



Effect of Different Weed Management Practices on Growth Characters of Chickpea in Mid-hills of Himachal Pradesh, India

**Shubham^{a++}, Ranjeet Singh Bochalya^{a#*},
Kartikeya Choudhary^a, Anmol Katoch^{a++}
and Ananya Sood^{a++}**

^a Department of Agronomy, MS Swaminathan School of Agriculture, Shoolini University of Biotechnology and Management Sciences, Solan-173229 Himachal Pradesh, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Chickpea (*Cicer arietinum*) is one of the most important pulse legumes in many parts of the world. India is largest producer of chickpea in the world, sharing 65 and 70 % of the total global area and production, respectively. Different weed control practices use of herbicides were followed for better management. Application of herbicide at critical growth stages followed by one or two hand weeding at proper time or manipulation of row spacing for improving the weed suppressing effect of crops gives marginal improvement in crop yield. A field experiment titled "Effects of Different Weed Management Practices on Growth Characters of Chickpea in Mid-hills of Himachal Pradesh" was

⁺⁺ M.Sc. Student;

[#] Assistant Professor;

*Corresponding author: E-mail: rbochalya2023@gmail.com, ranjeetbochalya@shooliniuniversity.com;

conducted during *rabi* season of 2022 at Chamelti Agriculture Farm, MS Swaminathan School of Agriculture, Shoolini University of Biotechnology and Management Sciences, Solan. The soil of the experimental field was sandy loam in texture, slightly alkaline in reaction with EC in a safer range, medium in organic carbon, available nitrogen, potassium, and high in available phosphorus. The experiment was laid out in randomized block design with three replications comprising ten weed management treatments viz. (T₁) One hand weeding at 20 DAS, (T₂) Two hand weeding at 20 and 40 DAS, (T₃) Pendimethalin 30 EC @ 1.0 kg ha⁻¹ (PE), (T₄) Imazethapyr 10 SL @ 1.0 kg ha⁻¹ (PoE) at 25 DAS, (T₅) Pendimethalin 30 EC @ 1.0 kg ha⁻¹ (PE) + One hand weeding at 30 DAS, (T₆) Imazethapyr 10 SL @ 1.0 kg ha⁻¹ (PoE) at 25 DAS + One hand weeding at 40 DAS, (T₇) Fenoxaprop-p-ethyl 9.3 EC @ 60 g ha⁻¹ (PoE) at 25 DAS + One hand weeding at 40 DAS, (T₈) Pendimethalin 30 EC @ 1.0 kg ha⁻¹ (PE) + Imazethapyr 10 SL @ 1.0 kg ha⁻¹ (PoE) at 25 DAS, (T₉) Weed free and (T₁₀) Weedy Check. The recommended dose of fertilizer (30:60:30 kg ha⁻¹) was applied through Urea, SSP, and MOP at the time of sowing. PBG-7 variety of chickpea was used for sowing. Weed management practices were done as per treatment. Other crop management practices were followed as per the recommendation of the area. Application of (T₈) Pendimethalin 30 EC @ 1.0 kg ha⁻¹ (PE) + Imazethapyr 10 SL @ 1.0 kg ha⁻¹ (PoE) at 25 DAS registered higher growth parameters viz. plant height, number of branches plant⁻¹, dry matter accumulation and crop growth rate. Thus, study suggest that chickpea can successfully grown under Mid-hills of Himachal Pradesh on (T₈) Pendimethalin 30 EC @ 1.0 kg ha⁻¹ (PE) + Imazethapyr 10 SL @ 1.0 kg ha⁻¹ (PoE) at 25 DAS.

Keywords: Chickpea; weed; herbicide; yield; PE; POE; B:C ratio.

1. INTRODUCTION

“Pulses are rich source of dietary proteins and inseparable ingredients of vegetarian diet. India contributes about 25 per cent of global pulse production. India is the first largest producer of pulses in the world” [1]. “Chickpea (*Cicer arietinum* L.) is the most important winter season pulse crop. It is a source of protein and it plays an important role in human nutrition for large population in the developing world. Chickpea is the second most important pulse crop after pigeon pea in the world for human diet and other use. Chickpea also plays a main role in increasing soil fertility due to its nitrogen fixing ability. Chickpea can fix up to 140 kg N ha⁻¹ in a growing period” [2]. It leaves substantial amount of residual nitrogen for subsequent crops and adds plenty of organic matter to maintain and improved soil health and fertility. Chickpea has been characterized into two main categories primarily on seed characteristics, the ‘Desi’ types, with relatively small, angular seeds with rough, usually yellow to dark brown testa, constitute about 85% of annual world production and are confined entirely to the Indian sub-continent, Ethiopia, Mexico and Iran. The ‘Kabuli’ types, which have larger more rounded and creamed colored seeds, comprise only a minor area and production, but account entirely for the crops of Europe and the America, except Mexico. It ranks first in area cultivated in India, grown over an area of 9.85 million ha with production of

