwalior was 26º13' N latitude, 78º14' East longitude and 206 m above mean sea level. The soil was silty-clay-loam with pH 7.4 and EC 0.23 dS/m, being low in organic carbon (0.37%) and available nitrogen (165.93 kg/ha), medium in available phosphorus (20.35 kg/ha) and high in available potassium (395.20 kg/ha). The experiment was laid out in randomized block design with 3 replications. There were 10 treatments, viz. T_1: Cycloxydim @ 75 g a.i./ha, T_2: Cycloxydim @ 100 g a.i./ha, T_3: Cycloxydim @ 125 g a.i./ha, T_4: Cycloxydim @ 75 g a.i./ha + MSO Adjuvent @ 2ml/l of water, T_5: Cycloxydim @ 100 g a.i./ha + MSO Adjuvent @ 2ml/l of water, T_6: Cycloxydim @ 125 g a.i./ha + MSO Adjuvent @ 2ml/l of water, T_7: Quizalofop-ethyl @ 37.5 g a.i./ha (PoE), T_8: Fenoxoprop-ethyl @ 100 g a.i./ha (PoE), T_9: Weed Free check, T_{10}: Weedy check., The recommended dose of N, P_2O_5 and K_2O were applied @ 20, 40 and 20 kg/ha, respectively for the crop. Nitrogen, phosphorus and potassium were applied through urea, single super phosphate (SSP) and muriate of potash (MOP).respectively All the doses of fertilizers were applied as basal (at the time of sowing). 'HG 563' was used as variety of clusterbean in this experiment. Prior to sowing, the field was well layout and prepared as per the standard procedure. Sowing was done on 22th July, 2015, seed was sown @ 20 kg/ha and sowing was done manualy at a depth of 1.5 - 2.0 cm.

Weed control efficiency (%) and Weed index (%): were computed based on the following formula:

$$\text{W.C.E.} = \frac{(\text{Dry weight of weed in control plot} - \text{Dry weight of weeds in treated plot})}{(\text{Dry weight of weeds in control plot})} \times 100$$

$$\text{Weed index (W.I.)} = \frac{(\text{Yield in weed } \textit{free} \text{ plot} - \text{Yield in treated Plot})}{(\text{Yield in weed free plot})} \times 100$$

The data pertaining to weed population recorded at 20, 40, 60 DAS and harvest were subjected to Log (X+1) and $\sqrt{x + 0.5}$ transformations as per requirement for statistical analysis. Data were analyzed as per standard procedure with 5% probability level. Five clusterbean plants were randomly sampled from the inner rows of the each plot leaving the border rows. The sampled plants were carefully dunged up, the roots thoroughly washed under running water, put in labeled envelop bags and taken to the laboratory where the growth and yield parameters were recorded. The plant samples were partitioned into various plant fractions and after sun drying sample were subjected to oven-drying at 52°C until a constant weight was attained. Completely dried samples were weighed and the dry matter (DM) content of different plant parts was measured and expressed in g/plant. Growth parameter and yield attributes were recorded at 20, 40, 60 and harvest stage. Post-emergence herbicides were applied at 20 days after sowing. The observations on population of major grassy weeds were recorded by using the quadrate of 1 m^2 was randomly placed at three places in each plot and then the species wise and total weed count was recorded at 20, 40, 60 and harvest stage after herbicide application.

Weed Studies

Weed population/m^2

The effect of climate variabilities such as long drought periods and occasional wet years, may affect weed invasion. Weeds with high reproduction and efficient seed dispersal mechanisms may be better able to take advantage of expected calamities like cyclones and floods. The population of narrow leaf weed species viz., *Cyperus rotundus, Dactylactonium aegyptium, Eragrostis sp., and Leptochloa chinensis*, were reduced drastically with the use of herbicides at 20 DAS stage of the crop. The higher density of *Cyperus rotundus* may be due to the fact that it belongs to C_4 plant and has quick germination and survival capacity as well as the greater competitive ability than the other weeds. At 20 and 40 days stages of crop growth, lowest weed population of weeds was recorded in weed free check as shown in plate 2. Thus, minimum *Cyperus rotundus, Dactylactonium aegyptium, Eragrostis sp.* weed population reported by quizalofop @ 37.5 g a.i./ha. Cycloxydim herbicide with different doses, efficiently reduced population of *Leptochloa chinensis* weed. *Leptochloa chinensis* is a strongly tufted annual grass of aquatic and semi aquatic environment and is known to be invasive. The genus Leptochloa belonging to the Poaceae family includes 45 species widespread in tropical and subtropical areas. It is characterized by very small, non-dormant seeds able to germinate in completely anoxic conditions. Thus, this species is one of the very few able to germinate in complete oxygen depletion.

