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Effect of weed management on weed flora, weed population, weed dry weight, weed control efficiency and weed index of grain amaranth (*Amaranthus hypochondriacus* L.) under south Gujarat condition

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Abstract
A field experiment was conducted during *rabi* season of 2023-24 at the College Farm, Navinchandra Mafatlal College of Agriculture, Navsari Agricultural University, Navsari to study the "Weed management in grain amaranth (*Amaranthus hypochondriacus* L.) under south Gujarat condition." The experiment was laid out in Randomized Block Design with three replications and ten treatments. *Cyperus rotundus, Cynodon dactylon, Echinochloa crusgalli, Convolvulus arvensis, Trianthema portulacastrum* and *Euphorbia hirta* were observed major weed flora in grain amaranth field. Weed free treatment was recorded significantly the lowest number of grassy, broad leaved and sedge weeds. Among the chamical practices, significantly lowest weed dry weight were found under Oxadiargyl @ 50 g a.i. ha^{-1} (PE) followed by hand weeding & Interculture at 30 DAS at 45 DAS and Oxadiargyl @ 50 g a.i. ha^{-1} (PE) followed by Quizalofop @ 50 g a.i. ha^{-1} at 30 DAS (PoE) at harvest. Oxadiargyl @ 50 g a.i. ha^{-1} (PE) followed by Quizalofop @ 50 g a.i. ha^{-1} at 30 DAS (PoE) were found the maximum weed control efficiency and minimum weed index.

Keywords: Grain amaranth (*Amaranthus hypochondriacus* L.), Weed management, South Gujarat conditions

Introduction
Grain amaranth (*Amaranthus hypochondriacus* L.) is an edible pseudo-cereal crop belong to the order *Caryophyllales*, amaranth family *Amaranthaceae*, sub-family *Amaranthoideae* and genus *Amaranthus*. The word amaranth derived from the Greek word Anthos" (flower) which means everlasting or unwilting.

Weeds are one of the most important serious constraint for cultivation and easy harvesting in grain amaranth. The earlier weeks of germination, amaranth has slow growth and hence it is very susceptible to weed competition. Competition is more in the earlier stage compared with the later stage, which is why weed management must be in the earlier stage of the crop. Weed infestation is one of the most important factors for decreasing the yield by up to 91% and its quality due to crop-weed competition for light, nutrients, CO_2, space and moisture. Weeds work as host plants to harmful insects, diseases, and cause damage to the crop. To control the weeds population there is no standardized herbicide application. Manual weeding is a must for weed control, but labour scarcity is more as well as the cost of cultivation is increasing. Weeds cause a reduction in yield, especially under south Gujarat conditions. The right time and the right method of application should be maintained for high-yield and quality seeds. A number of sprays of herbicides, hand weeding and cultural operations are used for weed management and better crop production.

Limited study is available on efficacy and economic viability of herbicide based weed management in grain amaranth in south Gujarat. Moreover, changes in crop production practices, availability of new herbicides, labour and market conditions warrant a re-evaluation of the weed management in grain amaranth in south Gujarat.

Materials and Methods

A field experiment was conducted during *rabi* season of 2023-24 on Block B, plot no. 12, College Farm, N. M. C. A., Navsari Agricultural University, Navsari to study the "Weed management in grain amaranth (*Amaranthus hypochondriacus* L.) under south Gujarat condition." The soil of the experimental plot was clayey in texture with low in organic carbon (0.44%), low in available nitrogen (193 kg ha^{-1}) and medium in available phosphorous (33 kg ha^{-1}), fairly rich in available potash (356 kg ha^{-1}) having pH value of 7.8. The experiment was laid out in Randomized Block Design with three replications. The treatments comprised of ten methods of weed management *viz.*, T_1: Weedy check, T_2: Weed-free (Hand weeding and IC at 20, 40 and 60 DAS), T_3: Pendimethalin @ 400 g a.i. ha^{-1} (PE), T_4: Pendimethalin @ 400 g a.i. ha^{-1} (PE) followed by hand weeding & Interculture at 30 DAS, T_5: Pendimethalin @ 400 g a.i. ha^{-1} (PE) followed by clodinofop @ 50 g a.i. ha^{-1} at 30 DAS (PoE), T_6: Pendimethalin @ 400 g a.i. ha^{-1} (PE) followed by Quizalofop @ 50 g a.i. ha^{-1} at 30 DAS (PoE), T_7: Oxadiargyl @ 50 g a.i. ha^{-1} (PE), T_8: Oxadiargyl @ 50 g a.i. ha^{-1} (PE) followed by hand weeding & Interculture at 30 DAS, T_9: Oxadiargyl @ 50 g a.i. ha^{-1} (PE) followed by clodinofop @ 50 g a.i. ha^{-1} at 30 DAS (PoE) and T_{10}: Oxadiargyl @ 50 g a.i. ha^{-1} (PE) followed by Quizalofop @ 50 g a.i. ha^{-1} at 30 DAS (PoE). Grain amaranth variety GA 5 was used and sown at a distance of 45 cm between the rows. The data were statistically analyzed for various charecters as described by Panse and Sukhatme (1967). Also DNMRT test is done for comparing treatment means.

