International Journal of Plant & Soil Science

Volume 38, Issue 7, Page 95-103, 2026; Article no.IJPSS.160557
ISSN: 2320-7035

Integrated Weed Management for Enhanced Growth and Yield of Grain Amaranth

N. M. Thesiya [a*], R. R. Pisal [a], J. V. Varsani [b], K. A. Shah [a] and H. M. Virdia [a]

[a] *Department of Agronomy, N.M. College of Agriculture, Navsari Agricultural University, Navsari 396450, India.*
[b] *Department of Economics, N.M. College of Agriculture, Navsari Agricultural University, Navsari, India.*

Authors' contributions

This work was carried out in collaboration among all authors. Authors NMT, RRP, KAS, HMV and JVV conceptualized the research work and designed the experiment. Author NMT executed the field experiments and collected the data. Authors NMT and JVV analyzed and interpreted the data and prepared the manuscript. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/ijpss/2026/v38i76145

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://pr.sdiarticle5.com/review-history/160557

Original Research Article

Received: 17/04/2026
Published: 20/06/2026

Abstract

Weed infestation is a major constraint in grain amaranth because the crop grows slowly during its early stages and remains vulnerable to competition for light, moisture, nutrients and space. A three-year field experiment was conducted during the rabi seasons of 2022-23 to 2024-25 at the Instructional Farm, Department of Agronomy, Navsari Agricultural University, Navsari, to evaluate integrated weed management practices for weed suppression, crop growth, yield and economics of grain amaranth (*Amaranthus hypochondriacus* L.). The experiment comprised ten treatments arranged in a randomised block design with three replications. Treatments included unweeded control, weed-free maintenance at 20, 40 and

**Corresponding author: E-mail: nmthesiya@nau.in;*

Cite as: *Thesiya, N. M., Pisal, R. R., Varsani, J. V., Shah, K. A., & Virdia, H. M. (2026). Integrated Weed Management for Enhanced Growth and Yield of Grain Amaranth. International Journal of Plant & Soil Science, 38(7), 95–103. https://doi.org/10.9734/ijpss/2026/v38i76145*

60 days after sowing, interculturing followed by hand weeding, sugarcane trash mulch, stale seedbed-based practices and pre-emergence pendimethalin treatments, either alone or combined with hand weeding. The pooled results indicated substantial variation among treatments for weed density, weed dry weight, weed control efficiency, crop growth, yield attributes, yield and economics. Weed-free maintenance at 20, 40 and 60 days after sowing recorded the lowest weed population (12.22 m^{-2}), lowest weed dry weight (3.50 kg ha^{-1}), highest weed control efficiency (98.01%) and zero weed index. The same treatment also recorded the highest plant height (131.43 cm), spike length (63.44 cm), number of spikelets per spike (65.67), grain yield (1614 kg ha^{-1}), stalk yield (4598 kg ha^{-1}), net realisation (₹ 94,492 ha^{-1}) and benefit:cost ratio (2.73). Interculturing followed by hand weeding at 20 and 40 days after sowing performed statistically at par with the weed-free treatment for important growth and yield traits. The findings indicate that timely integration of interculturing and hand weeding can provide effective weed management and improve productivity and profitability of grain amaranth under south Gujarat conditions.

Keywords: Grain amaranth; Amaranthus hypochondriacus; integrated weed management; weed control efficiency; weed index; interculturing; hand weeding.

1. Introduction

Amaranth (*Amaranthus hypochondriacus* L.) is a rapidly growing, multipurpose crop classified as a pseudocereal. Despite its considerable nutritional potential, it remains an underutilised and neglected crop species. Amaranth exhibits vigorous growth, substantial tolerance to drought and high temperatures, resistance to various pests and a marked capacity to adapt to diverse environmental conditions. The grain of amaranth has been reported to possess superior nutritional quality compared with many conventional cereal grains. According to Munjal et al. (1999), amaranth grain contains 16.86% crude protein, 11.88% moisture, 4.30% crude fat, 2.90% crude fibre, 2.10% ash and 63.13% carbohydrates. It is also a rich source of essential minerals, including calcium (169.63 mg 100 g^{-1}), iron (10.42 mg 100 g^{-1}) and phosphorus (395.33 mg 100 g^{-1}). Weed infestation is one of the principal constraints affecting grain amaranth production, often resulting in substantial yield reductions. Under irrigated conditions, weed pressure is typically more severe, and intense crop-weed competition significantly limits the attainment of the crop's full productivity potential. Although grain amaranth is characterised by its tall growth habit, its initial growth rate is relatively slow, rendering the crop highly vulnerable to weed competition during the early stages of development.

