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The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; SP-10(12): 542-547

www.thepharmajournal.com
Received: 01-10-2021
Accepted: 03-11-2021

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Integrated weed management practices against weed control in cluster bean during kharif

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Abstract
A field experiment was undertaken at the All India Coordinated Research Project on Vegetable Crops, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra. The experimental field was infested with various weeds to control weed infestation some integrated practices were followed. Based on two year experimentation, it was found that, during kharif of 2015, 2016 and pooled treatment weed free check reported significantly highest weed control efficiency than rest of all the treatments as there was total eradication of weeds which resulted in achieving 100% weed control efficiency. Post emergence application of herbicides in integration with the hand weeding gave better control of weeds during crop growth period which lowered the total weed population and ultimately resulted in achieving higher weed control efficiency. This could be explained based on the fact that, maximum uptake and better assimilation of herbicides was pronounced as soon as weeds emerged. Less weed intensity and its dry weight in integrated weed control treatments compared to weedy check may also one of the reasons of higher WCE with these treatments. Pooled data of two years indicated that significantly maximum pod yield was recorded due to increase values of yield attributing characters due to favorable environment in the root zone resulting absorption of more water and nutrient as less crop weed competition during critical stage.

Keywords: integrated, weed, imazethapyr, imazamox, cluster bean

1. Introduction
Guar commonly known as Cluster bean [Cyamopsis tetragonoloba (L.) Taub] is a versatile and multipurpose under exploited leguminous vegetable crop of arid and semi-arid region belonging to the family Fabaceae. It is a kharif pulse crop, considered as one of the most drought tolerant grain, deep-rooted and annual legume in India. Weed management in the present agriculture is most important crop protection practice to increase the global food production. Weed management create an atmosphere in the crop zone so that the crop gets favorable situation for its growth and development by minimizing the population of competitive weed plants. Chemical herbicides provide a convenient, economical and effective way to help manage weeds. Many factors determine when, where, and how a particular herbicide can be used most effectively. The present investigation is therefore, undertaken to find out suitable chemical herbicide and their dose combined with hand weeding for controlling weed population.

2. Materials and Methods
The experiment was conducted during *kharif* of 2015, 2016 at the All India Coordinated Research Project on Vegetable Crops, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri (Maharashtra). There were ten treatments laid out in Randomized Block Design with three replications. The allocation of treatments in the replication was done by random method. Clusterbean variety Phule Guar (RHRCB-10) was used for experiment. The experiment consisted of ten integrated weed management treatments viz. T1: Imazethapyr 10% SL PoE 75 g ha-1 at 15 DAS, T2: Imazethapyr 10% SL PoE 100 g ha-1 at 15 DAS, T3: Imazethapyr 10% SL PoE 75 g ha-1 at 15 DAS + Hand weeding at 30 DAS, T4:Imazethapyr 10% SL PoE 100 g ha-1 at 15 DAS + Hand weeding at 30 DAS, T5: Imazamox 35% + Imazethapyr 35%,70% WG PoE 60 g ha-1 at 15 DAS, T6: Imazamox 35% + Imazethapyr 35%,70% WG PoE 70 g ha-1 at 15 DAS, T7: Imazamox 35% + Imazethapyr 35%,70% WG PoE 60 g ha-1 at 15 DAS + Hand weeding at 30 DAS, T8:Imazamox 35% + Imazethapyr 35%,70% WG PoE 70 g ha-1 at 15 DAS + Hand weeding at 30 DAS, T9:Weed free check, and T10:Weedy check (Control).

Important weed species associated with clusterbean crop in the experimental plot were recorded and identified.

The data on total weed count was recorded at 30, 45, 60 and 75 DAS by placing the quadrat with a size of 1 m x 1 m quadrant in randomly selected places in each treatment and counted the number of different weed species enclosed in it, average number of weeds per quadrant was worked out. The weed population in the controlled plot taken as reference to compare other treatment plots. The treatment wise total weed count was recorded and expressed as number m^{-2} and the total weed count data were subjected to square root transformation $\sqrt{(X+1)}$ before statistical analysis.

The treatment wise total weed count was recorded and expressed as number m^2 and the total weed count data were subjected to square root transformation $\sqrt{(X+1)}$ before statistical analysis. Thereafter treatment wise total dry matter of weed was recorded and expressed as grams at 75 DAS.