Weed control efficiency (WCE) is defined as the efficiency to control the weed in term of dry matter accumulation in treated plot compared to unweeded control plot and expressed in percent.

Weed control efficiency (%) was computed by using formula given by Kondap and Upadhyay (1985) [20].

$$\text{Weed control efficiency (\%)} = \frac{\text{DWC} - \text{DWT}}{\text{DWC}} \times 100$$

Where,

DWC = Dry matter accumulation of weeds in unweeded control (kg ha^{-1})

DWT = Dry matter accumulation of weeds in treated plot (kg ha^{-1})

Weed index (WI) or weed competition index is defined as the reduction in yield due to presence of weeds in comparison to weed free plot and expressed in percent.

Weed index was worked out by using the formula suggested by Gill and Kumar (1969) [14].

$$\text{Weed index (\%)} = \frac{X - Y}{X} \times 100$$

Where,

X = Yield from weed free plot (kg ha^{-1})

Y= Yield from treated plot for which WI is to be worked out (kg ha^{-1})

Results and Discussion

Weeds flora

Predominant weeds flora observed in the experimental field is presented in photo 1.

Weed population

The data presented in Table 1 indicated that periodical grassy, broad leaved and grassy weeds population at 30, 45, 60 DAS and at harvest were significantly influenced by various weed management treatments. Weed free treatment was recorded significantly the lowest number of grassy, broad leaved and sedge weeds per square metre (1.8, 1.7, 3.3 and 1.5) (1.9, 1.5, 1.4 and 1.6) (1.7, 1.4, 1.6 and 1.9) at 30, 45, 60 DAS and at harvest respectively. In case of herbicidal treatments tried at 30, 45, 60 DAS and at harvest, lower grassy weeds recorded with the application of Oxadiargyl @ 50 g a.i. ha^{-1} (PE) followed by Quizalofop @ 50 g a.i. ha^{-1} at 30 DAS (PoE) which remained at par with Oxadiargyl @ 50 g a.i. ha^{-1} (PE) followed by Clodinofop @ 50 g a.i. ha^{-1} at 30 DAS (PoE). At 45 DAS, it was also at par with Pendimethalin @ 400 g a.i. ha^{-1} (PE) followed by Quizalofop @ 50 g a.i. ha^{-1} at 30 DAS (PoE). In case of broad leaved weeds, at 30 and 45 DAS, significantly lower broad leaved weeds recorded under Oxadiargyl @ 50 g a.i. ha^{-1} (PE) followed by Quizalofop @ 50 g a.i. ha^{-1} at 30 DAS (PoE), but it was at par with Oxadiargyl @ 50 g a.i. ha^{-1} (PE) followed by Clodinofop @ 50 g a.i. ha^{-1} at 30 DAS (PoE). At 30 DAS, which was also at par with Pendimethalin @ 400 g a.i. ha^{-1} (PE) followed by Quizalofop @ 50 g a.i. ha^{-1} at 30 DAS (PoE) and Pendimethalin @ 400 g a.i. ha^{-1} (PE) followed by Clodinofop @ 50 g a.i. ha^{-1} at 30 DAS (PoE). At 60 DAS and at harvest, Oxadiargyl @ 50 g a.i. ha^{-1} (PE) followed by Quizalofop @ 50 g a.i. ha^{-1} at 30 DAS (PoE)followed by T_9, T_6, T_5, T_8, T_4, T_7 and T_3. In case of sedges weed density at 30 and 45 DAS, application of treatment Oxadiargyl @ 50 g a.i. ha^{-1} (PE) followed by Quizalofop @ 50 g a.i. ha^{-1} at 30 DAS (PoE) controlled significantly higher sedges weed, which was at par with Oxadiargyl @ 50 g a.i. ha^{-1} (PE) followed by Clodinofop @ 50 g a.i. ha^{-1} at 30 DAS (PoE). At 30 DAS, it was also at par with T_6 and T_5. At 60 and at harvest, which was also at par with T_9 and T_6. These finding are in conformity with results obtained by Shukla *et al.* (2014) [35] and Singh *et al.* (2017) [36].

