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WEED MANAGEMENT THROUGH INTEGRATED APPROACH FOR ACHIEVING HIGHER PRODUCTIVITY OF CLUSTERBEAN (*CYAMOPSIS TETRAGONOLOBA* L.)

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ABSTRACT

A field experiment was conducted at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat during kharif 2023 to evaluate the performance of different integrated weed management practices in clusterbean (*Cyamopsis tetragonoloba* L.). The experiment was conducted in randomized block design with three replications and twelve treatments *viz*., pendimethalin 750 g/ha PE (T_1), imazethapyr + imazamox 50 g/ha PoE at 20 DAS (T_2), imazethapyr + imazamox 70 g/ha PoE at 20 DAS (T_3), stale seedbed *fb* mustard straw mulch 5 t/ha at 10 DAS (T_4), stale seedbed *fb* IC and hand weeding at 20 DAS (T_5), mustard straw mulch 5 t/ha at 10 DAS *fb* imazethapyr + imazamox 50 g/ha PoE at 20 DAS (T_6), mustard straw mulch 5 t/ha at 10 DAS *fb* imazethapyr + imazamox 70 g/ha PoE at 20 DAS (T_7), imazethapyr + imazamox 50 g/ha PoE at 20 DAS *fb* IC at 40 DAS (T_8), imazethapyr + imazamox 70 g/ha PoE at 20 DAS *fb* IC at 40 DAS (T_9), IC *fb* hand weeding at 20 and 40 DAS (T_{10}), Weed free (T_{11}), Unweeded check (T_{12}).

The results revealed that IC *fb* hand weeding at 20 and 40 DAS, imazethapyr + imazamox 70 g/ha PoE at 20 DAS *fb* IC at 40 DAS, and imazethapyr + imazamox 50 g/ha PoE at 20 DAS *fb* IC at 40 DAS had significantly reduced weed density of narrow, broad-leaf and total weeds after weed free treatment. All the weed control treatments significantly reduced crop-weed competition at all growth stages of clusterbean over unweeded check plot. Weed free plot had resulted the highest yield attributes and yield along with the lowest weed index followed by imazethapyr + imazamox 70 g/ha PoE at 20 DAS *fb* IC at 40 DAS, and imazethapyr + imazamox 50 g/ha PoE at 20 DAS *fb* IC at 40 DAS. These three treatments found at par with each other with respect to yield attributes and yield. The minimum seed and stover yield were observed under unweeded check plot which were significantly lower than all the weed control treatments. The maximum gross realization was accrued under weed free (T_{11}) which was followed by IC *fb* hand weeding at 20 and 40 DAS (T_{10}), *w*hereas, the maximum net realizations and B:C ratio were recorded under IC *fb* hand weeding at 20 and 40 DAS (T_{10}). The lowest gross return and net realizations were observed under unweeded check (T_{12}).

Keywords **:** Clusterbean, Weed control treatments, Weed density, Yield attributing characters, Yield, Economics

Introduction

Clusterbean (*Cyamopsis tetragonoloba* L.) is a self-pollinated, annual crop belongs to family Leguminosae. It is known as guar, recognized as one of the most important commercial crops of arid and semi-arid regions. India is the center of its origin (Vavilov, 1926), but it is also grown in Pakistan, Italy, America and Tropical Africa. India is the largest producer of clusterbean in the world. The area, production and productivity of guar in India was 27.07 lakh ha., 13.02 lakh tonnes and 481 kg/ha, respectively during 2020-

21 (Anon., 2021). Major clusterbean producing states in India are Rajasthan, Gujarat, Haryana, Uttar Pradesh, Punjab and Madhya Pradesh. Gujarat is second in terms of area and production after Rajasthan. In Gujarat, it is mainly grown in Banaskantha, Mehsana, Ahmedabad, Anand, Kheda, Gandhinagar and Kachchh districts.

Guar has drought and high temperature tolerance. It has a deep tap root system that can absorb moisture from deeper layers of the soil thus offer better scope under rainfed cultivation. It is grown for different purposes *viz*. vegetable, green fodder, gum and green manuring. The discovery of the galactomannan gum in the endosperm during 1948, popularized guar as an industrial crop. The gum has its uses in several industries *viz*. textiles, paper, petroleum, pharmaceuticals, food processing, cosmetics, mining explosives, oil drilling etc., thus making it a good foreign exchange earner (Kumawat *et al.,* 2017). At fruiting stage of plant, when the level of HCN is not harmful, green fodder of clusterbean is fed to the cattle during summer and rainy season. The byproduct of clusterbean extraction process is high value feed for cattle as it contains about 40 per cent protein.

