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Growth and yield performance of cowpea as influenced by weed management practices in south Gujarat condition

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Abstract
A field experiment was carried out during the summer season of 2019 on vertisol soil to study the integrated efficacy of various herbicides applied as pre and post-emergence in cowpea (*Vigna unguiculata* L.). Among the different weed management practices, application of Pendimethalin 750 g/ha (PE) *fb* HW at 30 DAS found superior while weed free (2 HW at 20 and 40 DAS) and Pendimethalin 750 g/ha (PE) *fb* Imazethapyr 60 g/ha at 30 DAS remained at par and significantly reduced the density and dry weight of weeds. Hence, it resulted in significantly higher seed yield of cowpea. On the basis of results obtained, Pendimethalin 750 g/ha (PE) *fb* HW at 30 DAS found appropriate. Moreover, in view of the increasing wages and crisis of labour at critical periods, application of Pendimethalin 750 g/ha (PE) *fb* Imazethapyr 60 g/ha at 30 DAS can be proved equally effective and remunerative weed management option for cowpea.

Keywords: Cowpea, weed dry weight, herbicides, weed management

Introduction
Pulses are an integral part of many diets across the globe and they have great potential to improve human health, conserve our soils, protect the environment and contribute to global food security. The United Nations, declared 2016 as “International Year of Pulses” (IYP). India is the largest producer (25% of global production), consumer (27% of world consumption) and importer (14%) of pulses in the world. Pulses account for around 20 per cent of the area under food grains and contribute around 7-10 per cent of the total food grains production in the country (Mohanty and Satyasa, 2015) [16]. Cowpea (*Vigna unguiculata* L.) is one of the important legumes which grown extensively under tropical and sub-tropical areas of the world. Cowpea is a most versatile *kharif* as well as summer pulse, because of its smothering nature, drought tolerant character, soil restoring properties and multipurpose uses. The real yield limiting factor in cowpea is inadequate source and sinks, limiting quality seed production (Kumar and Sarlach, 2014) [12]. Besides these inadequate weed control had also been identified as a major contributory factor for yield gap. Cowpea competes poorly with weeds in the growing stage. This is made under irrigation where adequate moisture supply encourages the rapid growth of weeds. Yield losses caused by weeds alone in cowpea production can range from 25 to 76% depending on the cultivar and environment (Gupta *et al.*, 2016) [8]. Weeds may mechanically be managed by two hand weeding at 20 & 40 DAS. But manual hand weeding is labour intensive and tedious and does not ensure weed removal at critical stage of crop-weed competition. Even non-availability and high wages of labour during critical period warrant an effective and economical weed control practice. Nevertheless, chemical herbicides become cost-effective. Thus, it is a major challenge to maximize productivity of this important pulse crop. Under this situation, an integrated weed management (IWM) practice involving both chemical and other agronomic manipulation may be an efficient tool, as increasing crop density seems to be an alternative to shift crop weed competition in flavour of crop. Hence, evolving a proper management strategy was felt to avert such yield loss due to weeds in cowpea.

Materials and Methods
Description of the study area
The experiment was conducted at College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari during summer 2019.

The Navsari Agricultural University campus is geographically located at 20º 57’ N latitude and 72º 54’ E longitude at an altitude of 10 m above the mean sea level. The soil of the experimental field was clayey in texture, low, medium and high in available nitrogen (209 kg /ha), phosphorus (40.6 kg /ha) and potassium (384 kg /ha), respectively. Soil sample analysis was done at the department of soil science. During the course of investigation (11^{th} standard week to 23^{rd} standard week) the weekly mean maximum and minimum temperature varied from 33.4 °C to 39.4 °C and 13.8 °C to 27.1 °C, respectively. The mean morning relative humidity (7:00 a. m.) ranged from 80.7 to 89.0 percent and 38.6 to 71.2 percent at evening (2:30 pm). Mean bright sunshine hours were available in the range of 7.7 to 10.8 hrs/day. In general, the weather conditions were found normal and congenial for satisfactory growth and development of cowpea crop without the incidence of any major pest and disease during investigation.

Experimental material

Cowpea variety GC-5 was used as test crop in the experiment which was released from Sardar Dantiwada Krushi University (SDAU) in 2005. This variety is resistant to yellow mosaic virus. It attains physiological maturity in 70-75 days.