Weed dry weight

It is evident from the data furnished in Table 2 that dry weight of weeds at 45 DAS and at harvest significantly influenced by various treatments of weed management in grain amaranth. Significantly the maximum weed dry weight at 45 DAS and at harvest were recorded under the weedy check treatment. Among the chamical practices, significantly lowest weed dry weight were found under Oxadiargyl @ 50 g a.i. ha^{-1} (PE) followed by hand weeding & Interculture at 30 DAS at 45 DAS (17.1 g m^{-2}) and Oxadiargyl @ 50 g a.i. ha^{-1} (PE) followed by Quizalofop @ 50 g a.i. ha^{-1} at 30 DAS (PoE) at harvest (33.8 g m^{-2}).

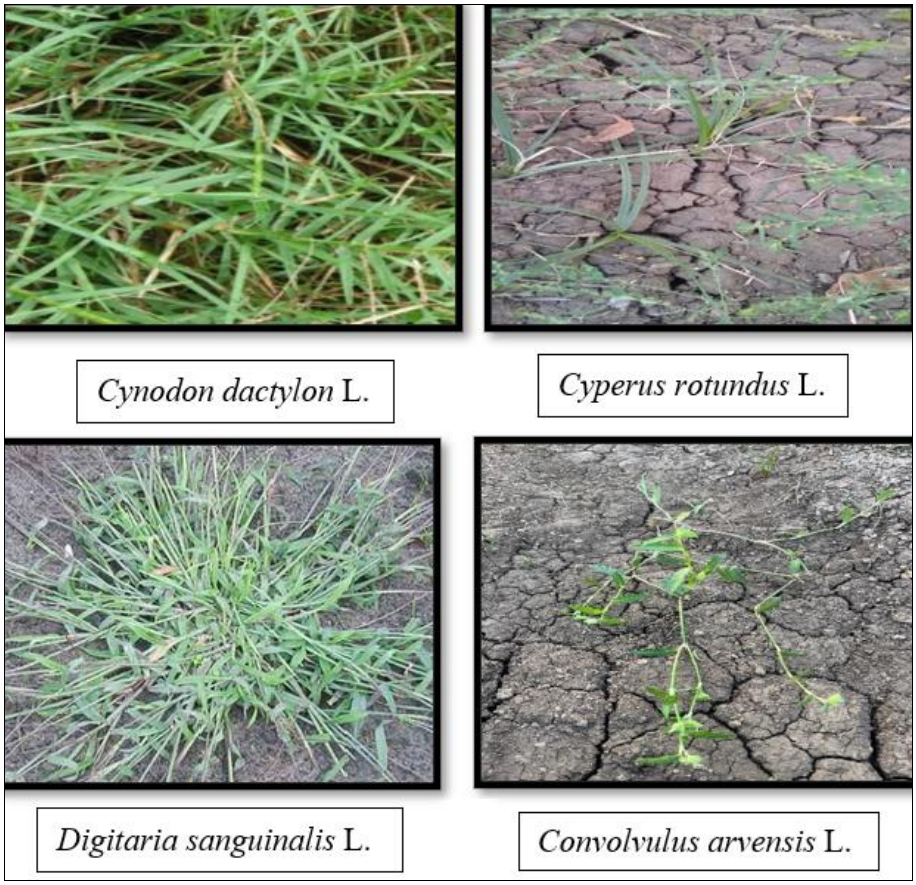
Weed control efficiency (WCE)