11.99 million tones and average productivity of 1217 kg ha⁻¹ [3]. Madhya Pradesh, Maharashtra, Rajasthan, Gujarat, Uttar Pradesh, Andhra Pradesh and Karnataka are the major chickpea producing states sharing over 95% area.

“Himachal Pradesh state has good agro-ecological situation for chickpea production but the average productivity is very less than other states. In chickpea production, one of the major constraints is weed infestation. Weeds compete with crop plants for space, water and nutrients and hence, it causes considerable yield losses. Thus, weeds are one of the major constraints to obtain high grain yield of improved crop cultivars if they are not controlled timely and properly. Chickpea is poor competitor to weeds because of slow growth rate and limited leaf development at early stage of crop growth and establishment, if weed management is neglected under these conditions, resulting in yield loss of 40 to 87%” [4]. “Weeds emerge with the winter sown crop and create severe competition unless controlled timely and effectively. Yield losses due to weed competition vary considerably depending on the level of weed infestation and weed species prevailing. The important weed flora of chickpea includes *Chenopodium album*, *Medicago denticulata*, *Echinochloa colona*, *Parthenium hysterophorus* and *Cynodon dactylon*. Hand weeding and mechanical weed control methods traditionally followed in the developing countries are becoming expensive due to increased labor

wages. Because of the sensitivity of chickpea to herbicides, most effective are the pre-emergence, and choices for post-emergence herbicides are limited. The pre-emergence herbicides are effective in controlling weeds at early stage of seedling growth, but weeds germinating after crop emergence become dominant in the field and cause substantial yield losses. Therefore, chickpea cultivars with improved herbicide tolerance, which can offer greater flexibility for use of post-emergence herbicides, are required by the farmers. Weed infestation in chickpea offer serious competition and cause yield reduction to the extent of 75%” [5]. “Weed management through herbicides is needed even in the developing countries, such as India, to make chickpea cultivation more profitable. Initial 60 days is the period considered too critical for weed crop competition in chickpea” [6]. “Generally, farmers adopt manual weeding for the control of weeds. However, with the increase in labour cost rate and scarcity, manual weed control has become problematic in chickpea. Weed control in chickpea in the initial stages of crop growth is vital since crop-weed competition is maximum” [7]. “Weed management through herbicides is not only economical but also facilitates zero tillage or minimum tillage methods, which help in practicing conservation agriculture. Chemical control of weeds also involves various options; pre-planting treatment is applied before crop is sown, where the herbicides used are acting on germinating seedlings. Pre emergence treatments are applied after seeding but before the crop emerges, chemicals may control weeds by killing weed seedlings. While, post-emergence herbicides are applied after the emergence of crop plants and weeds, with selective herbicides. weeds are killed with little damage to crop plants due to differential tolerance of the crop and weed to the herbicides. Chickpea is known to be sensitive to many herbicides and, therefore, choices for using post-emergence herbicides for weed control are limited” [7]. “Within the limited available herbicide options, the main chickpea herbicide Pendimethalin are registered only for pre-emergent use. Pendimethalin has been registered for use in chickpea in Canada. No post-emergence herbicide has been recommended for weed control in chickpea in South Asia where bulk of chickpea is grown. This is mainly because the available chickpea cultivars are sensitive to herbicides. Up to 1 kg ha⁻¹ Pendimethalin is registered for pre-emergent use on chickpeas. Many research workers from the various parts of the country have reported

that the application of pendimethalin as pre-emergence at 1.0 kg ha⁻¹” [8]. Chickpea varieties are sensitive to Pendimethalin applied post emergence. Lack of effective post-emergent herbicide options in chickpea poses difficulties in managing weeds which emerge after sowing. The imidazolinone class of herbicides provides a broad spectrum of weed control activity, flexibility in timing of application, low usage rates and low mammalian toxicity. Imazethapyr is an herbicide belongs to imidazolinone class, applied as pre-plant incorporation, pre-emergence and early-post emergence for control of annual grass, broad-leaf weeds and perennial sedges in chickpea and other legume fields.