Treatments and experimental design

The trial was laid out in a randomized block design with nine treatments with four replication. Nine treatments comprised *viz.*, Weedy check (W_1), Weed free (2 HW at 20 and 40 DAS: W_2), Pendimethalin 750 g/ha PE (W_3), Imazethapyr 60 g/ha at 20 DAS (W_4), Quizalofop ethyl 40 g/ha at 20 DAS (W_5), Pendimethalin 750 g/ha (PE) *fb* 1HW at 30 DAS (W_6), Pendimethalin 750 g/ha (PE) *fb* Imazethapyr 60 g/ha at 30 DAS (W_7), Pendimethalin 750 g/ha (PE) *fb* Quizalofop ethyl 40 g/ha at 30 DAS (W_8) and Stale seed bed (destroy one flush of weeds) (W_9).

Experimental procedure and management

The experimental field was ploughed to get a fine seedbed using tractor and the plots were leveled manually. The gross plot size was 2.7 m × 2.7 m (7.29 m^2). The pathway between replications and plots were 1 and 0.5 m, respectively. The ‘GC-5’ cowpea was sown manually keeping the row distance of 45cm with the seed rate of 25 kg/ha during second week of March. Entire quantity of nitrogen (20 kg/ha) and phosphorus (40 kg/ha) in the form of urea and single super phosphate, respectively were applied as basal. The herbicides were applied as per the treatment in the assigned plots as pre-emergence within one day after planting. The herbicides were applied using knapsack sprayer fitted with flat fan nozzle by mixing in 500 litres of water/ha. The outermost one row of each plot considered as borders. Thus the net plot size was 1.8 m × 1.8 m (3.24 m^2). All the recommended practices, except the treatments, were followed to raise the crop. The crop was harvested on 10 June 2019 at Navsari. The harvested produce was sun-dried for 5-6 days and threshing and winnowing was done subsequently.

Data collection and analysis

Weed data

Weed population was recorded using 0.25 quadrate and then converted into number of weeds/m^2. Two representative spots in each plot were selected randomly. The monocot, dicot and sedges weeds were separately counted at 20 and 40 DAS as well as at maturity of cowpea. The data were subjected to square root transformation (x+0.5) to normalize their distribution (Gomez and Gomez 1984). After uprooting of weeds, the weeds were sun-dried completely till reached to constant weight and finally the dry weight was recorded for each treatment and expressed as g/m^2. Weed control efficiency and weed index were calculated by the formulae suggested by Kondap and Upadhya (1985) [11].

Crop data

Plant height, branches, no. of pods/plant and no. of seeds/pod was taken from randomly pre tagged five plants from each net plot.

Grain yield (kg/ha)

The grain yield was measured after threshing the sun-dried plants harvested from each net plot and the yield was adjusted at 10.5% seed moisture content. The grain weight obtained in five plants was added to the final yield.

Harvest index (%)

This parameter was calculated by dividing the grain yield by the above ground biomass yield and multiplied by 100.

Results and Discussion

Crop parameters

Plant height

Higher plant height at 60 DAS and at harvest (73.95 cm and 74.50 cm, respectively) was found under Pendimethalin 30 EC 750 g/ha PE *fb* HW at 30 DAS treatment (W6), which was found to be at par with weed free (2 HW at 20 and 40 DAS: W2) and Pendimethalin 30 EC 750 g/ha PE *fb* Imazethapyr 10 SL 60 g/ha at 30 DAS (W7). It might be due to aforesaid treatments seems to be on account of their direct impact on reduction in density and periodical weed dry matter accumulation that caused reduction in crop–weed competition to the considerable extent. It results crop utilize more moisture and nutrient from deeper layers. These findings are in covenant with those of Mekonnen and Dessie (2017) [13].

Number of branches/plant

Application of Pendimethalin 30 EC 750 g/ha PE *fb* HW at 30 DAS (W6) observed significantly higher numbers of branches/plant and the lowest branches were found under weedy check (W1). This might be due to treatment provide a weed free environment which saved the growth inputs like moisture, nutrients, light, space and provided better edaphic and nutritional environment in rhizosphere. These finding are in harmony with the results with those of Telugu *et al.* (2014) [25].

