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Weed management in okra under foot hill conditions of North Eastern Himalaya

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ABSTRACT

A field experiment was conducted at Research Farm of College of Horticulture and Forestry, Central Agricultural University, Pasighat, Arunachal Pradesh during rainy season of 2013 and 2014. Almost 60 per cent of weed infestation was dominated by grassy and sedges, followed by broad-leaved weeds. Uncontrolled weed growth exerted significant reduction in mean green pod yield of okra by 43.84 and 45.90 per cent during 2014 and 2015, respectively. Application of different doses of Pendimethalin with or without hand weeding provided effective weed control but the late flushes and regenerated weeds at later stages hampered the crop yield. Weed free situation up to 60 days stage provided 67.6 and 60.2 per cent weed control efficiency and 0.99 and 1.01 per cent Weed Persistence Index during 2014 and 2015, respectively. During both the years of experimentation highest green pod yield were recorded in weed free plots while maximum Benefit: cost ratio obtained from plots treated with Pendimethalin 30EC @ 1.5kg ai.ha^{-1} + one time hand weeding.

Keywords: Economics, okra, weed management, yield.

Okra (*Abelmoschus esculentus* (L) Moench) is one of the most popular vegetables of India as well as in North East India. It is grown throughout the tropical and subtropical regions and also in the warmer parts of the temperate regions. Okra has good potential as a foreign exchang crop and accounts for 60 per cent of the export of fresh vegetables. It is cultivated in an area of 0.35 million hectare with production of 3.34 million tonnes and productivity of 9.6 t ha^{-1}. It is the lucrative vegetable used in fresh form as well as canned food. The crop is also used in paper industry as well as for the extraction of fibre. In north eastern region productivity of crop is quite low as compared to many okra growing regions of India. Low productivity of crop is due to many reasons, of which rainfed cultivation, lack of awareness about modern production technologies, lower input use, biotic and abiotic stresses are important. Crop is infested by repeated flushes of diversified weed flora throughout its growing season. Weed competition with the crop causes substantial yield losses (40-80%) which depends upon the type of weed flora, their intensity and stages (Sharma and Patel, 2011). The crop weed competition remains maximum during the early growth stage which slows initial growth rate of the crop and consequently causes poor competitive ability.

Continuous monitoring and refinement in management strategies is essential for alleviating adverse effects of weeds on agricultural productivity and environmental health (Rao and Nagmani, 2013). Besides this, weeds are preferred by hosts of insect pests and vectors of many important organisms and thus act as source of several diseases to okra. Therefore, it is greatly needed to evolve appropriate weed management strategy either through cultural or physical and mechanical or herbicidal or by combining herbicides with physical or mechanical and cultural weed control methods. Hence, the present investigation was, designed to find out the effective measures of weed management with combination of herbicide and physical methods.

MATERIALS AND METHODS

An experiment was conducted at Research Farm of College of Horticulture and Forestry, Pasighat (28°072 N Latitude and 95°332 E Longitude) in Arunachal Pradesh during the pre-*kharif* season of 2014 and 2015. The soil of the experimental site was sandy loam in texture with a pH of 5.6, organic carbon 23.4 g C kg^{-1}, available nitrogen 151 mg N_2 kg^{-1}, Bray's P 12.7 mg kg^{1}and available K 74 mg kg^{-1}of soil. The crop received total 1292.2 mm and 3427.5 mm rainfall during first and second year in 52 and 68 rainy days during crop period of 2014 and 2015, respectively. Nine weed control treatments consisting of T_1: Weed free (up to 60 days stage), T_2: Weedy check (control), T_3: Pendimethalin 30EC @ 0.5kg a.i.ha^{-1}, T_4: Pendimethalin 30EC @ 1kg a.i.ha^{-1}, T_5: Pendimethalin 30EC @ 1.5kg a.i ha^{-1}, T_6: Pendimethalin 30EC @ 0.5kg a.i ha^{-1}+ one hand weeding, T_7: Pendimethalin 30EC @ 1kg a.i ha^{-1}+ one hand weeding, T_8: Pendimethalin 30EC @ 1.5kg a.i ha^{-1} + one hand weeding and T_9: hand weeding twice at 20 and 40 DAS were evaluated in Randomized Complete Block Design (RCBD) with three replications. Seed of Okra cv Arka Anamika was sown at 45 × 20cm spacing. The recommended doses of fertilizers (100 kg N, 80 kg P_2O_5 and 80 kg K_2O ha^{-1}) were applied to crop. Nitrogen applied in two splits, ½ as basal along with full dose of