The weed dry matter data was subjected to square root transformation $\sqrt{(X+1)}$ before statistical analysis. According to Mani *et al*., (1973) [7] weed control efficiency as a derived parameter out of weed population/density per unit area for studying treatment performance in weed control. Weed Control Efficiency can be worked out taking in to consideration the reduction in weed population in treated plot over weed population in unweeded check. Weed control efficiency at 30, 45, 60 and 75 DAS was worked out based on weed count m^2 by adopting the formula, Weed control efficiency (WCE).According to Mani *et al.* (1973) [7] weed control efficiency is a derived parameter out of weed population/density per unit area for studying treatment performance in weed control. Weed Control Efficiency can be worked out taking in to consideration the reduction in weed population in treated plot over weed population in unweeded check. Weed control efficiency at 30, 45, and 60 and at 75 DAS was worked out based on weed count m^{-2} by adopting the formula,

$$WCE = \frac{WP_C - WP_T}{WP_C} \times 100\%$$

Where, WP_C - Weed population m^{-2} in control (unwedded) plot

WP_T - Weed population m^{-2} in treated plot.

3. Result and Discussions

The important weeds belonging to grasses, sedges and broad-leaved groups observed in experimental area at different stages of cluster bean crop. The weed flora associated with clusterbean crop was found during Kharif were *Cyperus rotundus* L., *Cynodon dactylon* (L.) Pers., *Commelina benghalensis* L., *Bracheria mutica* (Forssk.) Stapf., *Eragrotis minor* (L.) Wolf., *Parthenium hysterophorus* L., *Portulaca oleracea* L., *Amarathus viridis* L., *Trianthema portulacastrum* L., *Euphorbia hrita* L., *Dinebra arebica* Jacq., *Echinochloa colona* (L.) Link, *Celosia argentea* L. and *Agremone mexicana* L. The weed flora associated with cluster bean crop is on the line with that of Sumanth Kumar (2005) [20], Dhaker *et al*. (2009) [1], Vaghasia and Nadiyadhara (2013) [21], Patil *et al*. (2014) [10], Sangwan (2014) [12] and Sharma *et al*. (2017) [13].

3.1 Total weed count number per m2at 30, 45, 60 and 75 DAS

All the weed control treatments significantly reduced total weed count number per m2 as compared to weedy check at 30, 45, 60 and 75 DAS during kharif of 2015, 2016 and pooled data is presented in Table 1. There were no weeds in weed free treatment since the weeds were being removed and this treatment was kept weed free throughout the growing period, hence it recorded zero weeds and weedy check (control) noticed highest total weed count per m2at 30, 45, 60 and 75 DAS during kharif of 2015, 2016 and pooled.

However, during kharif 2015 treatment T8 (Imazamox 35% + Imazethapyr 35%, 70% WG PoE 70 g ha-1 at 15 DAS + Hand weeding at 30 DAS) was recorded significantly lowest total weed count number per m2 (18.67) while during kharif 2016 and pooled, treatment T6 (Imazamox 35% + Imazethapyr 35%, 70% WG PoE 70 g ha-1 at 15 DAS) recorded significantly lowest total weed count number per m2 (18.33 and 18.67, respectively). However, treatment T6 and treatment T8 were comparable with each other. In the present study, there were no weeds in weed free check; this is attributed to control of weeds by hand weeding at regular intervals. Post-emergence herbicidal treatments viz., Imazethapyr and Imazethapyr + Imazamox (Redimix) provided better control of weeds at initial stages. This might be due to Imazethapyr amd Imazamox kills the weeds by inhibition of enzyme acetohydroxy acid synthase (AHAS) and acitolactate synthase (ALS) in plants, causes a disruption in protein synthesis and targets the plastid enzyme acetolactate synthase (ALS) in plant, which catalyses the first step in the bio-synthesis of essential branched chain amino acids (Valine, Leucine and Isoleucine). The ALS inhibitors thus stop cell division and reduce carbohydrate translocation in the susceptible plants. The affected plants succumb to these herbicides completely in 7-20 days and thereby, finally causing death of weeds shortly after application. Hence, weed density in this treatment was less when compared to rest of the treatments. Similar results have been reported by Patel *et al*. (2005) [8], Dhaker *et al*. (2009) [1], Dhonde *et al*. (2009) [2], Patil *et al*. (2014) [10] and Sangwan (2014) [12]. The results of present study indicated that during kharif of 2015, 2016 and pooled at 45 DAS treatment T8 (Imazamox 35% + Imazethapyr 35%,70% WG PoE 70 g ha-1 at 15 DAS + Hand weeding at 30 DAS) recorded significantly lowest total weed count per m2 (3.33, 4.00 and 3.67, respectively) but it was comparable with treatment T7 (Imazamox 35% + Imazethapyr 35%,70% WG PoE 60 g ha-1 at 15 DAS + Hand weeding at 30 DAS) (4.33, 4.67 and 4.50, respectively) and T4 (Imazethapyr 10% , SL PoE 100 g ha-1 at 15 DAS + Hand weeding at 30 DAS) (4.33, 4.67 and 4.50, respectively). This reduction in total weed count per m2 in these treatments is attributed to the effect of the post-emergence application of herbicides or hand weeding. These results were inconformity with Patel *et al*. (2005) [8], Dhaker *et al*. (2009) [1], Dhonde *et al*. (2009) [2], Patil *et al*. (2014) [10] and Sangwan (2014) [12]. Scrutinizing the data at 60 and 75 DAS, presented in Table 1 revealed that similar trend was observed as that of 45 DAS during kharif of 2015, 2016 and pooled data.

