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**Research Paper**

# Herbicidal weed management options for clusterbean [*Cyamopsis tetragonoloba* Taub] in arid region of Rajasthan

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## ABSTRACT

A field experiments was conducted during *kharif* season of 2022 and 2023 at Agricultural Research Station, SKRAU, Bikaner to evaluate the efficacy of pre and post emergence herbicides towards weed management in clusterbean. The maximum yield attributes, yield and weed control efficiency was recorded in weed free check. Pre-emergence application of Pendimethalin 30% EC+ Imazethapyr 2% EC-800 g/ha recorded weed control efficiency among herbicidal options. Further, post emergence application of fomesafen 12% + quizalofop-ethyl 3% @ 165 g/ha found in next order of superiority. Among herbicide treatments, maximum plant height (99.8 cm), clusters/ plant (32.3), pods/cluster (11.0), seeds/pod (7.6), test weight (30.43 g), seed yield (16.02 q/ha) and straw yield (26.17 q/ha) was recorded under pre-emergence application of pendimethalin 30% EC+ imazethapyr 2% EC @ 800 g/ha. In monetary term weed free check recorded maximum net returns (Rs 60,627/ha) and benefit-cost ratio (2.55) followed by pendimethalin 30% EC+ imazethapyr 2% EC @ 800 g/ha (58,631/ha and 2.58).

***Keywords:*** Clusterbean, Herbicide efficacy, Imazethapyr, Pendimethalin, Yield

Clusterbean [*Cyamopsis tetragonoloba* (L.) Taub] is an important leguminous crop of arid and semi-arid regions, primarily cultivated during *kharif* season, this crop is known for high adaptability to irregular and poor rainfall, and require low levels of relative humidity, plenty of sunshine and little surface water during the cropping season (Pathak and Roy 2015). It has several industrial applications, including textiles, paper, petroleum, pharmaceuticals, food processing, cosmetics, mining explosives, oil drilling, and more. It is a major source of galactomannan (28-33% guar gum). India contributes about 75–82% to global clusterbean production in 2.70 m ha area and 1.30 million tonnes production with the productivity of 471 kg/ha (Anonymous, 2022) and a leading exporter of guar gum with 80% of global acreage, followed by Pakistan. Rajasthan, Haryana, Gujarat, Punjab, Uttar Pradesh and Madhya Pradesh are the major clusterbean producing states. Rajasthan contributes 86% in area and 76% in production. In Rajasthan clusterbean grown is 29.90 lakh ha area with 16.14 lakh tonnes production and productivity of 540 kg/ha (Anonymous, 2023). It mostly grown in Bikaner, Jaisalmer, Danganagar, Hanumangarh, Barmer, Jodhpur, Churu, Nagaur, Sikar, Jhunjhunu, Jalore, Pali, Sirohi, Jaipur, Alwar and Ajmer districts.

India's clusterbean production is incredibly poor and has been constant for several decades. The primary cause of the low yield may be use of conventional low-yielding cultivars and poor agronomic management. Due to the frequent rains during *kharif* season, the weed population grows significantly. The competition for nutrients, moisture and space results in a significant yield drop (29 to 48%) depending on the type of weed and its density. Broad-leaved weeds and grasses are both present in guar crops.

Hand weeding is a popular and traditional technique of controlling weeds; nevertheless, the main obstacles include labor shortages during peak weeding seasons, rising wages that make hand weeding less economically viable. Herbicides and other chemicals may provide fast, efficient, targeted, and cost-effective weed control in terms of labor and time, their usage has become increasingly important, especially in intensive agriculture. The goal of applying herbicides in a sequential manner is to consistently and broadly control weeds during the crop's growing season. Many pre-plants incorporated (PPI) and pre-emergence

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(PRE) herbicides, such as pendimethalin, trifluralin and fluchloralin are advised in clusterbean crop, they effectively suppress weeds in the early phases of crop growth. Pre-emergence herbicides like pendimethalin might occasionally become less effective due to insufficient moisture in the surface soil caused by prevailing winds during planting (Punia *et al.,* 2011). Weed flushes later in the growing season not only hinder crop growth but also make it more difficult to realize the crop's potential yield. Thus, controlling weeds in legume crops requires the use of herbicides with longer residual activities that offer weed control throughout the growing season or the administration of pre- and post-emergence herbicides in succession. In order to combat the emergence of cross and multiple herbicide resistances in weeds, there is a growing urge for further diversification in herbicide use cycles. In this backdrop, present investigation was carried out to find out some suitable pre and post emergence herbicide and optimize the application doses in clusterbean.