Yield losses attributable to weed infestation have been reported to range from 28% to 93%, depending on weed species composition, infestation intensity, crop growth stage and the nature and duration of crop-weed competition (Korav et al., 2018). The simultaneous emergence and rapid proliferation of weeds intensify competition for essential resources, including light, soil moisture, nutrients and growing space. Consequently, effective weed management during the early growth stages of grain amaranth is critical for minimising competitive stress and achieving higher crop productivity and yield.

Integrated weed management has emerged as a viable approach that combines herbicides with mechanical and cultural weed control strategies. The central objective of integrated weed management is to reduce weed infestation and its adverse effects on crop development and productivity while promoting sustainable resource utilisation and minimising environmental harm. The integrated use of herbicides with mechanical and cultural practices has been reported to be more effective for weed control than individual practices alone (Arya, 2004).

However, limited field-based information is available on the comparative performance of integrated weed management options that combine herbicidal, cultural and manual methods for grain amaranth under south Gujarat conditions across multiple rabi seasons. This gap restricts the development of locally relevant recommendations for reducing early crop-weed competition while maintaining crop productivity and economic returns.

Therefore, the present study was undertaken to identify the weed flora, evaluate the efficacy of different weed management treatments and assess their effects on growth and yield of grain amaranth.

2. Materials and Methods

2.1 Experimental Site and Soil Characteristics

The experiment was conducted for three years at the Instructional Farm, Department of Agronomy, Navsari Agricultural University, Navsari, during the rabi seasons from 2022-23 to 2024-25. The experimental farm is situated at 20°57′07.05″ N latitude and 72°54′16.50″ E longitude, at an elevation of 38 m above mean sea level. The soil of the experimental field was clayey.

2.2 Crop and Agronomic Details

The grain amaranth variety GA 5 was used, with a seed rate of 2 kg ha^{-1}, and spacing of 45 cm × 10 cm was maintained between rows and plants, respectively. The gross plot size was 4.50 m × 4.00 m, and the net plot size was 3.60 m × 3.00 m. Herbicide treatments were applied using a knapsack sprayer. The recommended fertiliser dose was 60:40:00 ($N:P_2O_5:K_2O$) kg ha^{-1}. Half of the nitrogen and the full amount of phosphorus were applied as a basal dose, and the remaining half of the nitrogen was applied at 30 DAS.

2.3 Weed Management Treatments

Integrated weed management in grain amaranth combined herbicides, interculturing and hand weeding for effective weed control. Weed sampling was carried out using two randomly selected quadrats of 0.25 m^2 (0.5 m × 0.5 m) within each sub-plot. The collected weeds were identified, categorised into broadleaf weeds, grasses and sedges, and subsequently counted. Following enumeration, the weed samples were carefully cleaned by removing root portions and adhering soil particles. The above-ground weed biomass was then oven-dried at 65 ± 2 °C for 72 h until a constant weight was attained. The resulting dry weight was recorded as weed biomass. Weed density and weed dry matter accumulation were expressed as number m^{-2} and kg ha^{-1}, respectively.

2.4 Observations Recorded

Growth parameters included plant height (cm), recorded at harvest. For the assessment of growth and yield parameters, five healthy plants were randomly selected from each plot. Yield attributes, including spike length (cm), number of spikelets per spike, grain yield (kg ha^{-1}) and stalk yield (kg ha^{-1}), were measured at harvest. Treatment-wise economics were computed based on the prevailing market prices.

2.5 Weed Control Efficiency

Weed control efficiency was computed at different stages as well as at maturity using the following formula suggested by Kondap and Upadhyay (1985).

$$WCE\ \% = \frac{DWC - DWT}{DWC} X\ 100$$

Where WCE = weed control efficiency (%), DWC = dry weight of weeds in control plots (weedy check), and DWT = dry weight of weeds in the treated plot.