During kharif of 2015, 2016 and pooled results, weed free check recorded significantly lowest total weed count number per m2 than rest of all the treatments. However, in weedy check there was profuse growth of weeds throughout the growth period resulting in the suppressing growth and yield of cluster bean. The herbicidal treatments integrated with one hand weeding i.e. treatment T8, T7, T4 and T3 recorded lower total weed count number per m2 than herbicide used alone

throughout the season at 30, 45, 60 and 75 DAS during the kharif season of year 2015 and 2016 than other treatments. This might be due to broad spectrum control of weeds because of integration of herbicides with hand weeding. These results are in great analogous with the results reported by Patil *et al*. (2014) [10], Sangwan (2014) [12], Hassan *et al*. (2015) [5], Prasanna *et al*. (2015) [11], Singh et.al (2016) [19] and Shyamlal *et al*. (2017) [15].

3.2 Weed dry matter (g) at 75 DAS

The weed dry matter g m-2 at all the stages of observations was significantly influenced by the various weed control treatments. The data regarding weed dry matter m-2 at 75 DAS is presented in Table 2 for kharif. During kharif of 2015, 2016 and pooled results noted significantly lower weed dry matter zero with treatment T9 (weed free check). This could be attributed to control of weeds by hand weeding at regular intervals which resulted in reduced dry matter production of weeds.

The data on weed dry matter during kharif of 2015, 2016 and pooled data revealed that treatment T8 (Imazamox 35% + Imazethapyr 35%, 70% WG PoE 70 g ha-1 at 15 DAS + Hand weeding at 30 DAS) has recorded significantly lowest weed dry matter (8.07, 7.87 and 7.97 g, respectively) than the other treatments. It was followed by treatments T7 (Imazamox 35% + Imazethapyr 35%, 70% WG PoE 60 g ha-1 at 15 DAS + Hand weeding at 30 DAS) (8.80, 9.63 and 9.22 g, respectively), T4 (Imazethapyr 10% , SL PoE 100 g ha-1 at 15 DAS + Hand weeding at 30 DAS) (9.63, 10.90 and 10.27 g, respectively) and T3 (Imazethapyr 10%, SL PoE 75 g ha-1 at 15 DAS + Hand weeding at 30 DAS) (12.00, 11.63 and 11.82 g, respectively). However, treatment T8 was found at par with treatment T7 and T4. Treatment T10 (weedy check) registered highest weed dry matter during both the years and pooled. All weed control treatments gave lower dry matter when compared with untreated control weedy check (T10) at 75 DAS. This might be attributed to less density of weeds due to application of herbicide alone and in integration with hand weeding resulted in lowering the emergence and interrupted growth of weeds this leads to lower weed intensity in weed control treatments. These results indicate the effect of weed control treatment on various morphological traits of weeds and finally reduce the total dry matter production. This has also been demonstrated by Sumanth Kumar (2005) [20], Dhaker *et al*. (2009) [1], Patil *et al*. (2014) [10], Sangwan (2014) [12], Gupta *et al*. (2015) [4], Hassan *et al*. (2015) [5] and Singh *et al*. (2016) [19].