## MATERIAL AND METHODS

A field experiments was conducted during *kharif* 2022 and 2023 at Agriculture Research Station, Beechwal, SKRAU, Bikaner. The soil of the experimental field was sandy loam in texture, saline in reaction (pH 8.2) and low in available N (115.5 kg/ha), medium in available P (18 kg/ha) with low organic carbon (0.13%) but high in available K (175.5 kg/ha). The experiment was laid out in Randomized block design with three replications. The 10 treatments were used such as weedy check, weed free, pendimethalin 30% EC @ 750 g/ha at PE, pendimethalin 30% + imazethapyr 2% EC @ 800 g/ha at PE, fomesafen 12% + quizalofop 3% SC @ 165 g/ha at 20 DAS, Sodium Acifluorfen 16.5% + clodinafop 8% EC @ 185 g/ha at 20 DAS, fomesafen 11.1% + fluazifop 11.1% SL @ 170 g/ha at 20 DAS, imazethapyr @ 40 g/ha at PE, fluazifop-p- butyl 13.4% @ 185g/ha at 20 DAS and propaquizafop 2.5% + imazethapyr 3.37 EC @ 95 g/ha at 20 DAS. Sowing of clusterbean variety RGr -12-1 with seed rate @ 16 kg/ha at 30 cm x 10 cm (row x plant). Other management practices were adopted as per recommendations of the crop under rainfed conditions. At harvest, five plants were taken randomly to determine the yield components as number of cluster/plants, number of pods/clusters, number of seeds/pods, test weight (1000 seed weight) and seed yield/plot. Whole plot was harvested to determine seed yield per net plot for all the plots recorded in kg and converted in to kg/ha by using conversion factors.

Weed density (number/$m^2$) and weed dry weight (g/$m^2$) were measured from the randomly selected samples at 2 places in each plot with the help of 0.5 $m^2$ quadrat at 45 days after sowing. Weed control efficiency (WCE) was calculated on the basis of dry-matter production of weeds. Data on weed count and weed biomass were subjected to square root transformation to reduce larger variation in original value by using formula [$\sqrt{(x + 0.5)}$] that is before carrying out analysis of variance and comparison among treatments were made on transformed values only. The economic analysis of each treatment was done on the basis of prevailing market prices of the inputs used and outputs obtained under each treatment. The data obtained on various observations were tabulated and statistically analysed by using the techniques of analysis of variance (ANOVA) and significance of the treatments was tested by F test. Critical difference (CD) at 5% level of significance was determined for each character to compare the differences among treatment means (Gomez and Gomez 1984).

## RESULTS AND DISCUSSION

### Effect of Weeds

#### *Weed flora*

*Amaranthus viridis, Gisekia poiedious, Digera arvensis, Portulaca olerecea, Trianthema portulacastrum* among broad-leaved weeds and *Cenchrus biflorus, Eragrostis pilosa* and *Eragrostis tanella* among grassy weeds were found in experimental field.

#### *Weed density and weed dry weight*

The maximum number of both narrow and broad-leaved weeds was found in weedy check (control), which was statistically higher over rest of treatments at 45 days after sowing (DAS) (Table 1). Among herbicide treatments, pendimethalin 30% + imazethapyr 2% EC @ 800 g/ha at PE recorded minimum and significantly lower count of both narrow and broad-leaved weeds as compared to rest of herbicidal treatments. Similarly, the maximum and significantly higher dry matter of weeds at 45 DAS was found under weedy check (control) over other treatments. Weed free check recorded the minimum dry weight of weeds. Among herbicidal treatments application of pendimethalin 30% + imazethapyr 2% EC @ 800 g/ha at PE resulted in significantly lower dry weight of weeds compared to herbicide treatments. It is because pendimethalin + imazethapyr prevented the weeds early growth. The results are in accordance with Meena *et al.* (2020). Pendimethalin + imazethapyr @ 800 g/ha as pre-emergence significantly reduced weed density and dry matter at 45 DAS. This may be attributable to the pre-emergence treatment of pendimethalin as an effective pre-emergence herbicide, pendimethalin efficiently penetrates weeds in the germination stage and inhibits both cell division and cell elongation in the root and shoot meristems of susceptible plants. With absorption through the roots and shoot area, the growth is immediately suspended. Imazethapyr suppresses ALS

