RESEARCH ARTICLE Legume Research- An International Journal, Volume 45 Issue 4: 481-486 (April 2022)

Effect of Crop Establishment Methods and Weed Management Practices on Productivity and Profitability of Clusterbean under Semi-arid Region of Rajasthan

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10.18805/LR-4737

ABSTRACT

Background: Adequate tillage checks and delays the emergence of weeds and provides a more favourable environment for early crop establishment. Slow growth of crop plant provides favourable environment for emergence of weeds. Cultural as well as mechanical practices such as hand weeding and intercultural are effective but unavailability of labour and continuous rainfall in rainy season does not permit for timely management of weeds Chemical weed control is effective weed management option which provides effective control of weeds. It is well known that weeds are ubiquitous but their presence in cropped area particularly in rainy season crops like clusterbean act as major limiting factor in achieving high potential yield. The current study aimed to study the impact of crop establishment methods and weed control practices on productivity and profitability of clusterbean.

Methods: A field experiment was carried out to find out suitable method of crop establishment methods and weed management practices in clusterbean during *kharif* seasons of 2018, 2019 and 2020. The experiment was conducted in spilt plot design with three replications. The treatments were four crop establishment methods *viz.,* conventional sowing, zero tillage sowing, broad bed sowing, zero tillage sowing with mulch as main plots and four weed control practices *viz*., weedy check, pendimethalin + imazethapyr 1000 g ha^{-1}, T_3- Imazethapyr 40 g ha^{-1}, T_4- Imazethapyr+imazamox 40 g ha^{-1} as sub plot treatments .

Result: The broad bed sowing of clusterbean along with pre-emergence application of pendimethalin + imazethapyr 1000 g ha^{-1} was found effective to achieve higher productivity and farm profitability.

Key words: Clusterbean, Crop establishment, Productivity, Profitability, Weed management, Weed.

INTRODUCTION

Clusterbean (*Cyamopsis tetragonoloba* L.) is one of the important drought hardy and deep rooted and adapted to the harsh climatic conditions of arid and semi arid zone of India. In India cluster bean mainly grown during *kharif* season. India accounts for more than three-fourth (about 80%) of the global production of cluster bean. The area under the crop is reported about 53.45 ha with production is about 32.86 tones and productivity is 615 kg per ha during the year 2018-19. (Anonymous, 2019a) Rajasthan is the largest cluster been producing state in India followed by Haryana, Gujarat, UP, MP and Punjab. Rajasthan has an area of 46.30 lakh ha, production of 27.47 M tonnes and with a productivity of 593 kg per ha during the agricultural year 2014-15. The state contributes about 85 per cent of the total area under crop in the country (Anonymous, 2019b).

The clusterbean is a slow growing warm legume *kharif* season crop and weeds are serious problem due to favourable conditions for their growth. Adequate tillage checks and delays the emergence of weeds and provides a more favourable environment for early crop establishment. Slow growth of crops plant provides a more favourable environment for emergence of weeds. Cultural as well as mechanical practices such as hand weeding and intercultural are effective but unavailability of labour and continuous rainfall in rainy season does not permit to remove weeds timely. Chemical weed control is effective option which is cheaper and provides effective control of weeds. Amongst agronomic factors known to augment crop production appropriate weed management is considered to be important. Poor weed management is one of the important factor for low yield of this crop. Slow growth at initial stages of the crop favors recurrent flushes of weeds, which compete with crop for essentials of growth and cause heavy reduction

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How to cite this article: Meena, O.P., Kumar, V., Jain, S.K., Yadav, M.R., Meena, B.R., Kumar, R.K. and Yadav, S.K. (2022). Effect of Crop Establishment Methods and Weed Management Practices on Productivity and Profitability of Clusterbean under Semi-arid Region of Rajasthan. Legume Research. 45(4): 481-486. DOI: 10.18805/LR-4737.

Submitted: 16-07-2021 **Accepted:** 29-11-2021 **Online:** 24-01-2022

in its seed yield. Critical period for crop-weed competition in cluster bean has been identified as 20 to 30 days after sowing and presence of weeds showed in yield reductions by 47 to 92% Punia *et al.,* (2011). Among different weed management practices, use of herbicides is the only choice under adverse situations.

Therefore, the present study was planned to asses the effect of crop establishment method and different weed control practice for enhancing crop productivity and farm profitability of clusterbean.