3.3 Weed control efficiency (%) at 30, 45, 60, 75 DAS

The weed control efficiency represents efficiency of weeds controlled by different weed management treatments in comparison with weedy check. The weed control efficiency was significantly influenced due to different weed management treatments at different stages. The data with respect to weed control efficiency (%) worked out at 30, 45, 60 and 75 DAS, during kharif of 2015, 2016 and pooled results are presented in Table 3 Cent per cent weed control efficiency was recorded in treatment T9 (weed free check) at 30, 45, 60 and 75 DAS during kharif of 2015, 2016 and pooled data. This is mainly due to total elimination of weeds at the critical stages of crop growth. Significantly reduced weed density resulting in higher weed control efficiency. However, the lowest weed control efficiency was observed under T10 (weedy check) in the kharif season of 2015 and 2016, this might be due to the high weed density. These results found conformity with Kamble *et al*. 2017. The weed control efficiency at 30 DAS during the kharif 2015 was found significantly maximum (84.75%) in treatment T8 (Imazamox 35% + Imazethapyr 35%, 70% WG PoE 70 g ha-1 at 15 DAS + Hand weeding at 30 DAS) than other treatments, while during kharif 2016 and pooled, treatment T6 (Imazamox 35% + Imazethapyr 35%, 70% WG PoE 70 g ha-1 at 15 DAS) recorded significantly highest weed control efficiency (86.81 and 85.65%, respectively). The figures concerning to weed control efficiency at 45 DAS represented in Table 3 shows similar trend during kharif of 2015, 2016 and pooled. Treatment T8 (Imazamox 35% + Imazethapyr 35%, 70% WG PoE 70 g ha-1 at 15 DAS + Hand weeding at 30 DAS) reported significantly highest weed control efficiency (97.57, 97.29 and 97.43%, respectively) but it was comparable with treatment T7 (Imazamox 35% + Imazethapyr 35%,70% WG PoE 60 g ha-1 at 15 DAS + Hand weeding at 30 DAS) (96.83, 96.87 and 96.85%, respectively) and T4 (Imazethapyr 10%, SL PoE 100 g ha-1 at 15 DAS + Hand weeding at 30 DAS) (96.84, 96.86 and 96.85%, respectively). The data pertaining to weed control efficiency at 60 and 75 DAS revealed that similar trend was observed as that of 45 DAS during kharif of 2015, 2016 and pooled. From the present investigation it was noticed that, during kharif of 2015, 2016 and pooled treatment weed free check reported significantly highest weed control efficiency than rest of all the treatments as there was total eradication of weeds which resulted in achieving 100% weed control efficiency. Post emergence application of herbicides in integration with the hand weeding gave better control of weeds during crop growth period which lowered the total weed population and ultimately resulted in achieving higher weed control efficiency. This could be explained based on the fact that, maximum uptake and better assimilation of herbicides was pronounced as soon as weeds emerged. Less weed intensity and its dry weight in integrated weed control treatments compared to weedy check may also be one of the reasons of higher WCE with these treatments. These results are in agreement with the findings of Singh *et al*. (2001) [16], Dungarwal *et al*. (2002) [3], Sumanth Kumar (2005) [20], Shete *et al*. (2007) [14], Vaghasia and Nadiyadhara (2013) [21] and Patil *et al*. (2014) [10].

3.4 Pod yield ha-1 (q)

Data pertaining to pod yield hectare-1 during kharif as influenced by different treatments are presented in Table 4. The data showed that, pod yield of cluster bean was influenced significantly at various treatments. The average pod yield was 80.78 and 76.34 q ha-1 during 2015 and 2016 respectively. Pooled data also exhibits the similar results (78.56 q ha-1). There was significant variation in pod yield due to weed management practices in both the years. During two years of experimentation, significantly highest pod yield of 113.37 and 105.91 q ha-1 was due to application of Imazamox 35% + Imazethapyr 35%, 70% WG PoE 70 g ha-1 at 15 DAS + Hand weeding at 30 DAS (T8) over all the integrated weed management practices except T9 (Weed free check). The data of pooled analysis showed that T8 (Imazamox 35% + Imazethapyr 35%, 70% WG PoE 70 g ha-1 at 15 DAS + Hand weeding at 30 DAS) recorded higher pod yield (109.64 q ha-1) which was significantly superior over rest of integrated weed management treatments except T9 (Weed free check). This might be due to less crop weed