**Table 1.** Effect of herbicidal weed management on weed density, weed dry matter and weed control efficiency at 45 DAS in clusterbean (2-year pooled data)

| Treatment | Narrow leaved weed density/m$^2$ | Broad leaved weed density/m$^2$ | Total weed dry matter g/m$^2$ | Weed control efficiency (%) |
|---|---|---|---|---|
| Weedy check | 4.25* (17.56) | 4.84 (23.00) | 8.29 (68.42) | - |
| Weed free | 0.71 (0.0) | 0.71 (0.00) | 0.71 (0.00) | 100.0 |
| Pendimethalin 30% EC @ 750 g/ha as pre-emergence | 3.25 (10.18) | 3.81 (14.00) | 3.62 (12.67) | 81.4 |
| Pendimethalin 30% + imazethapyr 2% EC @ 800 g/ha as pre-emergence | 0.71 (0.0) | 0.71 (0.00) | 0.71 (0.00) | 100.0 |
| Fomesafen 12% + quizalofop 3% SC @ 165 g/ha at 20 DAS | 1.86 (2.95) | 2.74 (7.00) | 2.05 (3.72) | 94.5 |
| Sodium acifluorfen 16.5% + clodinafop 8% EC @ 185 g/ha at 20 DAS | 2.59 (6.24) | 3.16 (9.50) | 2.50 (5.77) | 91.5 |
| Fomesafen 11.1% + fluazifop 11.1% SL @ 170 g/ha at 20 DAS | 2.10 (3.95) | 2.95 (8.25) | 2.20 (4.35) | 93.6 |
| Imazethapyr @ 40 g/ha as pre-emergence | 3.41 (11.11) | 4.32 (18.17) | 4.28 (17.80) | 73.7 |
| Fluazifop-p- butyl 13.4% @ 185 g/ha at 20 DAS | 3.62 (12.58) | 4.40 (18.83) | 4.67 (21.34) | 68.5 |
| Propaquizafop 2.5% + imazethapyr 3.37 EC @ 95 g/ha at 20 DAS | 3.17 (9.54) | 3.82 (14.13) | 3.14 (9.37) | 86.1 |
| SEm± | 0.04 | 0.04 | 0.06 | 0.6 |
| CD (P=0.05) | 0.13 | 0.12 | 0.19 | 1.8 |

Data in parentheses are original values. *Square root $\sqrt{(X+0.5)}$ transformation values

(aceto-lactate production) in plants, which may be exactly this occurs. In plants that are sensitive, ALS inhibitors inhibit cell division and decrease carbohydrates translocation (Gupta, 2008). Imazethapyr has the ability to control a wide range of weeds (including grassy and broad-leaved weeds) without creating any effective post-emergence methods of treatment. These findings closely match to Saras *et al.* (2016), and Meena e*t al.* (2020).

### *Weed control efficiency*

Among herbicidal treatments, maximum weed control efficiency was recorded in pendimethalin 30% + imazethapyr 2% EC @ 800 g/ha at PE which was statistically higher over rest of herbicidal treatments. The minimum weed control efficiency (68.5 per cent) was recorded in fluazifop-p-butyl 13.4% @ 185g/ha. Plants plastid enzyme aceto-lactate syntheses (ALS) is inhibited by imazethapyr. In vulnerable plants, the ALS inhibitors restrict cell proliferation and decrease the transfer of carbohydrates (Gupta, 2008). A wide spectrum of weeds is controlled by imazethapyr (Saltoni *et al.,* 2004).