MATERIALS AND METHODS

A field experiment was conducted at Agricultural Research Farm, Rajasthan Agricultural Research Institute, Durgapura, Jaipur (26° 51′ N, 75° 47′ E at an altitude of 390 m above mean sea level). The experiment was conducted during 2018 to 2020 on the same site and layout. The experimental site was characterized by cold winters and hot summers. Occurrence of frost (below 0°C) during December/January and hot desiccating winds (45 0°C) in May-June are quite common. The average annual rainfall of zone was 563 mm of which about 90% is received during later half of June to September with erratic distribution over time and apace. The soil of the experimental site was loamy sand in texture with slightly alkaline in reaction (pH 8.1). The experimental soil was low in organic carbon (2.1g kg^{-1}), high in phosphorus (34 kg ha^{-1}), medium in potassium (191 kg ha^{-1}) and sulphur (7.8 mg kg^{-1}). The experiment was conducted in spilt plot design with three replications. The treatments consisted of sixteen treatment combinations, main plots crop establishment methods *viz*. conventional sowing, zero tillage sowing, broad bed sowing, zero tillage sowing with mulch and four weed control practices are weedy check, Pendimethalin + imazethapyr 1000 g ha^{-1} pre-emergence, Imazethapyr 40 g ha^{-1} post-emergence Imazethapyr + imazamox 40 g ha^{-1} post-emergence the experiment was conducted in spilt plot design with three replications. Guar variety 'RGC 1038' was sown at 30 cm × 10 cm spacing using seed rate 20 kg ha^{-1} by seed cum fertilizer drill and by bed planter on raised beds with four rows of clusterbean on the bed (90 cm wide). The crop was fertilized with uniform dose of 20 kg N and 40 kg P_2O_5 ha^{-1} through urea and DAP, respectively. Herbicides were applied as per treatments. By knapsack sprayer fitted with a T-jet nozzle using a spray volume of 800 lt.ha^{-1} weedy check plots remain infested with native population of weeds till harvest.

Data on weed density were recorded from an area enclosed in the quadrate of 0.5m^2 randomly selected at two places in each plot. Weeds collected from 0.5 m^2 area at two places were first sun dried for 2-3 days and then oven dried at 70°C till the constant weight was recorded. The weed dry matter obtained at 60 DAS was expressed in gram per square meter (g/m^2). The data on weed density and weed dry weight thus obtained were subjected to square root transformation ($\sqrt{x+0.5}$) as wide variations existed among the treatments before statistical analysis.

The weed control efficiency (WCE) and weed index were calculated by using the following formula: The formula given by Mishra and Mishra (1997).

$$\text{Weed control efficiency (WCE)} = \frac{X-Y}{X} \times 100$$

Where,
X = Weed dry matter in weedy check (g).
Y = Weed dry matter in respective treatment (g).

Weed index is the per cent reduction in crop yield under a particular treatment due to the presence of weeds in comparison to weed free plot as suggested by Gill and Kumar (1969). This is used to assess the efficacy of a herbicide. Lesser the weed index, better is the efficiency of a herbicide. It is expressed in percentage and was determined with the help of following formula:

$$\text{Weed index (\%)} = \frac{X-Y}{X} \times 100$$

Where,
WI = Weed index; X = Crop yield from weed free plot and Y = Crop yield from the treated plot for which weed index is to be worked out.

The crop was harvested at physiological maturity when plants turned golden yellow. The net returns were computed by deducting the total cost of cultivation from the gross returns and Benefit: Cost ratio was calculated by dividing the net returns with the cost of cultivation. The data obtained on various parameters - weed count, weed density, yield attributes and yield, nutrient uptake by crop and nutrient removal by weeds were tabulated and subjected to analysis of variance techniques as described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Crop establishment methods and weed management practices on weed dynamics

The crop was mainly infested narrow leaved weeds and broad leaved weeds *viz Cyanadon dactylon, Echinochloa colona, Brachiaria ramose*, *Amarathus viridis, Digeraar vensis, Commelina benghalensis* and *Trianthema portulacustrum etc.* Pooled experimental results revealed that broad bed sowing method had significant reduce weed density over conventional method of sowing, zero tillage sowing and zero tillage sowing with mulch. The per cent of decrease in weed density in broad bed sowing method was 51 to 42% as compared to conventional method of sowing, 44 to 35% as compared to zero tillage sowing method and 40 to 25% as compared to zero tillage sowing method with mulch at different stage of crop (Table 1). This might have happened due to more foliage growth of bed sowing clusterbean which caused hindrance in germination of weeds and deeper burial of weed seeds during formation of raised beds. In the long run, pre-mixture of pendimethalin + imazethapyr @ 800 g ha^{-1} pre-emergence was found more effective for controlling monocot weeds as well as dicot

weeds. This might be due to the broad spectrum control of weeds because of combination of two herbicides with different mode of action and decreasing residual effect of pendimethalin and prolonged residual effect of imazethapyr. The result conformity was found with Soltani *et al.* (2012) Jha and Soni (2013). The weed dry weight of monocot and dicot weeds in conventional sowing plot were significantly higher than bed and zero tillage sowing with mulch.