It is well known that weeds are ubiquitous but their presence in cropped area particularly in rainy season act as major limiting factor in achieving yield potential. Inadequate weed control is one of the important factors affecting clusterbean production. Weeds reduce yield by competing with crops for water, nutrients and sunlight. Saxena *et al*. (2004) reported that the competition between weeds and crop caused 53.7% reduction in seed yield of clusterbean. Keeping the clusterbean crop weed-free during initial 20-30 days is critical for crop weed competition (Patel *et al.* 2005). Weed-free situation during initial 30 and 40 days reduced the weed dry weight by 63.4 and 75%, respectively. Mechanical methods of weed control are traditional and effective, but untimely rains, unavailability of labor at peak time and increasing labor cost are the main limitations of these methods. Hence, the alternatives of these methods need to be explored. Integrated weed management is one such option. Application of suitable herbicides with other techniques like interculturing, hand weeding, mulching and stale seedbed may be found efficient in managing weeds. Keeping in mind these facts, present experiment was planned and conducted to evaluate the performance of different integrated weed management practices in clusterbean (*Cyamopsis tetragonoloba* L.).

Materials and Methods

The field experiment was conducted at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar during *kharif* season of the year 2023. The location of the experiment comes under North Gujarat Agro-climatic Zone (AES-IV), which is characterized by semi-arid climate with cold winter and hot and dry windy summer. Generally, monsoon commences by the third week of June and retreats from the middle of September. Most of the precipitation is received from South-West monsoon, concentrating in the months of July and August. The standard week-wise meteorological data for the period of this investigation recorded at the Meteorological Observatory, Agronomy Instructional Farm, C.P. College of Agriculture, S.D. Agricultural University, Sardarkrushinagar, Banaskantha, Gujarat are presented in Fig. 1. Weather data reveled that the mean maximum temperature ranged between 30.4 to 37.4 ^{0}C, while mean minimum temperature ranged between 13.0 to 26.9 ^{0}C during the period of experimentation. The mean relative humidity recorded at morning and evening ranged from 69.3 to 95.8 and 55.8 to 89.5 per cent, respectively. During the experimental period, weekly average rainfall varied from 0.0 to 194.0 mm. The bright sunshine hours and evaporation ranged between 0.2 to 8.7 hours/day and 4.3 to 11.4 mm/day, respectively during crop period.

The soil samples were taken randomly from different spots at a depth of 0-15 cm before layout preparation of the experiment, and composite soil sample was prepared and analyzed for physical as well as chemical properties of soil. Mechanical composition analysis of the soil was done by following international pipette method as described by piper (1966) and found that the soil of the experimental field was loamy sand in texture. The pH of the soil was 7.51 (Potentiometric method; Jackson, 1973). The soil of the experimental plot was low in organic carbon (0.26%) and available nitrogen (146.0 kg/ ha); medium in available phosphorous (37.9 kg/ha) and potassium (264.16 kg/ha) content analysed through Walkley and Black method (Walkley and Black, 1934), Alkaline $KMnO_4$ method (Subbiah and Asija, 1956), Olsen's method (Olsen *et al*., 1954) and Flame photometric method (Jackson, 1973) methods, respectively.

The field experiment was carried out in randomized block design with three replications and twelve treatments. Seeds of clusterbean variety "GG-3" were sown at a depth of 2-3 cm in the lines maintaining 45 cm row to row spacing using 17 kg/ha seed rate. The crop was fertilized with 20:40:00 kg N:P:K/ha supplied through urea and DAP. The treatment comprised of pendimethalin 750 g/ha PE (T_1), imazethapyr + imazamox 50 g/ha PoE at 20 DAS (T_2), imazethapyr + imazamox 70 g/ha PoE at 20 DAS (T_3), stale seedbed *fb* mustard straw mulch 5 t/ha at 10 DAS (T_4), stale seedbed *fb* IC and hand weeding at 20 DAS (T_5), mustard straw mulch 5 t/ha at 10 DAS *fb* imazethapyr + imazamox 50 g/ha PoE at 20 DAS (T_6), mustard straw mulch 5 t/ha at 10 DAS *fb* imazethapyr + imazamox 70 g/ha PoE at 20 DAS (T_7), imazethapyr + imazamox 50 g/ha PoE at 20 DAS *fb* IC at 40 DAS (T_8), imazethapyr + imazamox 70 g/ha PoE at 20 DAS *fb* IC at 40 DAS (T_9), IC *fb* hand weeding at 20 and 40 DAS (T_{10}), weed free (T_{11}) and unweeded check (T_{12}).

Herbicides were applied as per the treatments using knapsack sprayer with flat fan nozzle. Imazethapyr + imazamox was a ready-mix herbicide. The required quantity of formulation of each herbicide for gross plots was calculated using the following formula.

$$\mathrm{Rh} = \frac{\mathrm{Ai}}{\mathrm{Ci}} \times 100$$

where,

Rh = Required quantity of formulation of herbicide per hectare (kg)

A_i = Quantity of active ingredient to be applied (kg)

C_i = Concentration of active ingredient in the trade formulation

Mustard straw mulch (5.0 t/ha) was uniformly applied in the experimental field at 10 DAS. In stale seedbed, weeds were allowed to germinate twice by providing irrigation at an interval of 15 days. After that weed were removed manually by hand weeding. Interculturing and hand weeding was done as per the treatments using manually operated cycle weeder and khurpi, whereas, in weed free plot weeding was done as and when required from sowing to harvest to maintain weed free situation. No weed management practices were done in the unweedy check plot.