## Effect on crop

### *Growth and yield attributes*

All the weed control treatments significantly increased the growth and yield attributes of clusterbean over weedy check. The maximum and significantly higher plant height (102.6 cm), cluster/plant (33.3), number of pods/cluster (11.2), number of seeds/pod (7.9) and test weight (31.0) was recorded in weedy free plot. Among herbicidal treatments maximum and significantly higher plant height (99.8 cm), cluster/plant (32.2), number of pods/cluster (11.0), number of seeds/pod (7.6) and test weight (30.4) was recorded with the pre-emergence application of pendimethalin 30% + imazethapyr 2% EC @ 800 g/ha however, it was at par with the application of fomesafen 12% + quizalofop 3% SC @ 165 g/ha at 20 DAS, sodium acifluorfen 16.5% + clodinafop 8% EC @ 185 g/ha at 20 DAS, fomesafen 11.1% + fluazifop 11.1% SL @ 170 g/ha at 20 DAS and propaquizafop 2.5% + imazethapyr 3.37 EC @ 95 g/ha (Table 2). There was less weed infestation and less competition for other growth resources like light, space, water and nutrients. Reduced crop-weed competition hence improved crop growth overall, as indicated by plant height, which in turn improved reproductive structure development and photosynthetic transfer into the sink. These results are in accordance with the finding of Yadav *et al.* (2021).

### *Yield*

Different herbicides had significant effect on seed and straw yield of clusterbean. Maximum and significantly

**Table 2.** Effect of herbicidal weed management on growth and yield attributes of clusterbean (2-year pooled data)

| Treatment | Plant Height (cm) | Cluster/plant (Nos) | Pods/cluster (Nos) | Seeds/pod (Nos) | Test weight (g) |
|---|---|---|---|---|---|
| Weedy check | 73.9 | 14.8 | 6.2 | 5.1 | 19.80 |
| Weed free | 102.6 | 33.3 | 11.2 | 7.9 | 31.02 |
| Pendimethalin 30% EC @ 750 g/ha as pre-emergence | 87.9 | 22.0 | 7.5 | 6.1 | 23.02 |
| Pendimethalin 30% + imazethapyr 2% EC @ 800 g/ha as pre-emergence | 99.8 | 32.3 | 11.0 | 7.6 | 30.43 |
| Fomesafen 12% + quizalofop 3% SC @ 165 g/ha at 20 DAS | 96.8 | 27.8 | 9.4 | 6.7 | 26.75 |
| Sodium acifluorfen 16.5% + clodinafop 8% EC @ 185 g/ha at 20 DAS | 93.3 | 26.0 | 8.6 | 6.3 | 25.12 |
| Fomesafen 11.1% + fluazifop 11.1% SL @ 170 g/ha at 20 DAS | 95.2 | 26.9 | 8.7 | 6.5 | 25.38 |
| Imazethapyr @ 40 g/ha as pre-emergence | 83.9 | 21.4 | 6.9 | 5.9 | 22.83 |
| Fluazifop-p- butyl 13.4% @ 185 g/ha at 20 DAS | 82.9 | 20.2 | 6.8 | 5.6 | 20.50 |
| Propaquizafop 2.5% + imazethapyr 3.37 EC @ 95 g/ha at 20 DAS | 93.0 | 24.5 | 8.3 | 6.2 | 25.93 |
| SEm± | 2.5 | 1.0 | 0.2 | 0.2 | 0.58 |
| CD (P=0.05) | 7.2 | 2.7 | 0.7 | 0.5 | 1.66 |

higher seed yield and straw yield was recorded in weed free plot. Among herbicides significantly higher seed, straw, biological yield and harvest index was recorded with the application of pendimethalin 30% + imazethapyr 2% EC @ 800 g/ha being at par with fomesafen 12% + quizalofop 3% SC @ 165 g/ha at 20 DAS, fomesafen 11.1% + fluazifop 11.1% SL @ 170 g/ha at 20 DAS, Sodium Acifluorfen 16.5% + clodinafop 8% EC @ 185 g/ha at 20 DAS, propaquizafop 2.5% + imazethapyr 3.37 EC @ 95 g/ha, pendimethalin 30% EC @ 750 g/ha at PE, imazethapyr @ 40 g/ha at PE, fluazifop-p- butyl 13.4% @ 185g/ha. It is notable that lower weed dry weight and higher weed control efficiency *i.e.*, lower crop-weed interface for sharing growth resources appeared to be a key factor in governing performance of yield and yield attributes of clusterbean crop. Among different weed control treat-