Weed dry weight (g/m^2)

Hand weeding twice was most effective and recorded minimum Weed dry weight (g/m^2) among all the treatments. Cycloxydim and quizalofop ethyl was effective against grassy weeds including *Leptochloa chinensis, Echinochloa colona, Cynodon dactylon*, but they were not effective against broadleaved weeds. Hand weeding superceded over all the treatments and attained minimum weed density and dry weight due to effective control of grassy as well as broadleaved weeds. In case of application of quizalofop @ 37.5 g a.i./ha reduced density and dry weight of monocot weeds, was observed by Idapuganti *et al*. (2005) [3] and Jain *et al* (2015) [4]. While fenoxaprop-p-ethyl @ 100 g a.i./ha, and Cycloxydim @ 75 g a.i./ha + MSO Adjuvent @2ml/l of water were found effective in suppressing narrow leaf weeds rather than broad leaf weeds. Among all Cycloxydim treatments, Cycloxydim @ 75 g a.i./ha, Cycloxydim @ 100 g a.i./ha, Cycloxydim @ 125 g a.i./ha were found inferior as compared to Cycloxydim @ 75 g a.i./ha + MSO Adjuvent @2ml/l of

water, Cycloxydim at 125 g a.i./ha + MSO Adjuvent @2ml/l of water, Cycloxydim at 100 g a.i./ha + MSO Adjuvent @2ml/l of water. Cycloxydim showed maximum efficiency in the control of *Leptochloa chinensis, Digitaria ciliaris* (Crab grass) was reported by Anderson (1990) [1]. This study shows that adjuvants improve herbicide efficacy on weeds. The superiority of quizalofop @ 37.5 g a.i./ha and fenoxaprop-p-ethyl @ 100 g a.i./ha in respect of controlling the weed especially narrow leaf was reported by Yadav *et al*. (2011) [11], and Singh *et al*. (2013) [8]. All the herbicidal treatments and hand weeding significantly reduced the density and dry weight of grassy weeds as compared to weedy check.

Weed control efficiency and Weed index

Higher weed control efficiency was recorded in weed free check at 60 DAS (100%), quizalofop @ 37.5 g (91.84%) followed by fenoxaprop-p-ethyl @ 100 g a.i./ha (85.52%). The higher weed control efficiency under these treatments was reflected due to lower dry weight of weeds. Weed index is indirectly related to the reduction in yield due to weed population and weed dry weight. Weed free check and quizalofop @ 37.5 g at 20 DAS recorded minimum weed index, which was followed by T_8 Fenoxoprop-ethyl @ 100 g and T_4 Cycloxydim @ 75 g a.i./ha + MSO Adjuvent @ 2ml/l of water. The highest weed index was noted in weedy check.

Crop Studies

Plant population/m^2

One of the important parameters for affects the yield of a crop is the number of plants per unit area. On reviewing the data related to plant population it was observed that the plant population was almost uniform under all the treatments recorded at initial and harvest stage. The slight variations among treatment as well as between both stages of observations in respect of plant population noted were statistically non-significant. Hence, it was evident that the herbicides used in present investigation did not affect the plant population because there was no phyto-toxic effect of herbicides on crop.

Plant height and number of branches per plant

All growth parameters viz., plant height and number of branches per plant were significantly influenced by weed control treatments at all crop growth stages except at 20 DAS in case of number of branches per plant. This may also be due to the fact that the plants under less crop weed competition had more vertical and horizontal growth as a result, these treatments recorded more plant height and number of branches as compared to other treatments. This study is supported by Saxena and Lodha (2003) [7] that weed management practices significantly increased plant height and number of branches per plant over the control. Data revealed in table no. 2 that among all narrow leafy herbicides, quizalofop @ 37.5 g a.i./ha (PoE) at 20 DAS showed maximum plant height as well as no. of branches followed by fenoxaprop-p-ethyl @ 100 g a.i./ha and cycloxydim @ 75 g a.i./ha + MSO Adjuvent @2ml/l of water. Whereas rest treatments of cycloxydim are significantly at par with each other.