2. MATERIALS AND METHODS

The fieldwork was done in the *rabi* season of 2022 at Chamelti Agriculture Farm, MS Swaminathan School of Agriculture, Shoolini University of Biotechnology and Management Sciences, Solan which is situated at a latitude 30° 85'67.30 N and longitude 77° 13'20.38 E and an elevation of 1284 meters above mean sea level (AMSL). The experiment was laid out in randomized block design with three replications and ten weed management treatments viz. (T₁) One hand weeding at 20 DAS, (T₂) Two hand weeding at 20 and 40 DAS, (T₃) Pendimethalin 30 EC @ 1.0 kg ha⁻¹ (PE), (T₄) Imazethapyr 10 SL @ 1.0 kg ha⁻¹ (PoE) at 25 DAS, (T₅) Pendimethalin 30 EC @ 1.0 kg ha⁻¹ (PE) + One hand weeding at 30 DAS, (T₆) Imazethapyr 10 SL @ 1.0 kg ha⁻¹ (PoE) at 25 DAS + One hand weeding at 40 DAS, (T₇) Fenoxaprop-p-ethyl 9.3 EC @ 60 g ha⁻¹ (PoE) at 25 DAS + One hand weeding at 40 DAS, (T₈) Pendimethalin 30 EC @ 1.0 kg ha⁻¹ (PE) + Imazethapyr 10 SL @ 1.0 kg ha⁻¹ (PoE) at 25 DAS, (T₉) Weed free and (T₁₀) Weedy Check. To record plant height, the tagged chickpea plants measured with the help of meter scale from the base of the plant to the tip of the last fully opened leaf at 30, 60,90 DAS and at harvest. Plant height at harvest was measured from the ground level to the uppermost portions of the leaf and the mean values thus worked out are presented in centimeters (cm). To record number of total branches produced plant⁻¹ counted at 60 DAS and at harvest stage of five randomly tagged plants in all the treatments. The mean of five plants were recorded as the number of branches plant⁻¹. To record dry matter accumulation, ten plants randomly selected from each plot and were pulled out at 30, 60, 90 DAS and at harvest stage. The plants were washed out and were

allowed to sun dried first and finally oven dried at 65° C for 24 hours up to dry and constant weight and recorded accordingly. The crop growth rate is the efficiency of the complete crop over a specific soil area. The CGR explains the dry matter accumulated per unit land area per unit time ($\text{g m}^{-2} \text{day}^{-1}$). The soil of experimental field was sandy loam in texture, slightly alkaline in reaction with EC in safer range, medium in organic carbon, available nitrogen, potassium and high in available phosphorus. The chickpea variety PBG-7 was sown on 8th November, 2022 at a row spacing of 30 × 10 cm using seed rate of 75 kg ha⁻¹ and Recommended dose of nitrogen, phosphorus and potassium (30:60:30 kg ha⁻¹) through urea, SSP and MOP at time of sowing. All the data were subjected to analysis of variance (ANOVA) as per the standard procedures. The comparison of treatment means was made by critical difference (RBD) at $p=0.05$.

3. RESULTS AND DISCUSSION

3.1 Plant Height (cm)

Plant height is a reliable index of growth and development representing the infrastructure build-up over a period of time. Periodic plant height recorded at 30, 60, 90 days after sowing (DAS) and at harvest is presented in Table 1. The data showed that plant height continued to increase with the advancement of crop age and this increase was rapid during early crop growth period and thereafter, a slow rate of increase in plant height was observed.

Different weed management practices had significant effect on plant height at all crop growth stages during investigation. At 30 DAS, treatment (T₉) weed free recorded significantly higher plant height at all the crop growth stages recorded during experimentation. Among the weed management practices, herbicidal application of (T₈) Pendimethalin 30 EC @ 1.0 kg ha⁻¹ as pre emergence + Imazethapyr 10 SL @ 1.0 kg ha⁻¹ as post emergence at 25 DAS recorded significantly higher plant height (13.01 cm) at 30 DAS over rest of the treatments. However, least plant height was noted under (T₁₀) weedy check treatment. Similar, trend was also observed at 60, 90 DAS and at harvest stage during course of study. Sharma et al. [9] propose that “the increased plant height is potentially a result of effective weed management, which minimizes competition between weeds and the main crop for essential resources such as light, nutrients, and moisture. Consequently, the successful control of weeds leads to decreased competition, fostering an