Effect of weed management practices

All the weed management practices significantly reduce weed density over weedy check and the highest weed density was noticed in weedy check. The application of pendimethalin + imazethapyr 1000 g ha^{-1} significantly reduce weed density over weed check plot which was statistically at par with Imazethapyr+imazamox 40 g ha^{-1} and Imazethapyr 40 g ha^{-1} at different stage of crop (Table 1). The per cent of decrease in weed density over weedy check due to application of Pendimethalin + imazethapyr 1000 g ha^{-1} was 79 to 82% at different stage of crop. This might have happened due to the fact that imazethapyr inhibits the plastid aceto-lactate synthesis (ALS) in plants. The ALS inhibitors stop cell division and reduces carbohydrate translocation in susceptible plants (Gupta, 2008) Imazethapyr by virtue of wide spectrum weed control (both grassy and broad-leaved weeds) without causing any phytotoxicity to crop plants emerged as economically viable option of post-emergence application. Similar results are reported by Patil *et al.* (2013) and Sharma *et al.* (2017) in clusterbean crop.

Effect of crop establishment method and weed management practices on weed dry weight and weed index

Effect of sowing method

Three years pooled data presented in Table 1 insinuates that, weed dry weight and weed index were significantly influced by different sowing method. The significantly lowest dry weights of weed was observed in broad bed sowing method followed by zero tillage with mulch and zero tillage while highest weed dry weight observed in conventional sowing method. The per cent of decrease in weed dry weight in broad bed sowing method was 54 to 71% as compared to conventional method of sowing, 27 to 34% as compared to zero tillage sowing method with mulch on pooled basis. Significantly lower dry weight of weeds (Table 1) was observed in broad bed planting method that may be due to better crop growth in bed planting which did not allow weeds to get optimum sunlight, moisture and nutrient supply for accumulation of more dry matter in them and thus checked their growth. Similar were the findings of Jha and Soni (2013) in soyabean and Kumar *et al.,* (2006) in blackgram where broad bed planting resulted in minimum total weed count and dry matter.

Effect of weed management practices

Different weed management practices significantly reduced the dry weight of both narrow-leaved and broadleaved weeds over weedy check. On pooled basis, pendimethalin+

Table 1: Effect of crop establishment and weed control practices on weed density, dry weight and WCE (data pooled over three years).

Treatments	Weed density at 15 DAS*	Weed density at 45 DAS	Weed density at harvest	Weed dry weight at 15 DAS ($g\ ha^{-1}$)	Weed dry weight at 45 DAS ($g\ ha^{-1}$)	Weed dry weight at harvest ($g\ ha^{-1}$)	WCE at 15 DAS (%)	WCE at 45 DAS (%)	WCE at harvest (%)	Weed Index (%)
Crop establishment methods										
Conventional sowing	3.42 (13.03)	4.87 (39.17)	5.52 (47.97)	32.3	68.8	126.2	-	-	-	-
Zero tillage sowing	3.48 (11.50)	4.61 (33.69)	5.33 (42.86)	31.5	66.4	107.0	-	-	-	-
Broad bed sowing	2.86 (6.43)	3.91 (19.14)	4.44 (27.89)	18.9	44.8	78.5	-	-	-	-
Zero tillage sowing with mulch	3.33 (10.74)	4.33 (28.46)	4.88 (37.25)	25.4	52.3	93.8	-	-	-	-
SEm±	0.08	0.08	0.05	0.85	2.50	4.0	-	-	-	-
CD at 5%	0.23	0.24	0.20	2.55	7.80	13.1	-	-	-	-
Weed management practices										
Weedy check	4.84 (24.49)	6.56 (73.50)	7.29 (93.83)	52.5	115.1	179.2	00.00	00.00	00.00	00.00
Pendimethalin + imazethapyr 1000 g ha^{-1}	2.31 (5.00)	3.23 (13.84)	3.82 (18.93)	14.9	30.7	47.0	71.62	73.33	73.77	82.53
Imazethapyr 40 g ha^{-1}	3.08 (6.50)	4.08 (17.66)	4.62 (22.75)	22.0	46.4	92.8	58.10	59.69	48.21	54.18
Imazethapyr + imazamox 40 g ha^{-1}	2.86 (5.70)	3.84 (15.48)	4.44 (20.46)	18.7	40.2	86.5	64.38	65.07	51.73	59.18
SEm±	0.07	0.08	0.09	0.90	2.2	4.0	-	-	-	-
CD at 5%	0.21	0.23	0.27	2.80	7.0	12.9	-	-	-	-

