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Integrated Weed Management on Growth, Yield and Economics in Okra (*Abelmoschus esculentus* (L.) Moench) Under Kharif

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A field experiment was carried out at College Orchard, Department of Vegetable Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore during 2014 to 2017 to investigate integrated weed management on growth, yield and economics in okra (*Abelmoschus esculentus* (L.) Moench) cv. COBhH 1 during kharif seasons. The experiment was laid out in Randomized Block Design (RBD) with seven treatments and replicated three times. The growth and yield attributes *viz*., plant height, number of fruits per plant, fruit yield per plant, fruit length, fruit girth, fruit yield kg per plot and fruit yield (q/ha) differed significantly due to different treatments. Growth and yield attributes increased significantly in weed free check (T_2) which led to appropriate timing of weeding which reduced the influence of weed interference and increased the yield in okra. The results revealed that weed free check (T_2) recorded the higher plant height (151.80 cm), number of fruits/plant (27.30) with an average fruit yield of 0.501 g per plant, fruit length (13.53 cm), fruit girth (7.53 cm), fruit yield (233.9 q/ha) and low weed density (12.03/m^2) at 60 days after sowing. Whereas, the high cost benefit ratio (2.88) was recorded in pre emergence of pendimethalin @ 1.0 kg/ha + one hand weeding (T_4) which also recorded 23.36 number of fruits/plant with fruit yield of 223.0 q/ha. It is therefore recommended that pre emergence application of pendimethalin @ 1.0 kg/ha + one hand weeding will be optimal for okra production in kharif season.

Key words: Weed management, Okra, Pendimethalin, Growth, Yield, Economics

Okra (*Abelmoschus esculentus*) L. (Moench), is a member of the malvaceae family and is an economically important vegetable crop grown in tropical and sub-tropical parts of the world. It is grown commercially in India, Pakistan, Burma, Japan, Malayasia, Brazil, Ghana, Ethiopian, Cyrpus and the Southern United States. India ranks first in the world with 5.7 million tonnes of okra produced from over 0.50 million ha land and productivity of 11.9 tonnes per hectare (NHB, 2015-16). It is quite popular in India because of easy cultivation, dependable yield and adaptability to varying moisture conditions. It is a tropical direct sown vegetable with duration of 90-110 days. It is the best source of iodine and calcium. The nutritional composition of okra includes calcium, protein, oil and carbohydrates, iron, magnesium and phosphorus.

In most of the vegetables crops, weeds are the silent robbers of plant nutrients, moisture, sun light and also compete for space that would otherwise be available to the main crop. Weed competition is especially dramatic when a direct-seeded vegetable is grown *viz*., okra, cluster bean, cowpea, yard long bean, lab lab and gourds. The critical period of weed competition (*i.e*. the period during which weed control has to be carried out) is usually longer in direct-seeded than in transplanted crops. For example, if transplanted pepper has to be weeded from the second week until the third month after transplant to prevent a 10 percent yield loss, direct-seeded pepper must be weeded during the first four months after emergence to prevent the same loss. Some traditional techniques are thought to increase crop competitiveness (e.g. transplant, earthing-up). Obviously, weather conditions and weed density have a great influence on the length of critical periods. Weeds also harbour pests and disease causing organisms; cause adverse allelopathic effects on okra and reduce the yield and quality of the produce. Because of the slow growth rate of okra during the initial stages, weeds take advantage of moisture, soil fertility and environmental conditions to suppress the growth of the crop. Due to this weed competition, the crop remains weak and unhealthy; this results in the reduction of yield and quality of the crop. A yield loss of about 54.1 to 90.6 per cent was reported in okra due to weed competition. The most critical period of crop weed competition in okra is upto 2-6 weeks after sowing (Singh *et al.,* 1981).

In okra, pendimethalin either alone or in mixtures with broad leaf herbicides, and supplemented with other weed control methods, especially hand weeding, has given effective control of weeds

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(Dhanappal and Gowda, 1996). Smith *et al.,* (2009) obtained effective weed control with pendimethalin and pendimethalin based weed management methods in okra.