2.6 Weed Index (%)

Weed index (WI), or weed competition index, is defined as the reduction in yield due to the presence of weeds in comparison with weed-free plots. Weed index was calculated using the formula suggested by Gill and Kumar (1969).

$$WI\ \% = \frac{X - Y}{X} X\ 100$$

Where X = yield from the weed-free plot, and Y = yield from the treated plot for which WI was calculated.

The application of weed control efficiency and weed index can help farmers make informed decisions to increase crop yield and reduce weed-related losses, thereby improving the sustainability and profitability of agriculture. These indices also help determine economic threshold levels, weed persistence, the effect of herbicides on the environment and their impact on crop yield and weed management strategies.

2.7 Statistical Analysis

All data related to weed count, weed dry matter, crop growth and yield parameters were analysed separately for each attribute according to the analysis of variance technique described by Panse and Sukhatme (1985). Treatment means were separated using the critical difference (CD) at the 5% level of significance ($P \leq 0.05$). The standard error of mean (SEm±) was also computed to assess the precision of the experimental results. Weed count and weed dry matter data were transformed using $\sqrt{(X + 0.5)}$ for the calculation of critical difference for significance. A pooled statistical analysis was performed for the series of experiments conducted over three consecutive years (2022-23, 2023-24 and 2024-25).

Table 1. Ten integrated weed management practices tested

T_1: Unweeded control
T_2: Weed-free maintenance at 20, 40 and 60 days after sowing
T_3: Interculturing followed by hand weeding at 20 and 40 days after sowing
T_4: Sugarcane trash mulch at 5 t ha^{-1} at 10 DAS
T_5: Stale seedbed (pre-sowing irrigation 15 days before sowing) followed by paraquat at 0.5 kg ha^{-1} before sowing
T_6: Stale seedbed (pre-sowing irrigation 15 days before sowing) followed by hand weeding at 40 DAS
T_7: Pendimethalin at 0.5 kg ha^{-1} as PE
T_8: Pendimethalin at 0.5 kg ha^{-1} as PE followed by hand weeding at 30 DAS
T_9: Pendimethalin at 0.75 kg ha^{-1} as PE
T_{10}: Pendimethalin at 0.75 kg ha^{-1} as PE followed by one hand weeding at 30 DAS

(PE = pre-emergence; DAS = days after sowing)

3. Results and Discussion

The data recorded for weed studies are presented in Table 2.

Table 2. Impact of weed management on weed population and dry weight in grain amaranth
(Pooled Mean Data of 2022-23 To 2024-25)

Treatment	Weed Population (M^{-2})	Weed DRY Weight (KG HA^{-1})	Weed Control Efficiency (%)	Weed Index (%)
	AT Harvest	AT Harvest	-	-
T_1	13.51 (182.33)	41.64 (173.8)	0.00	61.09
T_2	3.55 (12.22)	5.90 (3.50)	98.01	0.00
T_3	5.13 (27.22)	9.96 (10.40)	94.00	8.74
T_4	6.24 (39.22)	12.16 (15.00)	91.36	39.96
T_5	9.90 (99.67)	23.84 (58.10)	66.57	24.10
T_6	5.70 (32.78)	13.68 (19.10)	89.00	35.25
T_7	9.76 (94.89)	23.52 (55.30)	68.17	52.48
T_8	7.84 (61.11)	17.17 (29.50)	83.02	25.59
T_9	9.07 (82.44)	21.83 (48.10)	72.34	56.38
T_{10}	7.35 (56.22)	16.10 (27.20)	84.38	44.67
SEM+	0.16	0.36	-	-
CD (P=0.05)	0.47	1.09	-	-
CV (%)	14.03	13.30	-	-

** = Actual Value; ** = Transformed Value ($\sqrt{X + 0.5}$)*

3.1 Weed Flora

Seventeen weed species belonging to twelve families and three categories were recorded in the experimental field, comprising five monocot weeds, eleven dicot weeds and one sedge. The monocot weed species were *Cynodon dactylon* L., *Echinochloa crus-galli* L., *Eleusine indica* L., *Digitaria sanguinalis* L. and *Commelina benghalensis* L. The dicot weed species were *Trianthema portulacastrum* L., *Portulaca oleracea* L., *Euphorbia hirta* L., *Chenopodium album* L., *Physalis minima* L., *Eclipta alba* Hassk., *Phyllanthus niruri* L., *Digera arvensis* L., *Tridax procumbens* L. and *Vernonia cinerea* L. The sedge species recorded was *Cyperus rotundus* L. The experimental field was dominated mainly by dicot weeds, which comprised approximately 60% of the total weed population.