Observations recorded

Five plants from each net plot were tagged to record observations of plant height and yield attributing characters. Plant height was measured at 30, 60 DAS and at harvest. Branches per plant and pods per plant were counted at harvest. The average value was worked out and recorded accordingly. Length of five pods from each tagged plant at harvest was measured and averaged to calculate pod length. At the time of threshing, seeds from five pods from each tagged plant were counted to record the average number of seeds per pod. After threshing, winnowing and cleaning, the produce from each net plot was weighed separately and converted in terms of seed yield (kg/ha). The stover yield was calculated by subtracting the corresponding seed yield from the biological yield obtained from each net plot and then converted into kg/ha.

The monocot and dicot weeds density (No./m^2) were recorded randomly at 20, 40, 60 DAS and at harvest from each plot outside the net plot leaving border area using 50 cm × 50 cm quadrate (0.25 m^2/plot). The weed data were multiplied with four to convert into No./m^2.

To know the most effective treatment, economics of each treatment was calculated using gross returns, net returns and benefit: cost ratio (BCR). Gross returns in term of rupees per hectare was worked out for each treatment from the income received from seed and stover yield of clusterbean from each treatment separately considering the recent market prices. The cost of cultivation was calculated based on the cost incurred for all the operations from the preparation of land to the harvesting of the crop and the cost of all the other inputs involved. The net returns were calculated by subtracting the total cost of cultivation from the gross returns per hectare for each treatment and recorded accordingly. The BCR was calculated on the basis of formula given below.

$$\text{Benefit : cost ratio (BCR)} = \frac{\text{Gross returns (Rs./ha)}}{\text{Total cost of cultivation (Rs./ha)}} \times 100$$

Since the data related to weeds were not normally distributed, therefore, the data were transformed using the $\sqrt{x+0.5}$ transformation as suggested by Gomez and Gomez (1984). The statistical analysis of the data collected for different parameters was carried out following the procedures as described by Panse and Sukhatme (1967) using computer system at the Computer Centre, Department of Agricultural Statistics, C.P. College of Agriculture, S.D. Agricultural University, Sardarkrushinagar. The values of calculated 'F' are taken at 5 percent level of significance.

Result and Discussion

Weed density

Clusterbean was mainly infested with mixed flora of narrow and broad leaf weeds *viz. Cynodon dactylon* L., *Dactyloctenium aegyptium* L., *Digitaria sanguinalis* L., *Cyperus rotundus* L., among monocot weed and *Boerhavia erecta* L., *Digera arvensis* L., *Amaranthus viridis* L., *Commelina benghalensis* L., *Tribulus terrestris* L., *Portulaca oleracea* L., *Leucas aspera* L., *Euphorbia hirta* L. among dicot weeds.

Similar findings were perceived by Punia *et al.* (2011) and Kushwaha *et al.* (2022). The weed free plot significantly reduced the weeds density compared to all other treatments at 20, 40, 60 DAS as well as at harvest. After weed free treatment, the minimum narrow leaf, broad leaf and total weed density at 20 DAS was observed under pendimethalin 750 g/ha PE (T_1) *i.e*. 2.86, 3.87 and 4.76 weeds/m^2, respectively followed by stale seedbed *fb* mustard straw mulch 5 t/ha at 10 DAS (T_4) and stale seedbed *fb* IC and hand weeding at 20 DAS (T_5) (Table 1). These three treatments adjudged at par with each other and reduced the narrow leaf, broad leaf and total weed density significantly than all other weed control treatments except weed free. The minimum weed density in these treatments was due to pre-emergence herbicide application in T_1 and adoption of stale seedbed in T_4 and T_5. These findings were also supported by Singh *et al.* (2023). After weed free plot, minimum density of narrow leaf (2.86/m^2), broad leaf (3.71/m^2) and total weeds (4.64/m^2) at 40 DAS was observed under stale seedbed *fb* IC and hand weeding at 20 DAS (T_5) followed by IC *fb* hand weeding at 20 and 40 DAS (T_{10}). The reduction in weed density under these treatments is due to removal of weeds through manual and mechanical methods (T_5 and T_{10}) and killing of weeds by PoE application of imazethapyr + imazamox (ready mix). The highest narrow leaf (7.40/m^2), broad leaf (8.84/m^2) and total weed density (11.67/m^2) was recorded under unweeded check, which was significantly higher over rest of the treatments. These findings were accordance with the findings of Saras *et al.* (2016).