overall enhancement in crop growth. In a weedy condition, weeds take a bigger portion of the resources available in the soil and environment for their growth during the early stages of crop growth”. According to Tiwari et al. [10], “the highest plant height might be due to better weed management and minimizing the competition of weeds with the main crop for resources viz., light, nutrients and moisture with those effective weed control treatments”. Thus, reduced crop-weed competition resulted in overall improvement of crop growth as measured by plant height, which led to better reproductive structure and translocation of photosynthates to the sink. The results corroborated the findings of Yadav et al. [11].

3.2 Number of Branches Plant⁻¹

The number of branches plant⁻¹ area is recognized as a crucial determinant that markedly affect the yield of crops. Branches plant⁻¹ were recorded periodically at 60, 90 DAS and at harvest (Table 2) and data revealed that the number of branches plant⁻¹ showed an increasing trend up to 90 DAS.

Number of branches plant⁻¹ were significantly affected significantly due to weed management practices at all crop stages during course of investigation. Treatment (T₉) weed free recorded significantly higher number of branches plant⁻¹ at all the crop growth stages recorded during experimentation. Data presented in Table 4 revealed that the significantly higher number of branches plant⁻¹ (9.86), (16.58) and (17.68) at 30, 60 and 90 DAS, respectively recorded with herbicidal application of (T₈) Pendimethalin 30 EC @ 1.0 kg ha⁻¹ as pre emergence + Imazethapyr 10 SL @ 1.0 kg ha⁻¹ as post emergence applied at 25 DAS. Application of (T₈) Pendimethalin 30 EC @ 1.0 kg ha⁻¹ as pre emergence + Imazethapyr 10 SL @ 1.0 kg ha⁻¹ as post emergence at 25 DAS was statistically at par with (T₂) Two hand weeding at 20 and 40 DAS and (T₅) Pendimethalin 30 EC @ 1.0 kg ha⁻¹ as pre emergence + One hand weeding at 30 DAS. However, least number of branches plant⁻¹ was noted under (T₁₀) weedy check treatment at all crop growth stages studied. Grishin [12] reported a great demand for light, space, moisture and nutrients by plants with similar morphology and physiology. In agreement with present result, [13] found “differences in number of branches due to various intensities of weed competition with crop plants”.

Table 1. Plant height (cm) of chickpea as influenced by weed management practices at periodic intervals

Treatments	Plant height (cm)			
	30 DAS	60 DAS	90 DAS	At harvest
T1: One hand weeding at 20 DAS	11.45	26.15	50.12	49.57
T2: Two hand weeding at 20 and 40 DAS	11.65	29.67	53.27	52.67
T3: Pendimethalin 30 EC @ 1.0 kg ha ⁻¹ (PE)	11.45	25.98	49.65	48.57
T4: Imazethapyr 10 SL @ 1.0 kg ha ⁻¹ (PoE) at 25 DAS	10.95	26.02	50.02	49.67
T5: Pendimethalin 30 EC @ 1.0 kg ha ⁻¹ (PE) + One hand weeding at 30DAS	11.62	28.97	53.11	52.34
T6: Imazethapyr 10 SL @ 1.0 kg ha ⁻¹ (PoE) at 25 DAS + One handweeding at 40 DAS	10.98	28.12	52.87	51.67
T7: Fenoxaprop-p-ethyl 9.3 EC @ 60 g ha ⁻¹ (PoE) at 25 DAS + One hand weeding at 40 DAS	10.21	27.87	51.92	50.39
T8: Pendimethalin 30 EC @ 1.0 kg ha ⁻¹ (PE) + Imazethapyr 10 SL @ 1.0 kg ha ⁻¹ (PoE) at 25 DAS	13.01	30.56	54.12	53.28
T9: Weed free	13.25	31.24	58.97	57.91
T10: Weedy Check	8.69	21.17	43.18	42.38
SEm±	0.36	0.73	1.38	1.32
LSD ($p=0.05$)	1.11	2.16	4.21	4.17

Table 2. Number of branches plant⁻¹ of chickpea as influenced by weed management practices at periodic intervals