competition which provides higher availability of all natural resources. The higher yield under the effective weed control treatments is due to reduced stage of crop weed competition. As the plant have to face neither nor moisture stress due to lower weed infestation and because of this proper utilization of moisture, nutrient, light and space by cluster bean crop for growth and development which reflects its effect in to productive growth of cluster bean crop in terms of yield. These results are in affirmative with earlier findings of Sumanth Kumar (2005) [20], Singh *et al*. (2008) [18], Lhungdim *et al*. (2013) [6], Singh *et al*. (2013) [17], Vaghasia and Nadiyadhara (2013) [21], Patil *et al*. (2014) [10], Sangwan (2014) [12] and Patil *et al*. (2017) [9]. During kharif 2015, 2016 throughout the crop growth period the lowest weed intensity i.e. no weed was observed in weed free check. Because zero weed intensity leads to zero weed crop competition and hence due to this favorable environmental condition, the crop growth was enhanced and also yield was higher. In weedy check there was highest weed intensity resulting in high weed and crop competition for nutrients, sunlight, CO2 and water which hampered crop growth resulting in low yield. These results are in agreement with earlier findings of Lhungdim *et al*. (2013) [6], Sangwan (2014) [12] and Sharma *et al*. (2017) [13].

Table 1: Effect of different weed management treatments on total weed count number m^{-2} at 30, 45, 60 and 75 DAS in cluster bean during *kharif*

Treatments	30 DAS			45 DAS			60 DAS			75 DAS		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1	6.53 (41.67)	6.87 (46.33)	6.70 (44.00)	7.43 (54.33)	7.32 (52.67)	7.38 (53.50)	7.74 (59.00)	7.81 (60.00)	7.77 (59.50)	7.94 (62.00)	8.06 (64.00)	8.00 (63.00)
T_2	6.11 (36.33)	6.58 (42.33)	6.34 (39.33)	6.73 (44.33)	7.57 (56.33)	7.15 (50.33)	7.30 (52.33)	7.68 (58.00)	7.49 (55.17)	7.41 (54.00)	7.85 (60.67)	7.63 (57.33)
T_3	6.50 (41.33)	6.78 (45.00)	6.64 (43.17)	2.82 (7.00)	2.89 (7.33)	2.86 (7.17)	3.11 (8.67)	3.21 (9.33)	3.16 (9.00)	4.04 (15.33)	4.08 (15.67)	4.06 (15.50)
T_4	6.14 (36.67)	6.27 (38.33)	6.20 (37.50)	2.31 (4.33)	2.38 (4.67)	2.34 (4.50)	3.00 (8.00)	3.11 (8.67)	3.05 (8.33)	3.70 (12.67)	3.60 (12.00)	3.65 (12.33)
T_5	5.06 (24.67)	5.00 (24.00)	5.03 (24.33)	5.59 (30.33)	5.41 (28.33)	5.50 (29.33)	5.85 (33.33)	6.19 (37.33)	6.02 (35.33)	6.40 (40.00)	6.71 (44.00)	6.55 (42.00)
T_6	4.47 (19.00)	4.39 (18.33)	4.43 (18.67)	5.10 (25.00)	4.90 (23.00)	5.00 (24.00)	5.56 (30.00)	5.91 (34.00)	5.74 (32.00)	5.97 (34.67)	6.30 (38.67)	6.13 (36.67)
T_7	4.90 (23.00)	4.96 (23.67)	4.93 (23.33)	2.31 (4.33)	2.38 (4.67)	2.34 (4.50)	3.05 (8.33)	3.00 (8.00)	3.03 (8.17)	3.55 (11.67)	3.46 (11.00)	3.51 (11.33)
T_8	4.43 (18.67)	4.51 (19.33)	4.47 (19.00)	2.08 (3.33)	2.23 (4.00)	2.15 (3.67)	2.89 (7.33)	2.77 (6.67)	2.83 (7.00)	3.41 (10.67)	3.21 (9.33)	3.31 (10.00)
T_9	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
T_{10}	11.10 (122.33)	11.82 (138.67)	11.46 (130.50)	11.74 (137.00)	12.23 (148.67)	11.99 (142.83)	12.23 (148.67)	12.48 (154.67)	12.35 (151.67)	12.78 (162.33)	12.83 (163.67)	12.80 (163.00)
GM	5.62	5.82	5.72	4.71	4.83	4.77	5.17	5.31	5.24	5.62	5.71	5.66
SEm (±)	0.12	0.14	0.16	0.13	0.11	0.14	0.14	0.12	0.16	0.12	0.08	0.13
CD at 5%	0.36	0.41	0.46	0.37	0.32	0.41	0.40	0.37	0.46	0.35	0.25	0.36