*DAS: Days after spray.

imazethapyr 1000 g ha^{-1} recorded maximum reduction in total weed dry weight and maximum weed index as compared to weedy check but remained statistically at par with Imazethapyr + imazamox 40 g ha^{-1} and Imazethapyr 40 g ha^{-1} treatment. The percent of decrease in weed dry weight over weedy check due to application of Pendimethalin + imazethapyr 1000 g ha^{-1} was 72 to 84%, due to Imazethapyr + imazamox 40 g ha^{-1} was, 65 to 51% and due to Imazethapyr 40 g ha^{-1} was 60 to 48% on pooled basis. Weed index point of view highest weed index was recorded under Pendimethalin + imazethapyr 1000 g ha^{-1} (82.53%) and lowest weed index was recorded with Imazethapyr 40 g ha^{-1} (54.18%). Long lasting effects in reducing weed dry weight might be due to weed seed damage caused by pre-emergence application of Pendimethalin + imazethapyr 1000 g ha^{-1} and suppression of established plants of both narrow and broad leaved weeds by imazethapyr and its greater efficiency to retard cell division of meristems as a result of which weeds died very rapidly. Fayaz *et al.* (2017) also reported similar results of effective control in weed population and weed dry matter in mungbean. The effective control of weeds by early post-emergence application of imazethapyr + imazamox (ready mix) which was found effective against all kind of weeds especially broad-leaved weeds and resulted in significant reduction in the dry weight of weeds. Similar results are reported by Gupta *et al.* (2015) and Sharma *et al.* (2017) in clusterbean crop. All those weeds were suppressed by the application of post emergence herbicide or imposed with hand weeding. These results corroborate the findings of Gupta *et al.* (2015), Sharma *et al.* (2017) and Yadav and Mundra (2017) in clusterbean.

Crop establishment methods and weed management practices on yield attributes and yield of clusterbean

On pooled data basis the highest number of pods per plant, pod length and number of seeds per pod were found under broad bed sowing and application of pendimethalin+ imazethapyr 1000 g ha^{-1} as pre emergence herbicides. Significantly higher grain yield of cluster bean (980 kg ha^{-1}) was obtained with adoption of broad bed sowing compared to conventional sowing (849 kg ha^{-1}), zero tillage sowing with mulch (803 kg ha^{-1}) and zero tillage sowing (712 kg ha^{-1}). Significantly higher straw yield was recorded in broad bed furrow sowing as compared to conventional sowing, Broad bed provided the loose soil mass with adequate soil moisture, better growing condition and lesser competition by weeds which result in increase in yield. This might be due to the fact that under favourable soil conditions, the plant accumulates and translocates the photosynthates from source to sink more efficiently which in turn increased yield attributes and yield. Similar results of higher grain yield and straw yield were also reported earlier by Pandey *et al.* (2018) in blackgram, Garud *et al.* (2019) in pigeonpea and Halli and Angadi (2019) in cowpea also reported higher grain yield with broad bed method of sowing.