Okra suffers heavy yield losses in rainy season (kharif) due to weed infestation owing to congenial environmental conditions for luxurious weed growth coupled with wider row spacing and slow growth at early stages. Yield losses due to weeds varied from 40 to 80% depending on the type of flora, their intensity and stages (Patel *et al*., 2004). Scarcity of man power at critical period of crop-weed competition, costly herbicides and their availability in desired quantity are also problematic. The cumulative effects of weeds on crop production eventually lead to crop losses due to weed activities including competition, allelopathy, acting as alternative host to pests and pathogens, adulteration of farm produce etc. It was, therefore, considered necessary to undertake a study to find the performance of integrated weed management on growth, yield and economics in okra (*Abelmoschus esculentus* (L.) Moench) during kharif seasons.

Material and Methods

The experiment was conducted during three consecutive *Kharif* seasons of 2014 to 2017 at College Orchard (11.0152° N latitude, 76.9326° E longitude and 426 m altitude), Department of Vegetable Crops, HC&RI, Tamil Nadu Agricultural University, Coimbatore. The experimental soil was well drained and sandy loam in texture, having pH of 6.92. The experiment was laid out in a randomized block design (RBD) with seven treatments with three replications. The experimental fields was ploughed three times and FYM 10 kg, neem cake 1 kg, super phosphate 100 g and furadon 10 g/sq.m were incorporated uniformly in the last ploughing and ridges and furrows were formed. The ridges and furrow was earmarked for 45 cm apart for assigning treatments and replications. The drip laterals were laid over the ridges and furrow for irrigation. The treatments consists of

T1 : Weedy check

T2 : Weed free check

T3 : Pre-emergence application of pendimethalin @ 1.0 kg/ha

T4 : Pre-emergence application of pendimethalin @ 1.0 kg/ha + one hand weeding

T5 : Pre-emergence application of pendimethalin @ 1.0 kg/ha + Quizaflop ethyl 0.5 kg/ha at 20 DAS

T6 : Post emergence application of Metribuzin @ 0.5 kg/ha at 20 DAS

T7 : Post emergence application of Glyposate @ 1.0 kg/ha + 10 g urea as protected spray at 25 DAS

The field was fertilized with recommended doses of NPK at the rate of 100: 100:100 kg/ha, respectively and the fertilizers were given as WSF through drip fertigation system uniformly for all the treatments throughout the cropping period. The seeds of okra cv. COBhH 1 were sown on ridges at 60x30 cm spacing.

Morphological Parameters

The plant height was measured from the base of the plant to the terminal growing point of the main stem at last harvest. The average plant height was worked out and expressed in centimeters. The total numbers of fruits from 10 tagged plants were counted in all the pickings and the average total numbers of fruits plant^{-1} for the each treatment was worked out. Ten numbers of fruits from each treatment was weighed and they were worked out for single fruit weight and expressed in grams. The fresh fruit yield from the net plot area was taken to calculate the fruit yield per hectare. The total number of weeds present in 0.5 sq. mt area in a permanently marked sampling area was counted at 30 and 60 DAS in each treatment. The observation on plant height (cm) at final harvest stage, number of fruits/plant, fruit yield per plant, fruit length, fruit girth, fruit yield q/ha and weed density 60 days after sowing were recorded. The benefit cost ratio was arrived by using the formula given below.

Net returns (Rs. ha^{-1})

BCR = Total cost of expenditure (Rs. ha^{-1})

Data were subjected to statistical analysis by analysis of variance method (Panse and Sukhatme, 1985). The critical difference was worked out for 5 per cent probability. The results of the experiment was tabulated and presented below.

Results and Discussion

The results of the investigation on integrated weed management on growth, yield and economics in okra (*Abelmoschus esculentus* (L.) Moench) cv. CO Bh H 1 under kharif over the three years was pooled and the mean values were presented (Table 1 & 2) and discussed hereunder.

Growth characters

Weed management practices significantly influenced the crop growth characters like plant height (cm) and the data is presented in Table.1. The plant height varied significantly due to different treatments. Pre emergence application of pendimethalin @ 1.0 kg/ha + one hand weeding (T_4) showed superior performance in plant height than all other treatments tested except weed free check (T_2), with an plant height of (146.43 cm) indicating pre emergence application of pendimethalin + hand weeding practice had positive effect on the growth and development of okra followed by weed free check T_3 (143.80 cm). The lowest plant height (73.73 cm) was recorded in weedy check.