*(DAS – Days after Sowing)

*Figures in parenthesis are original values while figures outside the parenthesis are square root transformed $\sqrt{x+1}$ values.

Treatments: T_1- Imazethapyr 10% SL PoE 75 g ha^{-1} at 15 DAS , T_2- Imazethapyr 10% SL PoE 100 g ha^{-1} at 15 DAS, T_3-T_1+ Hand weeding at 30 DAS, T_4-T_2+ Hand weeding at 30 DAS, T_5- Imazamox 35% + Imazethapyr 35%,70% WG PoE 60 g ha^{-1} at 15 DAS, T_6- Imazamox 35% + Imazethapyr 35%,70% WG PoE 70 g ha^{-1} at 15 DAS, T_7-T_5 + Hand weeding at 30 DAS, T_8-T_6+ Hand weeding at 30 DAS, T_9- Weed free check, T_{10}- Weedy check (Control).

Table 2: Effect of different weed management treatments on weed dry matter g m^{-2} at 75 DAS in cluster bean during *kharif*

Treatments	*Kharif*		
	2015	2016	Pooled
T_1	6.40 (40.00)	6.42 (40.23)	6.41 (40.12)
T_2	6.08 (36.00)	6.26 (38.17)	6.17 (37.08)
T_3	3.60 (12.00)	3.55 (11.63)	3.58 (11.82)
T_4	3.26 (9.63)	3.45 (10.90)	3.35 (10.27)
T_5	5.60 (30.37)	5.56 (29.93)	5.58 (30.15)
T_6	5.06 (24.60)	5.41 (28.23)	5.23 (26.42)
T_7	3.13 (8.80)	3.26 (9.63)	3.19 (9.22)
T_8	3.01 (8.07)	2.98 (7.87)	2.99 (7.97)
T_9	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
T_{10}	10.13 (101.60)	10.21 (103.27)	10.17 (102.43)
GM	4.73	4.81	4.77
SEm (±)	0.08	0.06	0.09
CD at 5%	0.25	0.17	0.25

*(DAS – Days After Sowing)

*Figures in parenthesis are original values while figures outside the parenthesis are square root transformed$\sqrt{x+1}$values.

Treatments : T_1- Imazethapyr 10% SL PoE 75 g ha^{-1} at 15 DAS , T_2- Imazethapyr 10% SL PoE 100 g ha^{-1} at 15 DAS, T_3-T_1+ Hand weeding at 30 DAS, T_4-T_2+ Hand weeding at 30 DAS, T_5- Imazamox 35% + Imazethapyr 35%,70% WG PoE 60 g ha^{-1} at 15 DAS, T_6- Imazamox 35% + Imazethapyr 35%,70% WG PoE 70 g ha^{-1} at 15 DAS, T_7-T_5 + Hand weeding at 30 DAS, T_8-T_6+ Hand weeding at 30 DAS, T_9- Weed free check, T_{10}- Weedy check (Control).

Table 3: Effect of different weed management treatments on weed control efficiency (%) at 30, 45, 60 and 75 DAS in cluster bean for *kharif*