3.2 Weed Count Per Square Metre

The results showed that the maximum weed density (182.33 m^{-2}) was recorded in treatment T_1 (unweeded control), followed by T_5 [stale seedbed (pre-sowing irrigation 15 days before sowing) followed by paraquat at 0.5 kg ha^{-1} before sowing]. The lowest weed density (12.22 m^{-2}) was recorded under treatment T_2 [weed-free maintenance at 20, 40 and 60 days after sowing]. Under the control condition, weed density was high because no weed control measures were applied and weeds grew alongside the grain amaranth plants. In contrast, weed density was lowest under the weed-free condition because weeds were completely removed from the field. Similar results were also reported by Desai et al. (2023a), Illapu et al. (2024), Patidar et al. (2024), Shukla et al. (2014) and Chala et al. (2023).

3.3 Dry Weight of Weeds (kg ha^{-1})

At harvest, the highest total weed dry biomass (173.8 kg ha^{-1}) was recorded in the untreated control, whereas the lowest value (3.50 kg ha^{-1}) was observed in treatment T_2. The substantial reduction in weed biomass under T_2 may be attributed to the maintenance of a weed-free environment during the critical early growth period of the crop. Prolonged weed control up to 20 DAS or beyond facilitated the development of a dense crop canopy, which effectively suppressed subsequent weed emergence through shading and competitive exclusion. Consequently, late-emerging weeds were unable to establish and accumulate significant biomass, resulting in markedly lower weed density and dry matter production at 20, 40 and 60 DAS under weed-free conditions.

In contrast, the absence of weed management in the control treatment allowed unrestricted weed growth and development throughout the cropping period, leading to greater weed biomass accumulation. Effective weed control practices minimised weed competition and restricted weed establishment, thereby significantly reducing weed fresh and dry matter production compared with the unweeded control.

The findings are in conformity with those reported by Desai et al. (2023a), Illapu et al. (2024), Patidar et al. (2024), Shukla et al. (2014) and Chala et al. (2023).

3.4 Weed Control Efficiency (%)

The results showed that the maximum weed control efficiency was recorded in treatment T_2 (98.01%), followed by T_3 (94.00%). The minimum weed control efficiency was recorded under treatment T_1 (unweeded control). Significant variation was observed among the weed management treatments. The hand-weeding treatment recorded the lowest total weed density and consequently registered the highest weed control efficiency, which was superior to pendimethalin (T_7, T_8, T_9 and T_{10}), stale seedbed (T_5 and T_6) and sugarcane trash mulch (T_4) treatments. In the weed-free condition, weeds were removed, resulting in maximum weed control efficiency because weed growth was effectively prevented. This allowed grain amaranth to access resources with minimal competition, resulting in improved growth and yield. In contrast, weed control efficiency was lowest under the unweeded condition because weeds were allowed to grow freely alongside grain amaranth. The lack of weed management reduced efficiency and adversely affected grain amaranth productivity. Similar results were also reported by Patidar et al. (2024), Shukla et al. (2014) and Singh et al. (2017).

3.5 Weed Index (%)

The results showed that the maximum weed index (61.09%) was recorded in treatment T_1, followed by T_9. The lowest weed index (0.00%) was observed under treatment T_2. The presence and density of weeds were highest in the weedy check, where weed control measures were absent, whereas the weed-free condition exhibited the lowest weed index due to effective weed management. Similar results were also reported by Shukla et al. (2014) and Singh et al. (2017).

3.6 Growth Parameter

Severe weed infestation in plots maintained weedy up to maturity adversely affected the plant height of grain amaranth (Table 3). Keeping the crop weed-free up to 60 DAS or practising interculturing with hand weeding at 20 and 40 DAS produced greater plant height. At harvest, treatment T_2 [weed-free maintenance at 20, 40 and 60 days after sowing] recorded the highest plant height (131.43 cm), followed by T_3 (interculturing followed by hand weeding at 20 and 40 days after sowing). In contrast, treatment T_1 (unweeded control) recorded significantly lower plant height at harvest (101.70 cm). The higher plant height recorded under T_2 may be attributed to better weed control during the crop growth period, which improved the availability of moisture and nutrients to the crop and created more favourable conditions for crop growth. This, in turn, may have enhanced the smothering effect of the crop on weeds.