The density of narrow, broad leaf and total weeds was significantly reduced by all the weed management practices over unweeded check at 60 DAS. After weed free plot, minimum narrow leaf, broad leaf and total weed density was recorded under IC *fb* hand weeding at 20 and 40 DAS (T_{10}) *i.e.* 2.39, 3.12 and 3.87 weeds/m^2, respectively followed by imazethapyr + imazamox 70 g/ha PoE at 20 DAS *fb* IC at 40 DAS (T_9) and imazethapyr + imazamox 50 g/ha PoE at 20 DAS *fb* IC at 40 DAS (T_8) (Table 2). These three treatments remain at par with each other for reducing weed density. Maximum narrow leaf, broad leaf and total weed density was found under unweeded check which was significantly higher over all other treatments. The reduction in weed density in T_{10}, T_9 and T_8 was due to effective weed control through integrated approach. These findings were accordance with the findings of Yadav and Mundra (2017), Borana *et al.* (2021) and Saras *et al.* (2016). Similar trend was also observed at harvest. After weed free plot, the minimum narrow leaf, broad leaf and total weed density was recorded under IC *fb* hand weeding at 20 and 40 DAS (T_{10}) *i.e.* 2.12, 2.86 and 3.50 weeds/m^2, respectively followed by imazethapyr + imazamox 70 g/ha PoE at 20 DAS *fb* IC at 40 DAS (T_9) and imazethapyr + imazamox 50 g/ha PoE at 20 DAS *fb* IC at 40 DAS (T_8) (Table 2). These three-treatment adjudged at par with each other. At harvest also, the maximum narrow leaf, broad leaf and total weed density was recorded under unweeded check (T_{12}) *i.e.* 7.67, 10.09 and 12.67 weeds/m^2, respectively which was significantly higher over rest of the treatments.

Plant growth

The data related to effect of different weed management treatments on growth parameters of the clusterbean is presented in Table 3. Different weed control treatments did not significantly affect the plant height at 30 DAS. Unlike 30 DAS, weed management practices significantly affected plant height of clusterbean at 60 DAS and harvest. Significantly taller plants were observed under weed free treatment (T_{11}) *i.e.* 84.98 and 105.18 cm followed by IC fb hand weeding at 20 and 40 DAS (T_{10}) *i.e.* 80.84 and 102.90 cm, imazethapyr + imazamox 50 g/ha PoE at 20 DAS fb IC at 40 DAS (T_8) *i.e.* 78.42 and 100.70 cm and imazethapyr + imazamox 70 g/ha PoE at 20 DAS fb IC at 40 DAS (T_9) *i.e.* 75.29 and 96.60 cm at 60 DAS and harvest, respectively. All these treatments adjudged at par with each other with respect to the plant height at 60 DAS and harvest, and found significantly superior over rest of treatments. The lowest plant height *i.e.* 62.77 and 76.53 cm was recorded under unweeded check (T_{12}) at 60 DAS and harvest, respectively, which remained significantly lower than rest of the weed control treatments. Controlling weeds through interculturing and herbicide application resulted into less crop-weed competition and created favourable environment for plant growth. Thus, enhanced the availability of nutrients, water, light and space, which might have accelerated the photosynthetic rate, thereby increased the supply of carbohydrates leads to increase in growth in all treatments except unweeded check. Under unweeded check, significantly lower plant height was witnessed due to severe crop weed competition. The present outcomes were also supported by Saras *et al.* (2016).

The Maximum number of branches per plant were observed under weed free treatment (T_{11}) *i.e.* 8.53 followed by IC fb hand weeding at 20 and 40 DAS (T_{10}) *i.e.* 8.40, imazethapyr + imazamox 70 g/ha PoE at 20 DAS fb IC at 40 DAS (T_9) *i.e.* 8.20 and imazethapyr + imazamox 50 g/ha PoE at 20 DAS fb IC at 40 DAS (T_8) *i.e.* 7.67, which were significantly higher over rest of the treatments. More branches per plant was the result of better control of weeds as indicated by lower density of weeds which drastically lowered the crop weed competition and enhanced number of branches/plant. Unweeded check (T_{12}) witnessed the minimum branches per plant *i.e.* 6.67, due to higher competition for resources *viz.* sunlight, water, nutrients and air which were beneficial for better development of crop. Similar results were also reported by Saras *et al.* (2016). Data indicated that the different weed control treatments did not influence the pod length significantly. Though the pod length did not influence by different weed control treatments significantly, the maximum and minimum length of pods was obtained under weed free (T_{11}) *i.e.* 6.11 cm and unweeded check (T_{12}) *i.e.* 5.05 cm, respectively.