The herbicides when used in combination with one or two hand weedings, improves their efficiency and the pre-emergent herbicides are beneficial to keep the crop weed free in the early stages. During later stages, hand weeding helps to reduce the cost of weeding and keep the weed population below the economic threshold level throughout the crop growth period. (Shivalingappa *et al.,* 2014) (Adejonwo *et*

*al.,*1989). This has been attributed to the fact that okra varieties are sensitive to environmental changes (Ijoyah *et al.,* 2009) and also it might be due to the reason that, the crop faced minimum crop weed competition because of herbicidal action and hand weeding practice and it resulted into maximum height of plant.

Table. 1. Effect of different weed management practices on growth and yield attributes in okra

Treatments	Plant height (cm)				No .of fruits/ plant				Fruit yield/ plant (g)				Fruit length (cm)			
	2014-15	2015-16	2016-17	Mean	2014-15	2015-16	2016-17	Mean	2014-15	2015-16	2016-17	Mean	2014-15	2015-16	2016-17	Mean
T_1	70.9	75.7	74.6	73.73	12.1	13.4	13.7	13.06	0.171	0.175	0.170	0.172	10.2	10.4	10.4	10.33
T_2	147.1	154.4	153.9	151.80	26.2	27.4	28.3	27.30	0.484	0.511	0.509	0.501	13.3	13.6	13.7	13.53
T_3	140.9	146.1	144.4	143.80	21.0	21.3	20.9	21.06	0.357	0.361	0.370	0.363	13.1	13.4	12.9	13.13
T_4	143.3	150.4	145.6	146.43	23.0	23.4	23.7	23.36	0.455	0.439	0.450	0.448	13.3	13.5	13.3	13.37
T_5	86.7	91.0	88.0	88.56	15.4	17.0	16.5	16.30	0.185	0.208	0.193	0.195	10.2	10.8	11.5	10.83
T_6	95.1	99.9	97.3	97.43	15.9	17.8	16.3	16.66	0.239	0.235	0.264	0.246	12.9	13.2	13.0	13.03
T_7	110.8	115.7	114.3	113.60	18.5	18.2	18.7	18.46	0.316	0.310	0.320	0.315	12.4	12.6	12.9	12.63
CD 5%	6.22	6.48	6.31	1.87	2.90	1.90	2.5	1.00	0.048	0.035	0.042	0.038	0.857	0.86	0.85	0.842

Similar results were also recorded from the earlier findings of Quasem (2007) in Cauliflower, Anisuzzaman *et al.,* (2009) and Kolse *et al.*, (2010) in okra.

Yield characters and economics

The mean data presented in (Table: 1, 2 & Fig 1) revealed that yield and yield component of okra is significantly influenced by different weed control method.

Table. 2. Effect of different weed management practices on yield, weed density and economics in okra

Treatments	Fruit girth (cm)				Fruit yield (q/ha)				Weeds density No. / 0.5 sq. m 60 DAS				Benefit cost ratio
	2014-15	2015-16	2016-17	Mean	2014-15	2015-16	2016-17	Mean	2014-15	2015-16	2016-17	Mean	
T_1	6.1	6.4	6.3	6.27	83.6	81.1	85.2	83.30	86.3	85.1	82.3	84.56	1:1.91
T_2	7.4	7.7	7.5	7.53	236.7	222.2	242.9	233.9	12.7	11.3	12.1	12.03	1:2.48
T_3	6.6	6.8	6.7	6.70	174.3	166.5	173.2	171.3	28.5	28.4	27.9	28.26	1:2.61
T_4	7.0	7.4	7.2	7.20	222.4	215.7	231.1	223.0	15.3	15.5	16.4	15.73	1:2.88
T_5	6.6	6.9	6.8	6.77	90.6	87.9	94.7	91.06	35.6	43.4	45.7	41.56	1:1.98
T_6	6.4	6.7	6.3	6.47	117.0	107.6	122.1	115.5	34.9	36.3	39.0	36.73	1:2.52
T_7	6.7	7.0	6.9	6.87	154.5	151.4	159.5	155.1	42.8	42.2	39.3	41.43	1:2.54
CD 5%	0.54	0.47	0.52	0.49	23.04	15.39	22.7	5.88	5.13	5.66	5.44	4.54	-