Treatments	Number of branches plant ⁻¹		
	60 DAS	90 DAS	At harvest
T1: One hand weeding at 20 DAS	8.11	14.68	15.64
T2: Two hand weeding at 20 and 40 DAS	9.18	16.02	17.65
T3: Pendimethalin 30 EC @ 1.0 kg ha ⁻¹ (PE)	7.56	14.02	15.34
T4: Imazethapyr 10 SL @ 1.0 kg ha ⁻¹ (PoE) at 25 DAS	7.89	14.21	15.38
T5: Pendimethalin 30 EC @ 1.0 kg ha ⁻¹ (PE) + One hand weeding at 30 DAS	8.94	15.67	15.96
T6: Imazethapyr 10 SL @ 1.0 kg ha ⁻¹ (PoE) at 25 DAS + One hand weeding at 40 DAS	8.79	15.42	16.57
T7: Fenoxaprop-p-ethyl 9.3 EC @ 60 g ha ⁻¹ (PoE) at 25 DAS + One handweeding at 40 DAS	8.51	15.11	16.24
T8: Pendimethalin 30 EC @ 1.0 kg ha ⁻¹ (PE) + Imazethapyr 10 SL @ 1.0 kg ha ⁻¹ (PoE) at 25 DAS	9.86	16.58	17.68
T9: Weed free	10.27	18.67	19.52
T10: Weedy Check	6.10	10.12	11.23
SEm±	0.33	0.56	0.54
LSD ($p=0.05$)	1.05	1.72	1.68

Table 3. Dry matter accumulation plant⁻¹ (g) of chickpea as influenced by weed management practices at periodic intervals

Treatments	Dry matter accumulation plant ⁻¹ (g)			
	30 DAS	60 DAS	90 DAS	At harvest
T1: One hand weeding at 20 DAS	7.11	35.12	70.59	84.71
T2: Two hand weeding at 20 and 40 DAS	8.14	37.11	80.53	97.44
T3: Pendimethalin 30 EC @ 1.0 kg ha ⁻¹ (PE)	6.51	34.54	63.21	75.22
T4: Imazethapyr 10 SL @ 1.0 kg ha ⁻¹ (PoE) at 25 DAS	6.87	34.98	68.56	82.96
T5: Pendimethalin 30 EC @ 1.0 kg ha ⁻¹ (PE) + One hand weeding at 30DAS	7.91	36.87	78.90	97.84
T6: Imazethapyr 10 SL @ 1.0 kg ha ⁻¹ (PoE) at 25 DAS + One handweeding at 40 DAS	7.54	36.13	76.60	94.98
T7: Fenoxaprop-p-ethyl 9.3 EC @ 60 g ha ⁻¹ (PoE) at 25 DAS + One hand weeding at 40 DAS	7.32	35.68	73.86	90.11
T8: Pendimethalin 30 EC @ 1.0 kg ha ⁻¹ (PE) + Imazethapyr 10 SL @ 1.0 kg ha ⁻¹ (PoE) at 25 DAS	8.51	38.69	84.34	105.43
T9: Weed free	8.87	40.12	88.67	111.72
T10: Weedy Check	4.11	27.56	54.29	67.86
SEm±	0.23	1.00	2.04	1.97
LSD ($p=0.05$)	0.72	3.04	6.15	5.96

Table 4. Crop growth rate (g plant⁻¹ day⁻¹) of chickpea as influenced by weed management practices at periodic intervals

Treatments	Crop growth rate (g plant ⁻¹ day ⁻¹)			
	0-30 DAS	30-60 DAS	60-90 DAS	90 DAS-At harvest
T1: One hand weeding at 20 DAS	0.24	0.93	1.18	0.71
T2: Two hand weeding at 20 and 40 DAS	0.27	0.97	1.45	0.85
T3: Pendimethalin 30 EC @ 1.0 kg ha ⁻¹ (PE)	0.22	0.93	0.96	0.60
T4: Imazethapyr 10 SL @ 1.0 kg ha ⁻¹ (PoE) at 25 DAS	0.23	0.94	1.12	0.72
T5: Pendimethalin 30 EC @ 1.0 kg ha ⁻¹ (PE) + One hand weeding at 30DAS	0.26	0.97	1.40	0.95
T6: Imazethapyr 10 SL @ 1.0 kg ha ⁻¹ (PoE) at 25 DAS + One hand weeding at 40 DAS	0.25	0.95	1.35	0.92
T7: Fenoxaprop-p-ethyl 9.3 EC @ 60 g ha ⁻¹ (PoE) at 25 DAS + One hand weeding at 40 DAS	0.24	0.95	1.27	0.81
T8: Pendimethalin 30 EC @ 1.0 kg ha ⁻¹ (PE) + Imazethapyr 10 SL @ 1.0 kg ha ⁻¹ (PoE) at 25 DAS	0.28	1.01	1.52	1.05
T9: Weed free	0.30	1.04	1.62	1.15
T10: Weedy Check	0.14	0.78	0.89	0.68
SEm±	0.01	0.03	0.03	0.02
LSD ($p=0.05$)	0.03	0.09	0.11	0.08