Table 1: Growth, yield attributes & yield and economics of cowpea as influenced by different weed management practices

Treatments	Plant height (cm)	No. of branches/ plant	Pods/plant (no.)	Seeds/pod (no.)	Seed yield (kg/ha)	Stover yield (kg/ha)	B:C	Net return (₹/ha)
Weedy check (control)	58.75	13.30	6.65	7.40	404	829	0.50	8887
Weed free (2 HW at 20 and 40 DAS)	71.75	19.00	11.25	10.95	1335	2026	2.55	61930
Pendimethalin 750 g/ha (PE)	64.25	15.50	9.25	8.50	715	1602	1.48	28485
Imazethapyr 60 g/ha at 20 DAS	65.85	16.45	9.55	9.00	801	1711	1.80	34217
Quizalofop ethyl 40 g/ha at 20 DAS	63.70	14.75	9.20	8.35	667	1484	1.31	25196
Pendimethalin 750 g/ha (PE) *fb* HW at 30 DAS	74.50	19.50	11.70	11.20	1354	2047	2.90	64956
Pendimethalin 750 g/ha (PE) *fb* Imazethapyr 60 g/ha at 30 DAS	74.00	18.25	11.00	10.50	1305	1969	3.14	63850
Pendimethalin 750 g/ha (PE) *fb* Quizalofop ethyl 40 g/ha at 30 DAS	64.70	16.50	10.55	9.30	934	1767	1.97	40684
Stale seed bed (Destroy one flush of weeds)	62.00	14.45	7.75	8.15	548	1121	0.90	17207
CD (p=0.05)	8.01	2.56	1.27	1.41	136	237	--	--

Yield attributes and yield

Number of pods/plant and number of seeds/pod: The results concerning to number of pods /plant and number of seeds/pod in table 1 show that significantly maximum number of pods /plant and number of seeds /pod observed with application of Pendimethalin 30 EC 750 g/ha PE *fb* HW at 30 DAS (W6) which was found to be at par with weed free (2 HW at 20 and 40 DAS: W2) and Pendimethalin 30 EC 750 g/ha PE *fb* Imazethapyr 10 SL 60 g/ha at 30 DAS (W7). The remarkable increase in number of pods /plant under these treatment (W2 and W7) might be due to effective control of weeds, reduction in dry weight of weeds and higher weed control efficiency, which cumulatively facilitated the crop to utilize more nutrients and water for better growth ultimately reflecting in better development measured in terms number of pods/plant and number of seeds/pod. On the contrary, minimum number of pods/plant was found under weedy check (W1) treatment which are corroborated with the findings of Chattha *et al.* (2007) [4] and Telugu *et al.* (2014) [25]. Ayaz *et al.* (2001) [2] stated that the number of pods produced per plant or maintained to final harvest depends on a number of environmental and management practices. Mirshekari (2008) [14] also showed that the presence of weeds is a prominent factor in reducing the number of pods in cowpea plant. Further, Dadari (2003) [5] reported that competition between weeds and crop starts right from germination of the crop up to harvest affecting both growth and yield parameters adversely. Paudel *et al.* (2008) [20] revealed that the average number of pods per plant was affected by different treatments of pre-emergence and post emergence herbicides against weeds in cowpea and the treatments showed a significant difference from the uncontrolled plots. This result is in agreement with that of Jafari *et al.* (2013) [10] who stated that pre-emergence herbicides increased the number of pods per plant significantly as compared to the weedy check in common bean. Sylvestre *et al.* (2013) [24] has documented earlier the role of yield contributing factors that enhanced yield on account of herbicidal control of weeds. This result agrees with the findings of Tenaw *et al.* (1997) [26] and Sharma *et al.* (2004) [22] who reported that the number of seeds per pod was significantly reduced with the increased weed infestation and significantly increased with the weed free period in common bean. In agreement with this observation, Jafari *et al.* (2013) [10] also stated that pre-emergence herbicides increased the number of seeds per pod significantly as compared to the weedy check.

Seed index: There were no significant differences observed in seed index (Table 1) under different weed management treatments showing that these are the genetically governed characters hence, not influenced. Similar findings were also reported by Omisore *et al*. (2016) [19].