Table 3. Impact of integrated weed management on growth and yield parameters of grain amaranth (pooled mean data of 2022-23 to 2024-25)

Treatment	Plant height at harvest (cm)	Spike length (cm)	Number of spikelets per spike	Grain yield (kg ha^{-1})	Stalk yield (kg ha^{-1})
T_1	101.70	38.87	43.01	628	1893
T_2	131.43	63.44	65.67	1614	4598
T_3	126.76	61.42	63.71	1473	4154
T_4	113.49	47.79	46.62	969	2625
T_5	116.32	51.47	54.08	1225	3567
T_6	114.30	49.49	50.37	1045	2864
T_7	106.45	43.84	43.47	767	2171
T_8	115.28	50.53	53.12	1201	3292
T_9	105.82	41.03	43.33	704	2000
T_{10}	108.52	45.49	45.23	893	2371
SEm+	0.99	0.72	0.47	49.17	153.51
CD (P=0.05)	2.95	2.13	1.41	146.09	456.11
CV (%)	7.32	11.45	11.98	12.83	13.18

Table 4. Impact of integrated weed management on economics of grain amaranth

Treatment	Total cost (₹ ha^{-1})	Gross realisation (₹ ha^{-1})	Net realisation (₹ ha^{-1})	BCR
T_1	27238	50250	23012	0.84
T_2	34638	129130	94492	2.73
T_3	32521	117827	85305	2.62
T_4	29280	77506	48226	1.65
T_5	28971	98022	69050	2.38
T_6	30493	83614	53121	1.74
T_7	28355	61336	32982	1.16
T_8	30821	96072	65251	2.12
T_9	28355	56316	27962	0.99
T_{10}	30821	71426	40605	1.32

The lowest plant height (101.70 cm) under the weedy treatment throughout the growth period (T_1) may be attributed to severe weed competition for resources, which reduced crop access to moisture and nutrients and adversely affected plant height. These findings are in close conformity with those reported by Shukla et al. (2014), Chaudhari et al. (2019) and Desai et al. (2023b).

3.7 Yield Attributes and Yield

Weed competition adversely affected yield-attributing characters and grain yield of grain amaranth. Data presented in Table 3 showed that significantly higher spike length (63.44 cm) was recorded under the weed-free treatment at 20, 40 and 60 days (T_2), which remained at par with interculturing followed by hand weeding at 20 and 40 days after sowing (T_3). Significantly lower spike length (38.87 cm) was observed in the unweeded treatment (T_1). The weed-free treatment at 20, 40 and 60 days (T_2) recorded a significantly greater number of spikelets per spike (65.67), whereas the lowest number of spikelets per spike (43.01) was recorded under the unweeded treatment (T_1).

Significantly higher grain yield (1614 kg ha^{-1}) was obtained under the weed-free treatment at 20, 40 and 60 days (T_2), and it remained at par with interculturing followed by hand weeding at 20 and 40 days after sowing (T_3). Similarly, the highest stalk yield (4598 kg ha^{-1}) was obtained under treatment T_2, which remained at par with treatment T_3. Significantly lower grain yield (628 kg ha^{-1}) and stalk yield (1893 kg ha^{-1}) were recorded under the unweeded treatment (T_1). This indicates that the presence of weeds at any stage competes with the crop for nutrients and water and significantly reduces crop yield. Analogous findings have been reported by Shukla et al. (2014), Chaudhari et al. (2019) and Desai et al. (2023b). The increased weed density and biomass (Table 2) under the unweeded treatment (T_1) may be attributed to the uninterrupted growth of weeds, which ultimately suppressed growth and yield-attributing characters of grain amaranth.