Treatments	30 DAS			45 DAS			60 DAS			75 DAS		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1	65.92	66.56	66.24	60.15	64.52	62.33	60.36	61.15	60.76	61.78	60.87	61.33
T_2	70.24	69.52	69.88	67.65	62.06	64.86	64.84	62.52	63.68	66.79	62.92	64.86
T_3	66.03	67.47	66.75	94.87	95.07	94.97	94.17	93.96	94.06	90.53	90.43	90.48
T_4	69.98	72.26	71.12	96.84	96.86	96.85	94.63	94.39	94.51	92.17	92.68	92.42
T_5	79.84	82.71	81.28	77.79	80.93	79.36	77.50	75.83	76.67	75.27	73.14	74.20
T_6	84.49	86.81	85.65	81.65	84.49	83.07	79.75	77.99	78.87	78.65	76.35	77.50
T_7	81.13	82.89	82.01	96.83	96.87	96.85	94.38	94.83	94.61	92.82	93.27	93.05
T_8	84.75	86.04	85.39	97.57	97.29	97.43	95.06	95.69	95.38	93.45	94.29	93.87
T_9	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
T_{10}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GM	70.23	71.42	70.83	77.33	77.81	77.57	76.07	75.64	75.85	75.15	74.40	74.77
SEm (±)	1.18	1.21	1.46	1.12	0.88	1.23	1.03	1.06	1.28	0.75	0.65	0.86
CD at 5%	3.50	3.59	4.19	3.32	2.61	3.53	3.05	3.14	3.66	2.24	1.92	2.46

*(DAS – Days After Sowing)

Treatments : T_1- Imazethapyr 10% SL PoE 75 g ha^{-1} at 15 DAS , T_2- Imazethapyr 10% SL PoE 100 g ha^{-1} at 15 DAS, T_3-T_1+ Hand weeding at 30 DAS, T_4-T_2+ Hand weeding at 30 DAS, T_5- Imazamox 35% + Imazethapyr 35%,70% WG PoE 60 g ha^{-1} at 15 DAS, T_6- Imazamox 35% + Imazethapyr 35%,70% WG PoE 70 g ha^{-1} at 15 DAS, T_7-T_5 + Hand weeding at 30 DAS, T_8-T_6+ Hand weeding at 30 DAS, T_9- Weed free check, T_{10}- Weedy check (Control).

Table 4: Effect of different weed management treatments on yield hectare^{-1} (q) in cluster bean during *kharif*

Treatments	Yield hectare^{-1} (q)		
	2015	2016	Pooled
T_1	56.23	54.00	55.12
T_2	57.30	54.70	56.00
T_3	87.79	81.29	84.54
T_4	92.22	87.62	89.92
T_5	73.72	67.91	70.81
T_6	75.67	65.49	70.58
T_7	102.33	95.77	99.05
T_8	113.37	105.91	109.64
T_9	122.07	120.71	121.39
T_{10}	27.06	29.96	28.51
GM	80.78	76.34	78.56
SEm (±)	2.66	2.09	2.93
CD at 5%	7.90	6.21	8.40

*(DAS – Days After Sowing)

Treatments: T_1- Imazethapyr 10% SL PoE 75 g ha^{-1} at 15 DAS , T_2- Imazethapyr 10% SL PoE 100 g ha^{-1} at 15 DAS, T_3-T_1+ Hand weeding at 30 DAS, T_4-T_2+ Hand weeding at 30 DAS, T_5- Imazamox 35% + Imazethapyr 35%,70% WG PoE 60 g ha^{-1} at 15 DAS, T_6- Imazamox 35% + Imazethapyr 35%,70% WG PoE 70 g ha^{-1} at 15 DAS, T_7-T_5 + Hand weeding at 30 DAS, T_8-T_6+ Hand weeding at 30 DAS, T_9- Weed free check, T_{10}- Weedy check (Control).

4. Conclusions

The first 30-45 days are very critical for cluster bean crop - weed competition. Therefore, weed management in the initial growth phase of cluster bean by manually, mechanically or using effective herbicides is very crucial for harvesting good crop yield. From the present study it can be concluded that, application of Imazamox 35% + Imazethapyr 35%,70% WG PoE 70 g ha-1 at 15 DAS with hand weeding at 30 DAS (T8) is most effective treatment to minimize the weed density, lowering the weed dry matter than rest of the treatments except weed free check during and kharif . according to the findings of study it is concluded that effective control of weeds and improved productivity of cluster bean can be attained with application of Imazamox 35% + Imazethapyr 35%,70% WG PoE 70 g ha-1 at 15 DAS with one hand weeding at 30 DAS. It was followed by Imazamox 35% + Imazethapyr 35%, 70% WG PoE 60 g ha-1 at 15 DAS with one hand weeding at 30 DAS where unavailability of labour at peak time and increasing labour cost are the main limitations of manual weeding.

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