3.3 Dry Matter Accumulation Plant⁻¹ (g)

Dry matter accumulation is an important index indicating the photosynthetic efficiency of the crop which ultimately influences the crop yield. It is a direct index of plant proliferation. Dry matter accumulation increased progressively with advancement in crop age as presented in Table 3. Dry matter accumulation varied significantly in response to weed management practices at all stages. Crop accumulated dry matter at faster rate upto 90 DAS and thereafter, slower rate was reported.

Dry matter accumulation varied significantly due to weed management practices. Treatment (T₉) weed free recorded significantly higher dry matter accumulation plant⁻¹ during experimentation. Further, from the data it is clear that significantly higher dry matter accumulation (8.51 g plant⁻¹) recorded with herbicidal application of (T₈) Pendimethalin 30 EC @ 1.0 kg ha⁻¹ as pre emergence + Imazethapyr 10 SL @ 1.0 kg ha⁻¹ as post emergence at 25 DAS which was statistically at par with (T₂) Two hand weeding at 20 and 40 DAS and (T₅) Pendimethalin 30 EC @ 1.0 kg ha⁻¹ as pre emergence + One hand weeding at 30 DAS, respectively at 30 DAS during experimentation. Similar trend was also noted at 60, 90 DAS and at harvest stage. However, least dry matter accumulation plant⁻¹ at all crop growth stages were recorded with (T₁₀) weedy check treatment during experimentation. "This was due to the effective control of weeds, less crop weed competition throughout the crop growth period and due to better control of both grassy as well as broad-leaved weeds during early crop growth period which resulted in improved dry matter accumulation of the crop" [14,15].

3.4 Crop Growth Rate (g plant⁻¹ day⁻¹)

Crop growth rate is completely depends on dry matter accumulated by crop plants. Crop growth rate increased progressively with advancement in crop age as presented in Table 4. It was varied significantly in response to weed management practices at all stages. Crop accumulated growth rate at faster rate upto 60-90 DAS and thereafter, slower rate was reported.

"Crop growth rate varied significantly due to weed management practices. Treatment (T₉) weed free recorded significantly higher crop growth rate recorded during experimentation. Further, from the data it is clear that significantly

higher crop growth rate (0.28 g plant⁻¹ day⁻¹) at 0-30 DAS was noted under herbicidal application of (T₈) Pendimethalin 30 EC @ 1.0 kg ha⁻¹ as pre emergence + Imazethapyr 10 SL @ 1.0 kg ha⁻¹ as post emergence at 25 DAS which was statistically at par with (T₂) Two hand weeding at 20 and 40 DAS, (T₅) Pendimethalin 30 EC @ 1.0 kg ha⁻¹ as pre emergence + One hand weeding at 30 DAS and (T₆) Imazethapyr 10 SL @ 1.0 kg ha⁻¹ as post emergence at 25 DAS + One hand weeding at 40 DAS, respectively during experimentation. Similar trend was also noted at 30-60, 60-90 DAS and 90 DAS to at harvest stage. However, least crop growth rate plant⁻¹ at all crop growth stages were recorded with (T₁₀) weedy check treatment during experimentation. This can be attributed to the successful management of weeds, reduced competition between the crop and weeds throughout the crop growth cycle, and improved control of both grassy and broad-leaved weeds during the early stages of crop growth. These factors collectively led to enhanced yield characteristics for the crop" [14,16].

4. CONCLUSION

Application of (T₈) Pendimethalin 30 EC @ 1.0 kg ha⁻¹ as pre emergence + Imazethapyr 10 SL @ 1.0 kg ha⁻¹ as post emergence at 25 DAS registered higher growth parameters viz. plant height, number of branches plant⁻¹, dry matter accumulation and crop growth rate.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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