All weed management practices had significant effect on yield of clusterbean as compared to weedy check. Application of pendimethalin + imazethapyr 1000 g ha^{-1} as pre emergence recorded significantly higher yields (seed and straw yield) as compared to weedy check which was statistically at par with Imazethapyr + imazamox 40 g ha^{-1} post emergence and Imazethapyr 40 g ha^{-1} post emergence during the years of experimentation. On pooled basis (Table 2), there were 82% improvement in seed yield and 745% improving in straw yield with the application of pendimethalin + imazethapyr 1000 g ha^{-1}, Imazethapyr + imazamox 40 g ha^{-1} post emergence were 59% higher in seed yield and 34 % higher in straw yield in case application of imazethapyr 40 g ha^{-1}post emergence were 54% have higher seed yield and 52% in straw yield over the weedy check, respectively. The huge losses in yield was observed in weedy check plots due to heavy flushes of weeds during entire crop growth period and thereby caused severe more crop weed competition throughout the crop growth period for nutrients as well as moisture and thus, resulted in higher yield losses. Increase in seed yield might be due to the direct influence of various weed management treatments on the suppression of weeds. Higher grain yield in chemical weed management practices may be attributed due to effective and timely weed management under these treatments reduced the density as well as dry weight of weeds which facilitated the crop plants to have sufficient space, light, nutrient and moisture and thus the number of pods plant^{-1}, test weight and finally the yield were increased. Similar results of more grain yield (Fayaz *et al.,* 2017) are also observed in mungbean and Lhungdim *et al.* (2014). These results corroborate the findings of Sharma *et al.* (2017) and Singh and Godara (2015) in cluster bean crop.

Crop establishment methods and weed management practices on economics of clusterbean

Three years pooled data shows that (Table 2) the maximum gross returns (₹34729 ha^{-1}) and net returns (₹20229 ha^{-1}) with B: C ratio (2.40) were observed with adoption of broad bed sowing method. Pandey *et al.* (2018) also reported higher B:C ratio of 1.82 in blackgram with broad bed method. Naresh *et al.* (2015) also found that zero tillage reduced the impact of solar radiation by acting as a physical barrier resulting in lower soil temperature than the plough soil. Mulched soils retained 20 to 50% more water than unmulched soils Blanco-Canqui *et al.* (2007).

Among the various weed management practices, application of herbicides recorded higher gross return, net returns and B:C ratio over the weedy check. Three years pooled data shows that (Table 2) application of pendimethalin + imazethapyr 1000 g ha^{-1} recorded significantly higher gross returns (₹36456 ha^{-1}) and net returns (₹22958 ha^{-1}) and B: C ratio (2.70) over weedy check, imazethapyr + imazamox 40 g ha^{-1}and imazethapyr @ 40 g ha^{-1}. The weedy check treatment had monetary returns and B:C ratio (₹7277 and 1.57) due to the heavy weed infestation in the weedy check treatment which was drastically reduce the seed yield of the clusterbean. The results were in

Table 2: Effect of crop establishment and weed control practices on pooled yield attributes, yield and economics (data pooled over three years).

Treatments	No. of pods plant^{-1}	Pod length cm	No. of seeds pod^{-1}	Seed yield kg ha^{-1}	Straw yield kg ha^{-1}	GR ₹ ha^{-1}	NR ₹ ha^{-1}	B:C ratio
Crop establishment methods								
Conventional sowing	27.57	5.57	6.24	849	1971	30125	15875	2.11
Zero tillage sowing	29.43	5.66	6.11	712	1904	25640	13140	2.05
Broad bed sowing	34.89	6.42	6.98	980	2246	34729	20229	2.40
Zero tillage sowing with mulch	30.78	5.90	6.62	803	1988	28678	15028	2.10
SEm±	0.56	0.104	0.068	25	52	-	-	-
CD at 5%	1.99	0.366	0.239	76	160	-	-	-
Weed control practices								
weedy check	23.24	5.10	4.81	561	1403	20057	7277	1.57
Pendimethalin + imazethapyr 1000 g ha^{-1}	35.96	6.71	7.77	1024	2460	36458	22958	2.70
Imazethapyr 40 g ha^{-1}	31.48	5.74	6.58	865	2134	30881	17481	2.30
Imazethapyr + imazamox 40 g ha^{-1}	32.00	6.00	6.78	893	2144	31792	18342	2.36
SEm±	0.53	0.132	0.226	22	60	-	-	-
CD at 5%	1.58	0.388	0.663	65	185	-	-	-

conformity with the findings of Poornima *et al.* (2018) and Tamang *et al.* (2015).

CONCLUSION

The results of the experiment revealed that broad bed sowing method in clusterbean the seed yield (980 kg ha^{-1}), straw yield (2246 kg ha^{-1}) and B:C ratio (2.40). This was statistically significantly superior over other methods of sowing. Secondly weed control practices in clusterbean highest seed yield (1024 kg ha^{-1}), straw yield (2460 kg ha^{-1}) and B:C ratio 2.70 with pendimethalin+imazethapyr 1000 g ha^{-1} which was statistically superior over weedy chick, imazethapyr + imazamox 40 g ha^{-1} and imazethapyr 40 g ha^{-1} treatments of weed control practices.

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