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phosphorus and potash and remaining ½ nitrogen supplied as top dressing 30 days after sowing during both the years. Crops were sown on 5th May, 2014 and 23rd May, 2015 during first and second year, respectively. Herbicide pendimethalin was applied on third day of sowing as pre emergence application with manually operated knapsack sprayer delivering a spray volume of 600 lit ha^{-1} through flat fan nozzle. The observations were recorded on weeds (density m^{-2}, dry weight g m^{-2}, and weed control efficiency %) and crop. The growth and yield parameters of okra were recorded from five randomly selected plants in each plot, and fruit yield was recorded from the net plots. Weed population and dry weight were recorded at 60 DAS by placing a quadrate of 50 x 50 cm randomly in each plot and then converted to per square meter. Data on weed population and dry weight were transformed through square root ["(x+0.5)] method before statistical analysis. Weed control efficiency was calculated based on the method suggested by Prachand *et al*. (2015) as follows:

$$WCE(\%) = \frac{DWC - DWT}{DWC} \times 100$$

(Where, WCE = Weed control efficiency in per cent, DWC = Dry matter weight of weed in

Control plot and DWT = Dry matter weight of weed in treated plot).

The data for different parameters were statistically analyzed as per the procedure of analysis of variance as suggested by Panse and Sukhatme (1985). For economic study, prevalent market price was used for different outputs and inputs and B: C ratio was calculated.

RESULTS AND DISCUSION

Effect on weeds

The prevalent weed flora infesting the crop in experimental fields during both the years were *Digera arvensis, Urena lobata, Cynodan dactylone, Cyperus iria, Commelina benghalensis, Amaranthus viridis, A. spinosus, Euphorbia hirta and Echinichloa colona*. Significant variation in weed density and weed dry weight was recorded due to different weed management practices (Table1). Significantly highest weed density was recorded in weedy check, followed by (fb) pendimethalin alone fb pendimethalin with one manual weeding at 40 DAS, whereas the lowest was recorded in weed free control. Hand weeding at 20 and 40 DAS also recorded significantly lower weed density as compared to weedy check and was at par with pendimethalin 1.5kg a.i ha^{-1} plus manual weeding at 40 DAS. Among herbicide treatments the lowest weed density was observed in pendimethalin 1.50 kg a.i ha^{-1} plus manual weeding at 40 DAS (56.1 and 59.3 weeds m^{-2} during 2014 and 2015, respectively). Similarly, significantly highest weed dry weight was observed in weedy check (15.3 and 15.9 g m^{-2}during 2014 and 2015, respectively) and the lowest in case of weed free plot fb pendimethalin 1.50 kg ai ha^{-1} plus manual weeding at 40 DAS which was at par with hand weeding twice and other herbicidal treatments.

Weed control indices were influenced considerably due to weed management practices. Weed free control was found to have the highest weed control efficiency followed by pendimethalin 1.50 kg ai ha^{-1} plus manual weeding at 40 DAS and hand weeding twice (20 and 40 DAS) was found to have highest weed control efficiency. Weed control efficiency recorded with pendimethalin 1.50 kg ai ha^{-1} plus manual weeding at 40 DAS and hand weeding twice (20 and 40 DAS) was found at par with pendimethalin 1.00 kg ha^{-1} with and without hand weeding and pendimethalin 1.50 kg ha^{-1}without hand weeding. The higher weed control efficiencies were mainly due to effective weed control under these treatments. Mathukia *et al*. (2017) also observed similar results under Gujrat conditions in groundnut crop with Pendimethalin supplemented with one hand weeding.