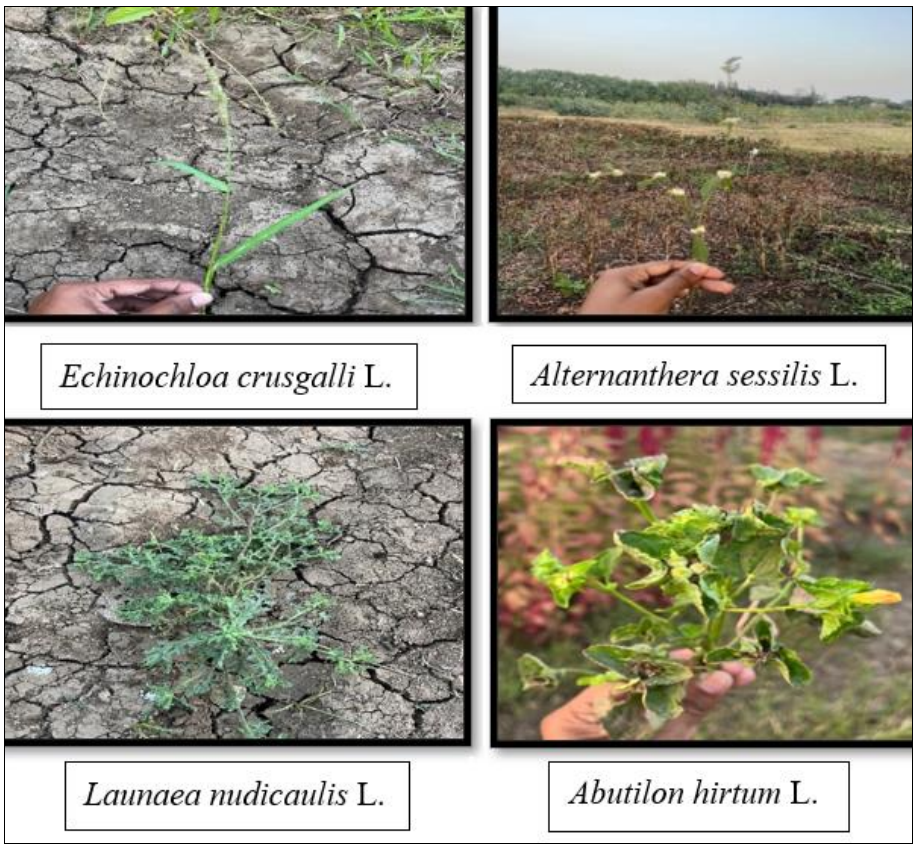
Data pertaining to the response of various weed management practices on weed control efficiency in grain amaranth are furnished in Table 2 and Fig. 1. Significantly higher weed control efficiency was found under weed free treatment. However, among the herbicidal treatments, Oxadiargyl @ 50 g a.i. ha^{-1} (PE) followed by Quizalofop @ 50 g a.i. ha^{-1} at 30 DAS (PoE) was found the maximum weed control efficiency (82.7%). The minimum weed control efficiency was observed in weedy check treatment.

Weed index (%)

Data pertained to weed index presented in Table 2 and Fig. 1. The maximum weed index was observed under the weedy check treatment. Whereas, among the chemical treatments, the

minimum weed index was observed under Oxadiargyl @ 50 g a.i. ha^{-1} (PE) followed by Quizalofop @ 50 g a.i. ha^{-1} at 30 DAS (PoE) (17.0%). More number of weeds under weedy check was responsible for higher dry weight of weeds which tended to increase the weed index. Similar findings were also reported by Shukla *et al.* (2014) [35] and Singh *et al.* (2017) [36].