Different weed control treatments significantly affected the number of pods per plant. The maximum pods per plant were observed under weed free (T_{11}) *i.e.* 33.13 followed by IC fb hand weeding at 20 and 40 DAS (T_{10}) *i.e.* 31.80, imazethapyr + imazamox 70 g/ha PoE at 20 DAS fb IC at 40 DAS (T_9) *i.e.* 30.73 and imazethapyr + imazamox 50 g/ha PoE at 20 DAS fb IC at 40 DAS (T_8) *i.e.* 29.20, which remained at par with weed free treatment, whereas, the minimum pods per plant was recorded under unweeded check (T_{12}) *i.e.* 22.53 which were significantly lower over all other weed control treatments. This might be due to severe competition by weeds in T_{12} for resources, which made the crop incompetent to take up adequate moisture and nutrients, consequently growth was adversely affected. Poor growth and less uptake of nutrients might have produced less photosynthates and partitioned less assimilates to numerous metabolic sinks which ultimately led to the poor development of pods. These results are in conformity with the findings by Saras *et al.* (2016) and Yadav and Mudra (2017). Different weed control treatments did not influence the seeds per pod significantly, but the maximum and minimum seeds per pod was obtained under weed free and unweeded check *i.e.* 8.67 and 7.00, respectively.

Yield

All weed management treatment significantly increased seed yield of clusterbean over unweeded check (Table 3). Critical examination of data revealed that the maximum seed yield *i.e.,* 1266.24 kg/ha was obtained under weed free treatment (T_{11}) followed by IC *fb* hand weeding at 20 and 40 DAS (T_{10}) *i.e.* 1189.31 kg/ha, imazethapyr + imazamox 70 g/ha PoE at 20 DAS *fb* IC at 40 DAS (T_9) *i.e.* 1134.03 kg/ha and imazethapyr + imazamox 50 g/ha PoE at 20 DAS *fb* IC at 40 DAS (T_8) *i.e.* 1112.89 kg/ha. All these above-mentioned treatments remained at par with each other with respect to seed yield. The lowest seed yield was observed under unweeded check (T_{12}) *i.e.* 707.40 kg/ha, which was significantly lower over all other treatments. The seed yield was reduced by 55.83 per cent in unweeded check as compared to weed free. The maximum seed yield in weed free treatment was due to maximum number of pods per plant which in turn was because of improvement in plant height and number of branches. The increased seed yield in this treatment could also be attributed to the efficient utilization of growth resources and reduced crop weed competition due to better control of weeds. Analogous findings have been reported by Saras *et al.* (2016) and Yadav and Mudra (2017). Similar to seed yield, different weed control treatments also affected the stover yield of clusterbean significantly (Table 3). Maximum stover yield *i.e.,* 3891.35 kg/ha was obtained under weed free treatment (T_{11}) followed by IC *fb* hand weeding at 20 and 40 DAS (T_{10}) *i.e.* 3524.92 kg/ha, imazethapyr + imazamox 70 g/ha PoE at 20 DAS *fb* IC at 40 DAS (T_9) *i.e.* 3294.67 kg/ha and imazethapyr + imazamox 50 g/ha PoE at 20 DAS *fb* IC at 40 DAS (T_8) *i.e.* 3266.29 kg/ha. All these above-mentioned treatments remained at par with each other with respect to seed yield. The lowest stover yield was observed under unweeded check (T_{12}) *i.e.* 1784.64 kg/ha which was significantly lower over all other treatments. The maximum stover yield of clusterbean in weed free treatment was due to improvement in plant height and number of branches. This was due to less competition of weeds for growth resources in these treatments that resulted in increased crop growth, resource utilization by the crop, efficient production, partitioning and translocation of photosynthates which finally turned into higher stover yield of clusterbean.

Seed index

The different weed control treatments did not influence the seed index significantly. Though the seed index did not influence by different weed control treatments significantly (Table 3), the maximum and minimum seed index was obtained under weed free and unweeded check *i.e.* 3.15 g and 2.92 g, respectively.

Economics

Data pertaining to economics of different treatments are presented in Table 4. The maximum gross realization (Rs. 1,00,774/ha) was accrued under weed free (T_{11}) which was followed by IC *fb* hand weeding at 20 and 40 DAS (T_{10}) Rs. 93,611/ha. Though, the maximum gross realization was obtained under $T_{11,}$ the maximum net realization (Rs. 56,911/ha) and B:C ratio (2.55) were recorded under IC *fb* hand weeding at 20 and 40 DAS (T_{10}). The maximum benefit under this treatment is due to of effective weed control and lower cost of cultivation as compared to weed free treatment. The higher cost of cultivation under weed free treatment was due to the highest labour cost incurred for weeding operations. The lowest gross return and net realizations *i.e.* Rs. 53,184 and 20251 per hectare, respectively were observed under unweeded check (T_{12}), whereas, the lowest B:C (1.55) was observed under stale seedbed *fb* mustard straw mulch 5 t/ha at 10 DAS (T_5). Kushwaha *et al.* (2022) also reported similar results.

Conclusion

Based on the results of one year experiment, it is concluded that carry out interculture *fb* hand weeding at 20 and 40 DAS or apply imazethapyr + imazamox 70 g/ha PoE at 20 DAS *fb* interculture at 40 DAS or imazethapyr + imazamox 50 g/ha PoE at 20 DAS *fb* interculture at 40 DAS for effective weed control and getting higher yield and net returns of clusterbean.