Grain yield: The higher yield achieved under application of Pendimethalin 30 EC 750 g/ha PE *fb* HW at 30 DAS (W6) is might be due to application of pre emergence herbicide and removal of weeds by hand weeding as evidenced by less number of weeds and dry weight of weeds, which resulted in less competition with plant nutrients and water, therefore, crop leading to increased their growth rate and biomass production of plant, ultimately increased rate and supply of photosynthates to various metabolic sinks might have favored yield. Improved yield under the treatments weed free (2 HW at 20 and 40 DAS: W2) and Pendimethalin 30 EC 750 g/ha PE *fb* Imazethapyr 10 SL 60 g/ha at 30 DAS (W7) was because of better control of weeds from the initial stage by periodical removal of weeds either by hand weeding or combine application of pre and/or post emergence herbicide as evident by reduced crop-weed competition under these treatments thus saved a huge amount of nutrients for crop which led to profuse growth enabling the crop to utilize more soil moisture and nutrients from deeper soil layers. These favourable effects in rhizosphere were apparent more in herbicides + HW, HW twice and pre + post herbicide combination treatments than application of herbicides alone because it improved the tilth by making soil more vulnerable for the plants to utilize water and air. All these favourable effects of weed management treatments resulted significant increase in various yield determining characters *viz.*, number of pods/plant, number of seeds/pod by providing better source sink relationship. Higher crop weed competition due to poor growth and less uptake of nutrients in the weedy check (W1) are in close conformity with those reported by Chattha *et al.* (2007) [4] and Oluwafemi *et al.* (2016) [18]. Grafton *et al*. (1988) [7] opined better translocation of photosynthates under lesser competition among plants and this could be one of the reasons for obtaining higher yields. Townley and Wright (1994) [27] stated that good weed management is critical to obtain higher yield from fieldpea. Askew *et al.* (2002) [1] reported that managing weeds and lesser competition within the plant community could result in utilization of the available resources efficiently, which, in turn, is reflected in higher grain yield. Morad (2013) [17] observed that yield of broad bean increased in plots treated with pre emergence herbicides due higher pods per plant, seed number per pod and hundred seed weight. Similarly, Mohamed *et al.* (1997) [15] reported that pre-emergence herbicides provided excellent suppression of weeds and the yield was significantly increased over weedy check. Prakash *et al.* (2000) [21] found that long season crop-weed competition reduced the fieldpea yield by 44.6 to 55.6%. Blackshaw (1991) [3] stated that the weeds reduce more than 75% of yield in cowpea crop.

Harvest index: Significantly higher harvest index (39.87%) was observed under Pendimethalin 30 EC 750 g/ha *fb* HW at 30 DAS (W6), which was found at par with Pendimethalin 30 EC 750 g/ha PE *fb* Imazethapyr 10 SL 60 g/ha at 30 DAS (W7: 39.80%) and weed free (2 HW at 20 and 40 DAS) (W2: 39.74%). Increase in shoot weight with increasing weed interference might have increased the vegetative growth duration and decreased root/shoot ratio resulting in reduced harvest index. Soltani *et al.* (2005) [23] reported that the harvest index of cowpea increases with increasing seed production.

Economics: Amongst the treatments, Pendimethalin 30 EC 750 g/ha PE *fb* HW at 30 DAS (W6) secured maximum net realization of ₹ 64956 /ha with B:C ratio of 2.90 in cowpea crop. However, it was followed by weed free (HW at 20 and 40 DAS: W2) (₹ 61930 /ha and 2.55) and Pendimethalin 30 EC 750 g/ha PE *fb* Imazethapyr 10 SL 60 g/ha (W7: ₹ 63850 /ha and 3.14). The higher B:C ratio achieved under superior treatments seems to be due to higher seed and stover yields and higher returns per rupee investment than poor yielding treatments. The lowest seed and stover yields achieved under weedy check treatment was eventually reflected in the lowest net returns (₹ 8887/ha) and B:C ratio (0.50). The results are reinforced with the studies of Gupta *et al.* (2017) [9].

Summary and Conclusion
Based on experiment, it is concluded that application of Pendimethalin 30 EC 750 g/ha (PE) *fb* HW at 30 DAS found effective for controlling the weeds and secure higher and profitable yield of cowpea under agro climatic condition of South Gujarat. In view of the increasing wages and crisis of labour at critical periods, integration of pre and post emerged herbicides is best option to manage the weeds in cowpea with profitable seed yield. Hence, Pendimethalin 30 EC 750 g/ha (PE) *fb* Imazethapyr 10 SL 60 g/ha at 30 DAS can be proved equally effective and remunerative weed management option for cowpea.

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