**Table 3.** Effect of herbicidal weed management on yield and economics of clusterbean (2-year pooled data)

| Treatments | Seed yield (q/ha) | Straw yield (q/ha) | Biological yield (q/ha) | Harvest Index (%) | Net returns (₹/ha) | Benefit: cost ratio |
|---|---|---|---|---|---|---|
| Weedy check | 8.25 | 13.63 | 21.88 | 37.89 | 15,942 | 1.48 |
| Weed free | 16.57 | 28.65 | 45.23 | 36.63 | 60,627 | 2.55 |
| Pendimethalin 30% EC @ 750 g/ha as pre-emergence | 9.97 | 19.08 | 29.05 | 34.71 | 25,211 | 1.71 |
| Pendimethalin 30% + imazethapyr 2% EC @ 800 g/ha as pre-emergence | 16.02 | 26.17 | 42.18 | 38.70 | 58,631 | 2.58 |
| Fomesafen 12% + quizalofop 3% SC @ 165 g/ha at 20 DAS | 12.10 | 23.73 | 35.83 | 33.81 | 37,311 | 2.01 |
| Sodium acifluorfen 16.5% + clodinafop 8% EC @ 185 g/ha at 20 DAS | 10.82 | 23.10 | 33.93 | 31.94 | 31,387 | 1.87 |
| Fomesafen 11.1% + fluazifop 11.1% SL @ 170 g/ha at 20 DAS | 11.52 | 22.09 | 33.62 | 34.36 | 34,971 | 1.99 |
| Imazethapyr @ 40 g/ha as pre-emergence | 9.60 | 18.77 | 28.37 | 33.93 | 23,742 | 1.67 |
| Fluazifop-p- butyl 13.4% @ 185 g/ha at 20 DAS | 9.59 | 18.14 | 27.73 | 34.53 | 22,903 | 1.64 |
| Propaquizafop 2.5% + imazethapyr 3.37 EC @ 95 g/ha at 20 DAS | 10.94 | 21.66 | 32.60 | 33.79 | 31,097 | 1.86 |
| SEm± | 0.54 | 1.29 | 1.21 | 1.80 | 2,633 | 0.07 |
| CD (P=0.05) | 1.55 | 3.70 | 3.46 | 5.16 | 7,551 | 0.21 |

ments, weed free check recorded the highest seed, haulm and biological yield but these were statistically at par with pendimethalin 30% + imazethapyr 2% EC @ 800 g/ha at PE (Table 2) revealing that these weed control options were equally effective as season long weed free check so far as productivity of in Rajasthan is concerned. This might have resulted in better availability of moisture and nutrients to the crop in absence of weeds. Moreover, increased nutrient and water uptake by crop, which could be increased photosynthates, which supply more carbohydrates, resulted in increased cell division and elongation of cells resulted to increase plant height and number of branches/plant. These results corroborate with the finding of Sangwan *et al.* (2018), Meena e*t al.* (2020) and Poonia *et al.* (2022) where application of pendimethalin + imazethapyr (RM) application resulted in higher seed yield of clusterbean as compared to other herbicide treatments due to lower weed dry matter accumulation and higher weed control efficiency providing the crop less competitive micro climate for better growth and higher seed yield. These results were in accordance with the findings of Yadav *et al.* (2011), Yadav *et al.* (2015), Kaur *et al.* (2016) and Yadav *et al.* (2021).

### *Economics*

Weed free check recorded maximum net returns (60,627 ₹/ha) followed by pendimethalin 30% + imazethapyr 2% EC @ 800 g/ha at PE (58,631 ₹/ha). This may be attributed to higher weed control efficiency, least labor requirement and higher grain and haulm yield under pendimethalin 30% + imazethapyr 2% EC @ 800 g/ha at PE. The higher seed yield recorded with this treatment might be responsible for higher net return. The comparatively lower net returns and benefit cost ratio in weed free check may be ascribed due to more labor cost. These results were in accordance with the finding of Yadav *et al.* (2013) and Yadav *et al.* (2021).

This can be concluded that pendimethalin 30% + imazethapyr 2% EC @ 800 g/ha as pre-emergence provided good control of weeds and highest weed control efficiency among herbicidal treatments.

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