Pre-emergence application of pendimethalin (T_7, T_8, T_9 and T_{10}) effectively controlled early-stage weeds by inhibiting cell division; however, its residual efficacy diminished over time. Sugarcane trash mulch (T_4) and stale seedbed treatments (T_5 and T_6) also suppressed early weed emergence, but maintaining a weed-free environment through periodic manual weeding resulted in superior crop growth and optimum yield parameters. In contrast, manual weeding at different growth stages facilitated the removal of monocot, dicot and sedge weeds, allowing better utilisation of nutrients, light and water by the crop.

3.8 Economics

Treatment T_2 (weed-free maintenance at 20, 40 and 60 days) had the highest total cost of cultivation (₹ 34,638 ha^{-1}), followed by T_3 (₹ 32,521 ha^{-1}). The lowest cost of cultivation (₹ 27,238 ha^{-1}) was recorded under treatment T_1 (unweeded control). Treatment T_2 recorded the highest gross return (₹ 129,130 ha^{-1}), followed by T_3 (interculturing followed by hand weeding at 20 and 40 days) (₹ 117,827 ha^{-1}). The lowest gross return was recorded under treatment T_1 (₹ 50,250 ha^{-1}). Treatment T_2 also recorded the highest net return (₹ 94,492 ha^{-1}), followed by T_3 (₹ 85,305 ha^{-1}), whereas the lowest net return was recorded under treatment T_1 (₹ 23,012 ha^{-1}). These findings are in close conformity with those reported by Shukla et al. (2014), Chaudhari et al. (2019) and Desai et al. (2023b).

4. Conclusions

The three-year pooled investigation demonstrated that weed management substantially influenced weed growth, crop growth, yield attributes, yield and economics of grain amaranth under south Gujarat conditions. Maintaining the crop weed-free at 20, 40 and 60 days after sowing was the most effective treatment, recording the lowest weed population and dry weight, the highest weed control efficiency and zero weed index. This treatment also produced the greatest plant height, spike length, number of spikelets per spike, grain yield, stalk yield, net realisation and benefit:cost ratio. Interculturing followed by hand weeding at 20 and 40 days after sowing remained statistically comparable with the weed-free treatment for key growth and yield parameters, indicating its practical suitability where continuous weed-free maintenance may not be feasible. Herbicidal, stale seedbed and mulching treatments reduced weed pressure compared with the unweeded control, but their performance was lower than that of manual and integrated approaches. The results suggest that timely weed removal during the critical early growth period is essential for minimising crop-weed competition and improving grain amaranth productivity. Interculturing followed by hand weeding at 20 and 40 days after sowing can therefore be considered a dependable integrated weed management option for enhancing yield and profitability.

5. Limitations

The present study was conducted at a single experimental site in south Gujarat under the soil and management conditions of the Instructional Farm, Navsari Agricultural University, Navsari. Therefore, the results should be interpreted with reference to these agro-climatic and edaphic conditions. Although the experiment was conducted over three consecutive rabi seasons, the treatments were evaluated only in one grain amaranth variety, GA 5, and the response of other varieties was not assessed. The study focused on weed density, weed dry weight, weed control efficiency, weed index, growth, yield and economics; it did not evaluate long-term changes in weed seedbank dynamics, herbicide residue behaviour, soil biological properties or environmental effects of repeated weed management practices. Labour availability and cost may also influence the practical adoption of manual and integrated weed control options. Further multi-location studies involving additional varieties and longer-term ecological assessment would help refine location-specific recommendations for grain amaranth.

Declaration of AI Use

This manuscript was prepared through the combined contributions of all author(s), including contributions to the study design, data, content development, results, interpretation, and related scholarly work. The author(s) acknowledge the use of Grammarly and ChatGPT to assist with grammar checking, language refinement, reference formatting. These AI-assisted tools were not used as authors and did not replace the intellectual contributions or scholarly judgment of the author(s). All AI-assisted outputs, including content, references, and interpretations, were carefully reviewed, revised, verified, and approved by the author(s). The author(s) accept full responsibility for the accuracy, integrity, and final content of the manuscript.