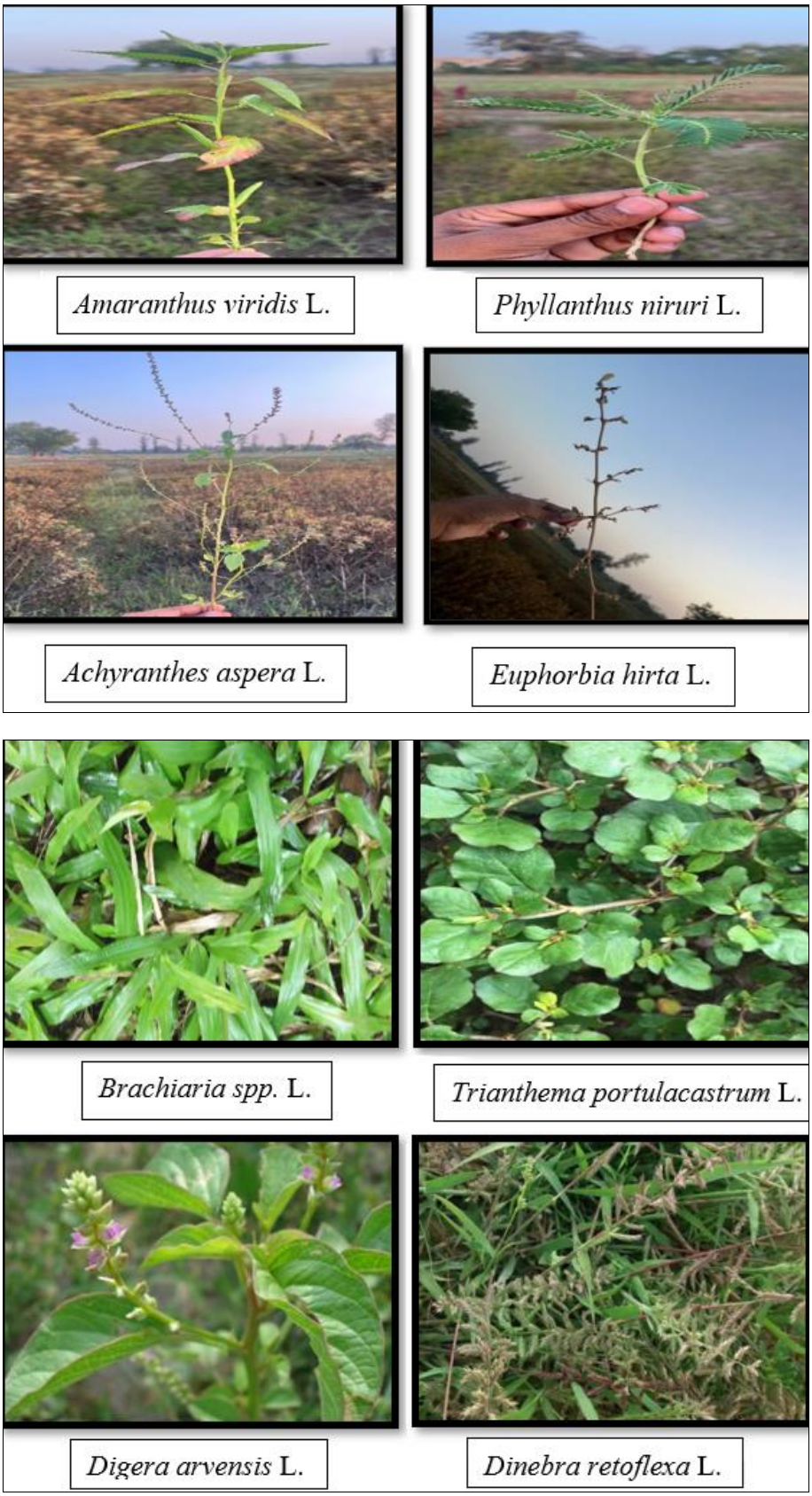


Photo 1: Major weed flora observed at experimental site

Table 1: Influence of different weed management treatments on periodical grassy, broad and sedges weeds in grain amaranth