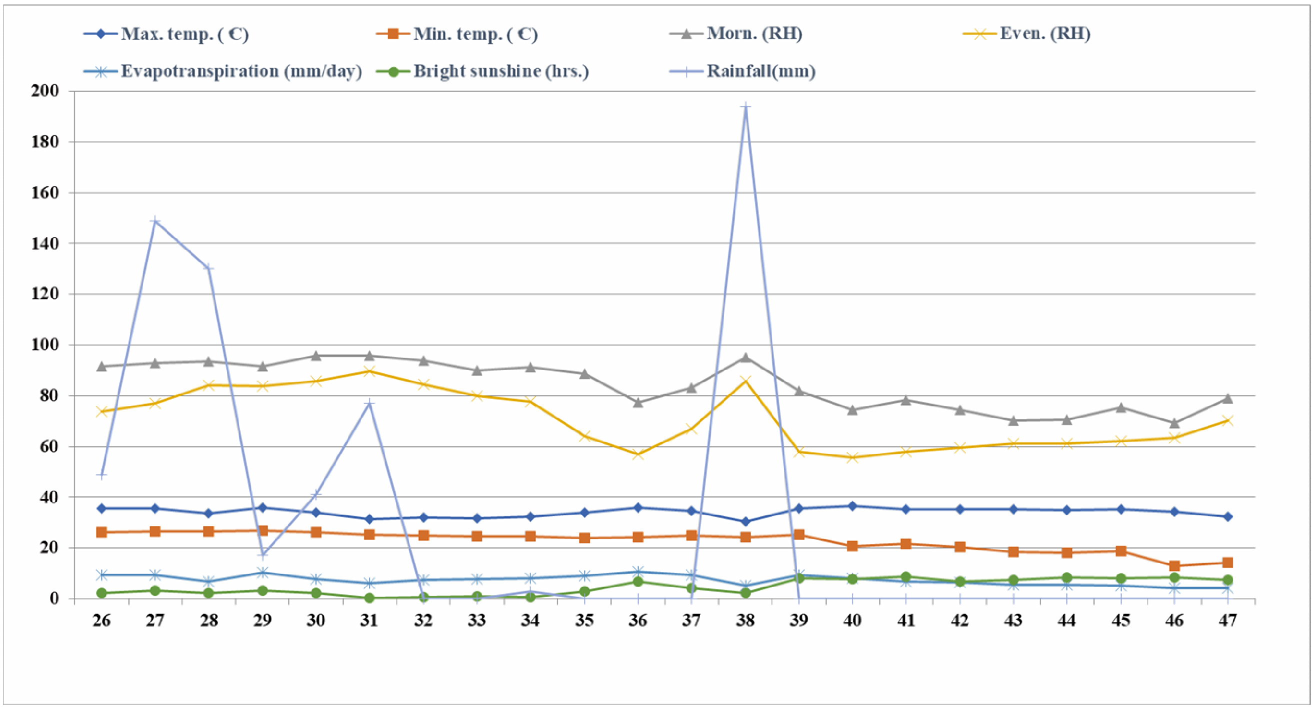

Fig. 1: Mean weekly weather parameters recorded during crop growth period of *kharif* 2023

Table 1: Effect of different weed control treatments on weed density at 20 and 40 DAS in clusterbean

Treatment		Weed density at 20 DAS (No./m^2)			Weed density at 40 DAS (No./m^2)		
		Narrow leaf	Broad leaf	Total	Narrow leaf	Broad leaf	Total
T_1	Pendimethalin 750 g/ha PE	2.86 (8.00)	3.87 (14.67)	4.76 (22.67)	4.81 (22.67)	5.21 (26.67)	7.06 (49.33)
T_2	Imazethapyr + imazamox 50 g/ha PoE at 20 DAS	5.06 (25.33)	6.76 (45.33)	8.43 (70.67)	3.89 (14.67)	4.81 (22.67)	6.15 (40.00)
T_3	Imazethapyr + imazamox 70 g/ha PoE at 20 DAS	4.67 (21.33)	6.56 (42.67)	8.02 (64.00)	3.57 (13.33)	4.37 (18.67)	5.64 (33.33)
T_4	Stale seedbed *fb* mustard straw mulch 5 t/ha at 10 DAS	3.33 (10.67)	4.18 (17.33)	5.31 (28.00)	5.06 (25.33)	5.44 (29.33)	7.42 (54.67)
T_5	Stale seedbed *fb* IC and hand weeding at 20 DAS	3.54 (12.00)	4.34 (18.67)	5.56 (30.67)	2.86 (8.00)	3.71 (13.33)	4.64 (22.67)
T_6	Mustard straw mulch 5 t/ha at 10 DAS *fb* imazethapyr + imazamox 50 g/ha PoE at 20 DAS	4.51 (26.67)	6.36 (41.33)	7.78 (68.00)	3.84 (14.67)	4.51 (20.00)	5.90 (36.00)
T_7	Mustard straw mulch 5 t/ha at 10 DAS *fb* imazethapyr + imazamox 70 g/ha PoE at 20 DAS	4.04 (21.33)	6.25 (38.67)	7.42 (60.00)	3.03 (9.33)	4.04 (16.00)	5.05 (28.00)
T_8	Imazethapyr + imazamox 50 g/ha PoE at 20 DAS *fb* IC at 40 DAS	4.81 (20.00)	6.86 (46.67)	8.35 (66.67)	3.66 (13.33)	4.64 (21.33)	5.88 (42.67)