Acknowledgements

All the authors gratefully acknowledge their parent institute for its unwavering support and infrastructural assistance in carrying out this research

Competing Interests

The authors declare that they have no known competing financial interests, non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Arya, R. L. (2004). Integrated weed management in chickpea (*Cicer arietinum* L.) + mustard [*Brassica juncea* (L.) Czernj. & Cosson] intercropping system under rainfed conditions. *Indian Journal of Agronomy, 49*(2), 98–100. https://doi.org/10.59797/ija.v49i2.5167

Chala, D., Tola, M., Abera, G., & Mogasa, E. (2023). Effect of hand weeding frequency and pre-emergence herbicide on weed control in soybean [*Glycine max* (L.) Merrill] at Bako, Western Ethiopia. *Agricultural Research & Technology: Open Access Journal, 27*(4), Article 556380. https://doi.org/10.19080/ARTOAJ.2023.27.556380

Chaudhari, D. I., Desai, L. J., & Kalal, P. H. (2019). Effect of integrated weed management on growth, yield, yield attributes and economics of grain amaranth (*Amaranthus hypochondriacus* L.) under South Gujarat condition. *International Journal of Current Microbiology and Applied Sciences, 8*(7), 2598–2604. https://doi.org/10.20546/ijcmas.2019.807.320

Desai, J. S., Chaudhary, A. N., Desai, C. K., & Patel, P. M. (2023a). Weed flora influenced by integrated weed management in grain amaranth (*Amaranthus hypochondriacus* L.). *The Pharma Innovation Journal, 12*(12), 1688–1693.

Desai, J., Chaudhary, A., Desai, C., & Chavda, M. (2023b). Yield, economics and quality of grain amaranth (*Amaranthus hypochondriacus* L.) influenced by integrated weed management. *Environment and Ecology, 41*(2B), 1204–1208. https://environmentandecology.com/wp-content/uploads/2024/03/MS15.pdf

Gill, G. S., & Kumar, V. (1969). Weed index: A new method for reporting weed control trials. *Indian Journal of Agronomy, 14*(2), 96–98. https://cir.nii.ac.jp/crid/1574231874752900224?lang=en

Illapu, B., Kalyana Murthy, K. N., & Anand, S. R. (2024). Nutrient dynamics in grain amaranth and competing weeds under different weed management practices. *International Journal of Environmental & Agriculture Research, 10*(11), 80–85. https://ijoear.com/assets/articles_menuscripts/file/IJOEAR-NOV-2024-21.pdf

Kondap, S. M., & Upadhyay, U. C. (1985). *A practical manual on weed control*. Oxford & IBH Publishing. https://opac.narc.gov.np/opac_css/index.php?id=2095&lvl=notice_display

Korav, S., Dhaka, A. K., Singh, R., Premaradhya, N., & Reddy, G. C. (2018). A study on crop weed competition in field crops. *Journal of Pharmacognosy and Phytochemistry, 7*(4), 3235–3240. https://www.phytojournal.com/archives/2018/vol7issue4/PartBB/7-4-488-795.pdf

Munjal, S. V., Mahajan, P. N., Patil, Y. M., & Patil, S. R. (1999). Evaluation of grain amaranth cultivar for biochemical and mineral constituents. *Journal of Maharashtra Agricultural University, 24*(1), 58–60.

Panse, V. G., & Sukhatme, P. V. (1985). *Statistical methods for agricultural workers* (4th ed., enlarged). Indian Council of Agricultural Research. https://iimsucat.iimb.ac.in/bib/344845

Patidar, K., Usadadiya, V. P., & Arvadiya, L. K. (2024). Effect of weed management practices on growth, yield and economics of grain amaranth (*Amaranthus hypochondriacus* L.) crop under South Gujarat condition. *International Journal of Research in Agronomy, SP-7*(12), 35–39. https://doi.org/10.33545/2618060X.2024.v7.i12Sa.2093

Shukla, D. K., Prasad, B., & Pratap, T. (2014). Weed management strategies for better yield and economics of grain amaranth (*Amaranthus hypochondriacus* L.) in mountain agriculture. *Journal of Hill Agriculture, 5*(2), 194–197. https://doi.org/10.5958/2230-7338.2014.00865.9

Singh, M. C., Phogat, B. S., & Raigar, H. L. (2017). Effect of different weed control practices on grain amaranth (*Amaranthus hypochondriacus* L.). *International Journal of Science, Environment and Technology, 6*(1), 849–853. https://ijset.net/journal/1615.pdf

Peer-review history:
The peer review history for this paper can be accessed here:
https://pr.sdiarticle5.com/review-history/160557