Treatments		Grassy weeds (m^2)				Broad leaved weeds (m^2)				Sedges weeds (m^2)			
		At 30 DAS	At 45 DAS	At 60 DAS	At harvest	At 30 DAS	At 45 DAS	At 60 DAS	At harvest	At 30 DAS	At 45 DAS	At 60 DAS	At harvest
T_1	Weedy check	3.7 (12.0)	6.3 (38.6)	6.5 (41.6)	5.7 (31.0)	8.1 (64.3)	9.2 (83.0)	8.8 (76.0)	8.6 (72.3)	6.4 (40.0)	7.4 (53.6)	7.3 (53.0)	7.2 (51.0)
T_2	Weed-free (Hand weeding and IC at 20, 40 and 60 DAS)	1.8 (2.3)	1.7 (2.0)	3.3 (3.6)	1.5 (1.3)	1.9 (2.6)	1.5 (1.3)	1.4 (1.0)	1.6 (1.6)	1.7 (2.0)	1.4 (1.0)	1.6 (1.6)	1.9 (2.6)
T_3	Pendimethalin @ 400 g a.i. ha^{-1} (PE)	3.1 (8.6)	4.4 (19.0)	5.1 (25.3)	4.7 (20.6)	8.0 (63.6)	8.0 (63.0)	8.0 (62.6)	7.7 (57.6)	5.8 (33.0)	5.7 (31.6)	5.6 (31.3)	5.4 (28.3)
T_4	Pendimethalin @ 400 g a.i. ha^{-1} (PE) followed by hand weeding & Interculture at 30 DAS	2.9 (7.6)	3.9 (14.6)	4.6 (20.0)	4.2 (17.0)	7.8 (60.3)	7.9 (60.6)	7.6 (56.6)	6.9 (46.3)	5.6 (30.6)	5.4 (28.3)	4.9 (23.6)	4.7 (21.0)
T_5	Pendimethalin @ 400 g a.i. ha^{-1} (PE) followed by Clodinofop @ 50 g a.i. ha^{-1} at 30 DAS (PoE)	2.8 (7.0)	3.7 (13.0)	4.2 (16.6)	4.0 (14.6)	7.6 (57.0)	7.4 (54.0)	7.2 (50.3)	6.8 (45.3)	5.2 (26.0)	5.3 (27.6)	4.3 (18.3)	4.1 (15.6)
T_6	Pendimethalin @ 400 g a.i. ha^{-1} (PE) followed by Quizalofop @ 50 g a.i. ha^{-1} at 30 DAS (PoE)	2.5 (5.3)	3.2 (9.6)	4.2 (16.3)	3.5 (11.3)	7.4 (54.3)	7.2 (51.3)	6.2 (37.0)	6.1 (36.3)	5.1 (25.0)	5.2 (26.3)	4.2 (17.0)	4.0 (15.0)
T_7	Oxadiargyl @ 50 g a.i. ha^{-1} (PE)	3.0 (8.3)	4.0 (15.0)	4.8 (21.6)	4.6 (20.0)	8.0 (63.3)	8.0 (62.6)	7.9 (61.3)	7.5 (56.0)	5.8 (32.3)	5.6 (30.6)	5.1 (25.0)	4.9 (23.0)
T_8	Oxadiargyl @ 50 g a.i. ha^{-1} (PE) followed by hand weeding & Interculture at 30 DAS	2.8 (7.3)	3.9 (14.6)	4.5 (19.6)	4.1 (16.0)	7.8 (60.0)	7.6 (57.0)	7.4 (53.6)	6.8 (45.3)	5.4 (28.6)	5.4 (28.3)	4.6 (20.3)	4.3 (17.3)
T_9	Oxadiargyl @ 50 g a.i. ha^{-1} (PE) followed by Clodinofop @ 50 g a.i. ha^{-1} at 30 DAS (PoE)	2.1 (3.6)	3.2 (9.3)	3.8 (13.0)	3.3 (10.0)	7.4 (54.0)	5.7 (31.3)	6.0 (35.6)	5.7 (31.3)	5.1 (25.0)	4.8 (22.3)	4.0 (15.0)	3.7 (13.0)
T_{10}	Oxadiargyl @ 50 g a.i. ha^{-1} (PE) followed by Quizalofop @ 50 g a.i. ha^{-1} at 30 DAS (PoE)	2.0 (3.3)	2.9 (7.6)	3.5 (11.6)	3.1 (9.0)	7.3 (52.6)	5.3 (27.0)	4.3 (17.3)	3.9 (14.0)	5.0 (23.6)	4.7 (21.2)	3.9 (14.3)	3.6 (12.0)
	S.Em ±	0.08	0.13	0.14	0.11	0.15	0.15	0.19	0.17	0.10	0.12	0.11	0.13
	CD at 5%	0.26	0.39	0.41	0.34	0.45	0.45	0.57	0.52	0.31	0.35	0.32	0.40
	CV (%)	5.70	6.05	5.40	5.24	3.71	3.88	5.19	5.00	3.59	4.07	4.09	5.36

*Data in parenthesis indicate actual value and $\sqrt{x+1}$ transformed value of weeds those outside

Table 2: Dry weight of weeds at 45 DAS, at harvest, weed control efficiency (WCE) and weed index (WI) as influenced by various weed management treatments