Table I: Effect of post-emergence herbicides on weed population/m^2, total narrow weeds, weed index (%) and weed control efficiency at 60 DAS (%)

Treatment	Weed population/m^2				Total Dry matter	Weed index (%)	Weed control efficiency (%)
	Cyperus rotundus	*Dactylactonium aegyptium*	*Eragrostis sp.*	*Leptochloa chinensis*			
T_1	3.44 (11.33)	2.71 (7.00)	2.80 (7.33)	1.56 (2.00)	151.67	47.49	28.45
T_2	3.23 (10.00)	2.77 (7.67)	2.85 (7.66)	1.46 (1.67)	130.00	45.33	37.17
T_3	3.53 (12.00)	3.45 (12.67)	2.51 (6.33)	1.44 (1.67)	126.67	41.14	38.81
T_4	3.44 (11.33)	2.73 (7.33)	3.13 (9.33)	1.46 (1.67)	81.67	27.51	64.8
T_5	3.62 (12.67)	2.66 (6.67)	3.03 (8.66)	1.39 (1.67)	91.67	30.30	60.52
T_6	3.67 (13.00)	2.59 (6.33)	1.95 (3.33)	1.34 (1.33)	105.33	32.27	53.12
T_7	2.34 (5.00)	1.86 (3.00)	1.67 (3.00)	1.95 (3.33)	34.00	19.56	87
T_8	2.78 (7.67)	1.95 (3.33)	2.08 (4.33)	1.56 (2.00)	38.00	27.00	85.52
T_9	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.00	0.00	100
T_{10}	4.01 (15.67)	4.48 (19.67)	3.89 (14.66)	4.33 (18.33)	206.00	49.09	0
S.E.(m)±	0.18	0.25	0.18	0.19	1.44	3.68	
C.D. (at 5%)	0.53	0.75	0.52	0.56	4.23	10.86	
Transformation	$\sqrt{X + 0.5}$	$\sqrt{X + 0.5}$	$\sqrt{X + 0.5}$	$\sqrt{X + 0.5}$			

Table 2: Effect of post-emergence herbicides on yield attributing parameters of clusterbean

Treatment	Plant height (cm)		No. of branches per plant		Pods per plant	Seeds per pod	Yield			Total cost	Income (Rs)	
	60 DAS	Harvest	60 DAS	Harvest	Harvest	Harvest	Seed yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)	Gross return (Rs/ha)	Net income (Rs/ha)	B:C Ratio
T_1	84.00	114.33	3.39	3.82	36.63	7.00	1098	5075	21.62	57437.73	41077.7	3.51
T_2	85.00	114.67	3.53	3.90	37.17	7.10	1129	4611	24.35	58805.56	41945.6	3.49
T_3	80.00	109.00	3.20	4.13	37.73	7.05	1233	4809	25.79	64054.33	46694.3	3.69
T_4	88.60	112.33	3.67	4.77	40.27	8.15	1513	5530	27.38	78414.82	61854.8	4.74
T_5	88.90	112.33	3.78	4.00	39.07	8.13	1450	5507	26.56	75253.71	58193.7	4.41
T_6	87.20	111.67	3.27	4.48	38.47	8.11	1427	5496	26.02	74098.16	56538.2	4.22
T_7	83.90	116.00	3.99	4.49	43.30	8.04	1677	5579	30.17	86639.51	70597.5	5.40
T_8	83.00	108.00	3.63	4.43	42.87	8.00	1533	5432	28.87	79366.07	63746.1	5.08
T_9	93.45	123.33	5.80	6.10	48.40	8.60	2097	6568	32.25	108143.2	86883.2	5.09
T_{10}	85.00	107.93	2.80	3.83	33.47	6.33	1058	4932	21.70	55382.72	41122.7	3.88
S.E.(m)±	2.25	2.34	0.70	0.56	1.95	0.58	112.84	426.54	1.84			
C.D. (at 5%)	6.64	6.89	2.05	1.64	5.74	1.71	332.55	1257.11	5.41			

Plate 1: Treatment (T_8) Fenoxaprop-p-ethyl @ 100 g a.i./ha (PoE) at 20 DAS

Plate 2: Treatment (T_9) Weed Free Check

Dry weight per plant (g)

The biomass per plant of clusterbean was recorded from each treatment at different growth intervals and the mean data after statistical analysis are depicted in graph no. 2, data revealed that dry weight per plant differed significantly among various treatments at 60 DAS and harvest stage. At 60 days stage, it ranged from 10.10 to 14.75 g/plant, while it reached up to the maximum ranging from 30.31 to 44.26 g/plant at harvest stage in various treatments. From weed free check significantly maximum dry weight was obtained among all treatments (14.75 g/plant at 60 DAS and 44.26 g/plant at harvest). While treatment T_4 Cycloxydim @ 75 g a.i./ha + MSO Adjuvent @ 2ml/l of water (12.85 g/plant at 60 DAS and 38.56g/plant at harvest) which is at par with T_7 Quizalofop-ethyl @ 37.5 g a.i./ha. The significantly lowest dry weight was noted in weedy check at both stages of observation.