Effect on crop growth and yield attributes

Results revealed that all the weed control treatments and weed free control except pendimethalin @ 0.50 kg ha^{-1} significantly improved growth parameters, over un-weeded control. Crop growth parameters as well as yield attributes of okra recorded maximum with application of Pendimethalin 30EC @ 1.5kg ai ha^{-1}+ one hand weeding during both the years of experimentation (Table 2). Favourable atmosphere because of reduction in competition of crop with weeds for space, air, sunlight, moisture and nutrients in this treatment might have influenced to score higher values of growth parameters. The unweeded okra plots produced the shortest plants, less number of leaves and fruits per plant. This indicated that weed interference till maturity of crop had an adverse effect on these growth parameters. Application of Pendimethalin 30EC @ 1.0 kg ai. ha^{-1}+ one hand weeding also produced better yield of okra during both the years of experimentation. Among several weed control treatments application of Pendimethalin 30EC @ 1.5kg ai.ha^{-1} coupled with one hand weeding at 30 DAS recorded maximum yield increment (73.73 and 81.58 percent) over control. The improvement in yield and economical parameters due to better weed control with undertaking different weed management practices in okra was also earlier reported by Singh *et al*. (2010).

Table 1: Effect of weed management practices on weed density, weed dry matter, weed control efficiency and weed persistence index of okra crop.

Treatments	Weed density (m^{-2})		Weed DM (g/m^2)		WCE (%)		WPI	
	2014	2015	2014	2015	2014	2015	2014	2015
T_1	5.6(32.5*)	6.3(39.6)	2.3(5)	2.6(6.4)	67.6	60.2	0.999	1.014
T_2	10(98.1)	10.1(100.5)	4(15.3)	4.1(15.9)	0	0	1	1
T_3	8.5(70.3)	8.4(67.8)	3.5(10.9)	3.6(11.5)	28	26.8	1.001	1.072
T_4	8.3(65.9)	8.6(71.8)	3.4(10.2)	3.5(11.1)	32.5	29.7	1	0.972
T_5	8.1(64.1)	8.5(72.4)	3.3(10)	3.3(10)	34.6	37.1	1	0.965
T_6	7.9(60.7)	8.4(68.1)	3.3(9.4)	3.4(10.1)	37.9	36	1	0.937
T_7	7.9(59.8)	8.3(65.7)	3.2(9.3)	3.3(9.8)	38.7	37.5	0.999	0.944
T_8	7.6(56.1)	7.9(59.3)	3.1(8.7)	3.2(9.3)	42.5	40.6	0.999	0.993
T_9	7.7(57.1)	8.3(65.8)	3.2(8.9)	3.3(9.6)	41.7	39.4	0.997	0.921
SEm(±)	**0.30**	**0.25**	**0.11**	**0.10**	**4.05**	**4.53**	**0.001**	**0.002**
LSD (0.05)	**0.89**	**0.74**	**0.32**	**0.30**	**12.13**	**13.60**	**0.004**	**0.006**

**Value in the parenthesis are original value which are subjected to square root transformation*

Table 2: Effect of weed management practices on growth and yield of okra.

Treatments	Plant height (cm)		No. of green leaves $plant^{-1}$		Number of fruit $plant^{-1}$		Fruit yield ($g\ plant^{-1}$)		Fruit yield ($t\ ha^{-1}$)		Yield increase over control (%)	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
T_1	195.4	190.3	33.1	28.2	16.3	14.5	108.2	101.1	12.02	11.24	78.03	85.38
T_2	140.6	143.4	22.5	20.2	9.2	8.2	60.8	54.7	6.75	6.08	0	0
T_3	163.5	159.8	27	22.3	12	11	78	73.3	8.88	8.15	31.8	34.53
T_4	177.2	173.5	23.8	21.8	13.3	12.2	88.9	82.6	9.87	9.18	46.21	51.14
T_5	180.7	177.4	31.2	26.9	14	12.8	94.3	87.4	10.63	9.72	57.35	59.98
T_6	180	176.1	32.4	28.1	14.3	13	95.7	87.5	10.55	9.74	56	60.11
T_7	192.2	186.8	33	29.4	15.2	13.4	98.9	90.5	10.92	10.08	61.26	65.13
T_8	194.3	190	33.3	29.3	16.2	14.7	105.7	99	11.74	11.02	73.73	81.58
T_9	190.5	184.7	32.4	28.1	15	13.2	99.8	89.6	11.03	9.96	64.9	65.38
SEm(±)	5.66	7.33	1.83	1.23	0.61	0.68	3.15	4.21	0.51	0.44	7.36	7.32
LSD (0.05)	16.97	21.99	5.49	3.71	1.82	2.05	9.45	12.62	1.52	1.33	22.07	21.95

Table 3: Effect of weed management practices on economics of okra.