Treatments		Dry weight of weeds (g m^{-2})		WCE (%)	WI (%)
		At 45 DAS	At harvest		
T_1	Weedy check	6.6 (42.4)	14.0 (195.7)	-	67.2
T_2	Weed-free (Hand weeding and IC at 20, 40 and 60 DAS)	2.4 (5.3)	3.9 (14.1)	92.7	-
T_3	Pendimethalin @ 400 g a.i. ha^{-1} (PE)	5.3 (26.8)	11.7 (136.8)	30.1	44.1
T_4	Pendimethalin @ 400 g a.i. ha^{-1} (PE) followed by hand weeding & Interculture at 30 DAS	4.4 (18.3)	10.9 (118.6)	39.3	36.6
T_5	Pendimethalin @ 400 g a.i. ha^{-1} (PE) followed by Clodinofop @ 50 g a.i. ha^{-1} at 30 DAS (PoE)	5.0 (24.5)	8.7 (74.4)	61.9	31.2
T_6	Pendimethalin @ 400 g a.i. ha^{-1} (PE) followed by Quizalofop @ 50 g a.i. ha^{-1} at 30 DAS (PoE)	4.9 (23.1)	7.9 (61.7)	68.4	28.2
T_7	Oxadiargyl @ 50 g a.i. ha^{-1} (PE)	5.3 (26.8)	11.3 (126.8)	35.2	39.5
T_8	Oxadiargyl @ 50 g a.i. ha^{-1} (PE) followed by hand weeding & Interculture at 30 DAS	4.3 (17.1)	10.8 (116.4)	40.5	31.9
T_9	Oxadiargyl @ 50 g a.i. ha^{-1} (PE) followed by Clodinofop @ 50 g a.i. ha^{-1} at 30 DAS (PoE)	4.7 (20.7)	6.7 (44.4)	77.2	23.4
T_{10}	Oxadiargyl @ 50 g a.i. ha^{-1} (PE) followed by Quizalofop @ 50 g a.i. ha^{-1} at 30 DAS (PoE)	4.8 (22.4)	5.9 (33.8)	82.7	17.0
	S.Em ±	0.23	0.32	-	-
	CD. at 5%	0.69	0.95		
	CV.%	8.45	6.04		

*Data in parenthesis indicate actual value and $\sqrt{x+1}$ transformed value of weeds those outside

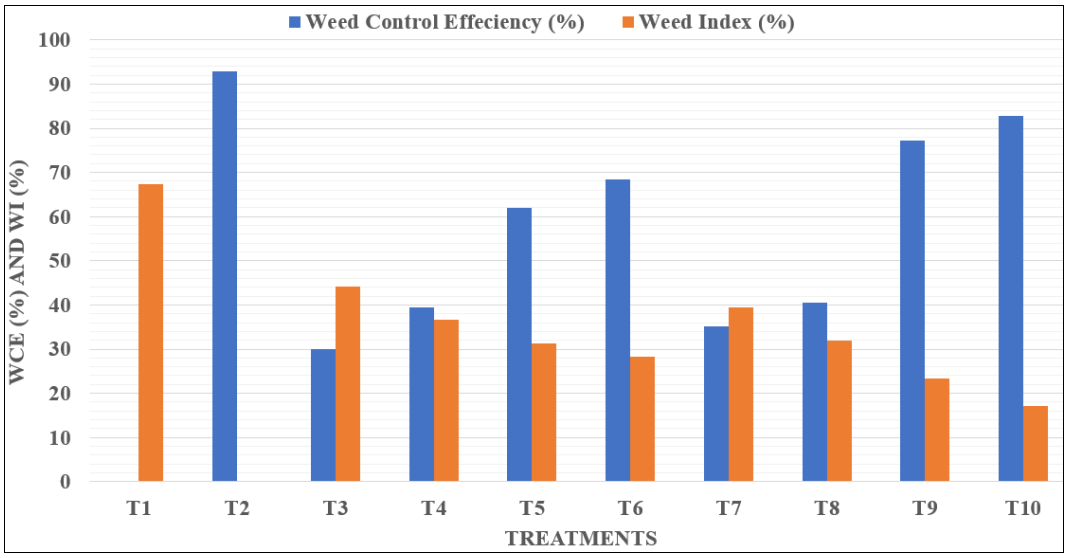


Fig 1: Weed control effeciency (WCE) and weed index (WI) as influenced by various weed management treatments

Conclusion

Based on the results of one year field experiment, it can be concluded that for effective weed control through maintaining weed free condition by three times hand weeding and inter culturing at 20, 40, 60 DAS in grain amaranth crop. In case of paucity of labourers, for better weed control, minimum weed population, lower weed dry weight, maximum weed control efficiency and lower weed index with the application of pre emergence herbicide Oxadiargyl @ 50 g a.i. ha^{-1} (PE) followed by either Quizalofop or Clodinofop @ 50 g a.i. ha^{-1} at 30 DAS (PoE) in grain amaranth crop under south Gujarat condition.

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