T_9	Imazethapyr + imazamox 70 g/ha PoE at 20 DAS *fb* IC at 40 DAS	5.17 (22.67)	7.00 (49.33)	8.20 (72.00)	3.54 (12.00)	4.22 (17.33)	5.46 (30.67)
T_{10}	IC *fb* hand weeding at 20 and 40 DAS	4.97 (24.00)	6.67 (44.00)	8.27 (68.00)	3.33 (10.67)	3.80 (14.67)	5.03 (25.33)
T_{11}	Weed free	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
T_{12}	Unweeded check	4.97 (25.33)	6.84 (46.67)	8.50 (72.00)	7.40 (54.67)	8.94 (81.33)	11.67 (136.00)
S.Em. ±		0.322	0.348	0.341	0.390	0.384	0.429
CD at 5%		0.95	1.02	1.00	1.14	1.13	1.56
C.V. (%)		13.80	10.90	8.70	15.80	14.70	10.90

Note: Square root transformation (√x+0.5) was applied to the original values which are given in the parenthesis

Table 2: Effect of different weed control treatments on weed density at 60 DAS and harvest in clusterbean

Treatment		Weed density at 60 DAS (No./m^2)			Weed density at harvest (No./m^2)		
		Narrow leaf	Broad leaf	Total	Narrow leaf	Broad leaf	Total
T_1	Pendimethalin 750 g/ha PE	5.21 (26.67)	5.89 (34.67)	7.85 (61.33)	4.94 (24.00)	5.56 (30.67)	7.43 (54.67)
T_2	Imazethapyr + imazamox 50 g/ha PoE at 20 DAS	4.53 (20.00)	5.33 (28.00)	6.96 (48.00)	4.37 (18.67)	5.07 (25.33)	6.66 (44.00)
T_3	Imazethapyr + imazamox 70 g/ha PoE at 20 DAS	3.89 (14.67)	4.81 (22.67)	6.15 (37.33)	3.71 (13.33)	4.51 (20.00)	5.81 (33.33)
T_4	Stale seedbed *fb* mustard straw mulch 5 t/ha at 10 DAS	5.46 (29.33)	6.04 (36.00)	8.11 (65.33)	5.06 (25.33)	5.90 (34.67)	7.77 (60.00)
T_5	Stale seedbed *fb* IC and hand weeding at 20 DAS	3.50 (12.00)	4.37 (18.67)	5.58 (30.67)	3.33 (10.67)	4.20 (17.33)	5.33 (28.00)
T_6	Mustard straw mulch 5 t/ha at 10 DAS *fb* imazethapyr + imazamox 50 g/ha PoE at 20 DAS	4.36 (18.67)	5.17 (26.67)	6.76 (45.33)	4.18 (17.33)	4.94 (24.00)	6.45 (41.33)
T_7	Mustard straw mulch 5 t/ha at 10 DAS *fb* imazethapyr + imazamox 70 g/ha PoE at 20 DAS	3.68 (13.33)	4.67 (21.33)	5.91 (34.67)	3.50 (12.00)	4.34 (18.67)	5.53 (30.67)
T_8	Imazethapyr + imazamox 50 g/ha PoE at 20 DAS *fb* IC at 40 DAS	2.86 (8.00)	3.66 (13.33)	4.61 (21.33)	2.65 (6.67)	3.50 (12.00)	4.36 (18.67)
T_9	Imazethapyr + imazamox 70 g/ha PoE at 20 DAS *fb* IC at 40 DAS	2.65 (6.67)	3.50 (12.00)	4.36 (18.67)	2.39 (5.33)	3.33 (10.67)	4.06 (16.00)
T_{10}	IC *fb* hand weeding at 20 and 40 DAS	2.39 (5.33)	3.12 (9.33)	3.87 (14.67)	2.12 (4.00)	2.86 (8.00)	3.50 (12.00)
T_{11}	Weed free	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
T_{12}	Unweeded check	8.11 (65.33)	10.21 (104.00)	13.03 (169.33)	6.84 (46.67)	9.75 (94.67)	11.90 (141.33)
S.Em. ±		0.249	0.278	0.261	0.272	0.292	0.295
CD at 5%		0.73	0.82	0.76	0.82	0.86	0.867
C.V. (%)		11.00	10.10	7.40	13.30	11.10	8.80

Note: Square root transformation (√x+0.5) was applied to the original values which are given in the parenthesis