Yield attributing characters

Number of pods/m^2 and number of seeds per pod

Number of pods/m^2 and number of seeds per pod, were significantly influenced by weed control treatments. All these yield attributing characters were significantly increased over weedy check by all weed control treatments except some treatments of cycloxydim herbicide. The highest number of pods/m^2, number of seeds per pod were reported in Weed free check. While Cycloxydim @ 75 g a.i./ha, Cycloxydim @ 100 g a.i./ha, Cycloxydim @ 125 g a.i./ha were found inferior as compared to Cycloxydim @ 75 g a.i./ha + MSO Adjuvent @2ml/l of water, Cycloxydim at 125 g a.i./ha + MSO Adjuvent @2ml/l of water, Cycloxydim at 100 g a.i./ha + MSO Adjuvent @2ml/l of water, quizalofop @ 37.5 g a.i./ha and fenoxaprop-p-ethyl @ 100 g a.i./ha, as shown in table no.2 and plate no.1. This might be due to less population of weeds especially narrow leaf weeds in the plots treated with these herbicides and in weed free check plots, where there was less competition between crop and weed plants for moisture, light, space and nutrients utilized which provided congenial condition to the crop for proper development of its reproductive phase which resulted in the enhancement of all these yield contributing characters. These results also collaborate with the finding of Singh *et al*. (2001) [9], Dungarwal *et al*. (2002) [2].

Seed and Stover yield

The highest grain and stover yield were due to effective suppression of weeds in the early stages. Which was evidenced from maximum growth parameters and yield attributes recorded. All the weed control treatments significantly increased the seed and stover yield over weedy check. The highest seed and stover yield recorded in weed free check, followed by Quizalofop @ 37.5 g a.i./ha (PoE) which is at par with Fenoxaprop-p-ethyl @ 100 g a.i./ha and Cycloxydim @ 75 g a.i./ha + MSO Adjuvent @2ml/l of water. While rest treatment of cycloxydim treatments were found inferior as compared to other treatments.

Economics

The choice of any weed control method ultimately depends on economics and efficiency in controlling weeds. The cost of chemical weed control is actually less than that of manual weeding. This has been a major incentive to many farmers for switching over to herbicides for weed management. Weed control by using herbicides is one of the easier, time saving and economical alternative as compared to manual weeding.

Among the different weed control treatments, weed free check produced highest net income of Rs 86883/ha followed by post emergence application of Quizalofop @ 37.5 g a.i./ha recording Rs. 70597/ha, respectively. Minimum net return was received in weedy check and Cycloxydim @ 75 g a.i./ha (Rs. 41122/h and Rs.41077.7/ha) respectively. Similarly, among all post emergence herbicides Quizalofop @ 37.5 g a.i./ha performed the highest benefit cost ratio of 5.40, followed by Fenoxaprop-p-ethyl @ 100 g a.i./ha 5.08. Weed control by using herbicides is one of the easier, time saving and economical alternative as compared to manual weeding.

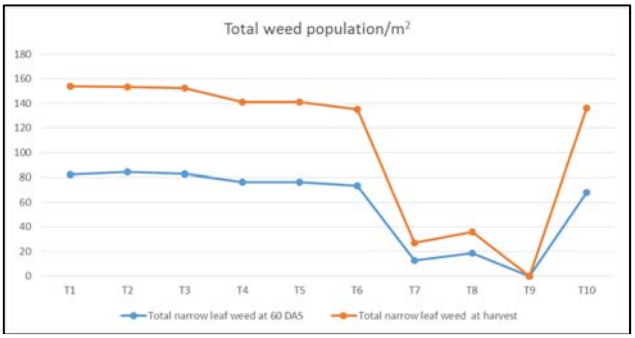

Fig 1: Effect of post-emergence herbicides on total no. of weed population/m^2

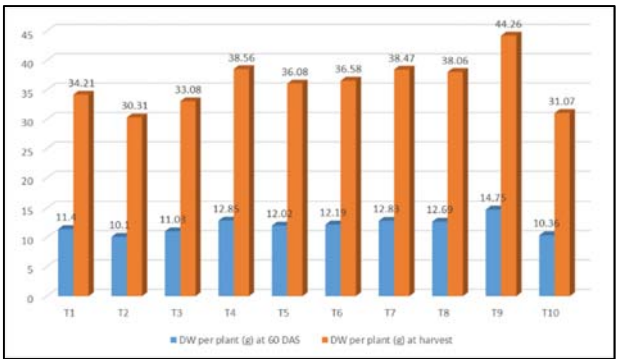

Fig 2: Effect of post-emergence herbicides on dry weight per plant (g) at 60 DAS and harvesting stage

Conclusion

On the basis of results obtained, it can be concluded that the weed flora of the area were shifted from the common weed flora of the experimetal year and *Leptochloa chinensis* was recorded as major dominating species in the cluserbean field which can be effectively controlled by grass weed killers cycloxydim and quizalofop-ethyl and control maximum grassy weeds as compared to other treatments.

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