Treatments	Fruit yield ($t\ ha^{-1}$)		Gross income (Rs.)		B:C ratio		Net benefit kg^{-1} of produce (Rs.)	
	2014	2015	2014	2015	2014	2015	2014	2015
T_1	12.02	11.24	180300	168600	3.76	3.30	11.01	10.46
T_2	6.75	6.08	101250	91200	2.53	2.17	9.07	8.09
T_3	8.88	8.15	133200	122250	3.23	2.82	10.36	9.69
T_4	9.87	9.18	148050	137700	3.52	3.11	10.74	10.17
T_5	10.63	9.72	159450	145800	3.71	3.22	10.96	10.34
T_6	10.55	9.74	158250	146100	3.61	3.15	10.84	10.24
T_7	10.92	10.08	163800	151200	3.66	3.20	10.90	10.31
T_8	11.74	11.02	176100	165300	3.86	3.42	11.11	10.62
T_9	11.03	9.96	165450	149400	3.65	3.11	10.89	10.18

T_1: Weed free (up to 60 days stage), T_2: Weedy check (control), T_3: Pendimethalin 30EC @ 0.5kg a.i. ha^{-1}, T_4: Pendimethalin 30EC @ 1kg a.i.ha^{-1}, T_5: Pendimethalin 30EC @ 1.5kg a.i ha^{-1}, T_6: Pendimethalin 30EC @ 0.5kg a.i ha^{-1}+ one hand weeding, T_7: Pendimethalin 30EC @ 1kg a.i. ha^{-1}+ one hand weeding, T_8: Pendimethalin 30EC @ 1.5kg a.i ha^{-1}+ one hand weeding and T_9: hand weeding twice at 20 and 40 DAS

Effect on crop yield and economics

In both years fruit yield parameters of okra were significantly influenced by the treatments. The highest fruit yield of 12.02 and 11.24 t ha^{-1} was recorded in the plots that were kept weed free up to 60 days after sowing during the both years, however the effect of the treatment was on par with all other weed control treatments except pendimethalin 30 EC @ 0.50 kg and 1.0 kg ha^{-1}alone. Crop yield was generally higher in 2014 than that of 2015. High rainfall during crop growth period in 2015 might have reduced crop yield. Unweeded plots produced significantly lowest yield (6.75 and 6.08 t ha^{1} (Table 2). This was due to an enhanced competition between crop and weeds for resources like nutrients, water and light. Singh *et al.* (2010) also reported a similar observation that pod yield was increased when herbicide was followed by hand weeding. The results showed that Pendimethalin 30 EC@1.5 kg ha^{-1} coupled with hand weeding once gave the highest B:C ratio (1:3.86 and 1:3.42) during both the years of experimentation. Similar results were recorded in case of net benefit/kg of produce (Table 3). Gogoi *et al*. (1997) and Kumar and Singh (2014) reported similar findings. While studying the effect of herbicides, either alone or in combination with one hand weeding. They reported that herbicide combined with hand weeding once resulted in better control of weeds than a single herbicide treatment, resulting in the maximum benefit B:C ratio. Unweeded plots produced lowest fruit yield in comparison to treated plots and provide cost: benefit ratio more than two might be due to lower cost of cultivation.

From the results of the present study it can be concluded that, pre-emergence application of Pendimethalin 30 EC @ 1.50 kg ha^{-1}coupled with hand weeding once is the best weed management practice in okra under foot hill conditions of Arunachal Pradesh to obtain greater yield and economic return with more efficient weed control.

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