Table 3: Effect of different weed control treatments on growth, yield attributing characters and yield of clusterbean

Treatment		Plant height (cm)			Branches per plant	Pod length (cm)	Pods per plant	Seeds per pod	Seed yield (kg/ha)	Stover yield (kg/ha)	Seed Index (g)
		30 DAS	60 DAS	At harvest							
T_1	Pendimethalin 750 g/ha PE	31.78	66.32	84.46	7.07	5.89	24.27	7.13	951.16	2478.47	2.93
T_2	Imazethapyr + imazamox 50 g/ha PoE at 20 DAS	26.23	68.14	89.45	7.20	6.07	24.80	7.40	989.23	2647.52	2.94
T_3	Imazethapyr + imazamox 70 g/ha PoE at 20 DAS	23.75	67.19	86.18	7.27	6.06	25.60	7.27	1013.08	2719.37	2.98
T_4	Stale seedbed *fb* mustard straw mulch 5 t/ha at 10 DAS	30.56	65.15	81.98	6.87	5.71	23.47	7.07	895.62	2181.25	2.93
T_5	Stale seedbed *fb* IC and hand weeding at 20 DAS	28.94	73.54	93.66	7.60	6.22	27.67	7.60	1075.11	3058.41	3.03
T_6	Mustard straw mulch 5 t/ha at 10 DAS *fb* imazethapyr + imazamox 50 g/ha PoE at 20 DAS	27.51	72.91	92.42	7.00	6.15	26.33	7.53	1046.67	2894.06	3.00
T_7	Mustard straw mulch 5 t/ha at 10 DAS *fb* imazethapyr + imazamox 70 g/ha PoE at 20 DAS	24.96	68.54	87.44	7.40	6.14	27.60	7.47	1060.90	2972.83	3.01
T_8	Imazethapyr + imazamox 50 g/ha PoE at 20 DAS *fb* IC at 40 DAS	26.82	78.42	100.70	7.67	6.31	29.20	8.13	1112.89	3266.29	3.04
T_9	Imazethapyr + imazamox 70 g/ha PoE at 20 DAS *fb* IC at 40 DAS	24.25	75.29	96.60	8.20	6.24	30.73	7.93	1134.03	3294.67	3.08
T_{10}	IC *fb* hand weeding at 20 and 40 DAS	28.25	80.84	102.90	8.40	6.57	31.80	8.33	1189.31	3524.92	3.14
T_{11}	Weed free	32.57	84.98	105.18	8.53	6.87	33.13	8.67	1266.24	3891.35	3.15
T_{12}	Unweeded check	22.57	62.77	76.53	6.67	5.52	22.53	7.00	707.40	1784.64	2.92
S.Em. ±		2.17	4.07	5.34	0.38	0.42	1.68	0.36	64.50	215.83	0.18
CD at 5%		NS	11.95	15.65	1.12	NS	4.92	NS	189.16	633.01	NS
C.V. (%)		13.76	9.80	10.11	8.81	11.78	10.66	8.09	10.79	12.92	10.17

Table 4: Effect of different weed control treatments on economics of clusterbean

Treatment		Total cost of cultivation (Rs./ha)	Gross realization (Rs./ha)	Net realization (Rs./ha)	BCR
T_1	Pendimethalin 750 g/ha PE	33793	72141	38348	2.13
T_2	Imazethapyr + imazamox 50 g/ha PoE at 20 DAS	34329	75588	41258	2.20
T_3	Imazethapyr + imazamox 70 g/ha PoE at 20 DAS	34737	77475	42737	2.23
T_4	Stale seedbed *fb* mustard straw mulch 5 t/ha at 10 DAS	43027	66709	23682	1.55
T_5	Stale seedbed *fb* IC and hand weeding at 20 DAS	39920	83599	43678	2.09
T_6	Mustard straw mulch 5 t/ha at 10 DAS *fb* imazethapyr + imazamox 50 g/ha PoE at 20 DAS	41203	80719	39516	1.96
T_7	Mustard straw mulch 5 t/ha at 10 DAS *fb* imazethapyr + imazamox 70 g/ha PoE at 20 DAS	41611	82132	40521	1.97
T_8	Imazethapyr + imazamox 50 g/ha PoE at 20 DAS *fb* IC at 40 DAS	35836	87339	51503	2.44
T_9	Imazethapyr + imazamox 70 g/ha PoE at 20 DAS *fb* IC at 40 DAS	36244	88729	52485	2.45
T_{10}	IC *fb* hand weeding at 20 and 40 DAS	36700	93611	56911	2.55
T_{11}	Weed free	48756	100774	52018	2.07
T_{12}	Unweeded check	32933	53184	20251	1.61

Abbreviations

DAS	:	Days after sowing
fb	:	Followed by
HW	:	Hand weeding
IC	:	Interculturing
PE	:	Pre-emergence
PoE	:	Post-emergence
SSB	:	Stale seedbed

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