The data on numbers of fruits per plant, fruit yield per plant, fruit length, fruit girth, fruit yield kg per plot and fruit yield q per ha indicated significant difference due to herbicide treatments and crop weed

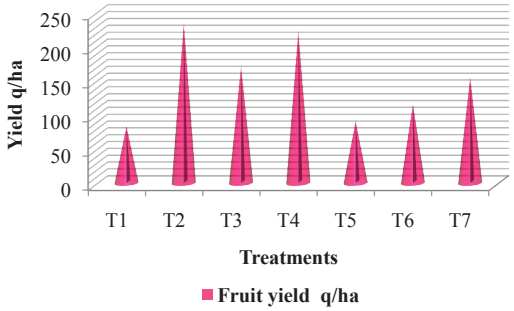

Fig. 1.Effect of different weed management practices on yield (q/ha) in okra

competition. Highest fruits per plant (27.30), fruit yield per plant (0.501) and fruit yield q per ha (233.9) is recorded in case of Weed free check (T_2) followed by Pre-emergence application of pendimethalin @ 1.0 kg/ha (T_3). Similar findings were also reported by Mekki *et al.*, (2010). However, lowest fruits per plant, fruit yield per plant and fruit yield q per ha is recorded in case of weedy check (T_1). The higher yield may be attributed to less competition of weeds and decrease in their population that helped in increasing the yield attributes which ultimately led to higher yield and also increase in plant height enhance the number of nodes per plant yielding maximum number of fruits in okra. This may also be attributed to better control of weeds thereby lower weed population and suppression of weed growth which might have resulted in lower accumulation of dry matter of weeds (Biradar *et al.*, 1999).In the trial broad leaved weeds were found to be predominant throughout the period of experiment. It was observed that *Parthenium hysterophorus* dominated the field followed by *Alternenthera triandra*, *Acalypha indica, Amaranthus viridis, Cyperus iria*, *Cynodon dactylon*, *Chenopodium album*, *Euphorbia hirta, Physalis minima, Portulaca oleraceae, Sonchus arvensis* and *Trianthema portulacastrum.* Efficiency of different treatment studied in the experiment in controlling the weeds in okra found effective in decreasing the weed density and increases the yield characters. Weed dry matter is a better parameter to measure the competition than

the weed number (Chnnappagoudar *et al.,* 2013). In the present study, weedy check (T_1) control recorded significantly higher weed density at all the stages of crop growth period. Among all the treatment lowest

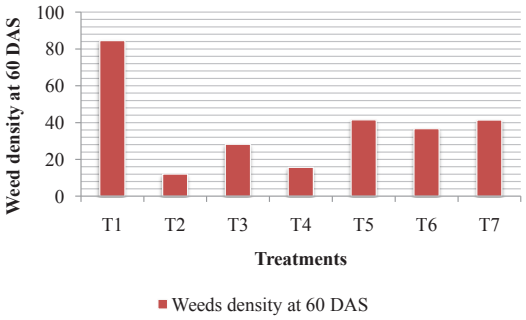

Fig. 2. Effect of different weed management practices on weed density per 0.5m² at 60 DAS in okra

weed density was recorded in the treatment weed free check (T_2) 12.03 at 60 DAS (Table 2 & Fig 2) followed by (T_4) pre emergence application of pendimethalin @ 1.0 kg/ha + one hand weeding (15.73 at 60 DAS). The variability in weed density in different treatments can be attributed to the fact that some herbicides are more effective for weed control than others (Khan *et al.,* 2008). The lowest weed density was observed in weed free check treatment may be ascribed to the less number of weeds, rapid depletion of carbohydrate reserves of weeds through rapid respiration (Dakshinadas, 1962) and may be due to reduced photosynthetic activity (Hilli and Santkemann, 1969). The maximum benefit: cost ratio (3.57) was obtained under pendimethalin (extra) (0.64 kg/ha) pre-transplanting + one hand weeding at 40 DAT + pendimethalin (extra) (0.64 kg/ha) at 45 DAT compared to weed free check (T_2).

Conclusion

Pre emergence application of pendimethalin @ 1.0 kg/ha + one hand weeding have more significant effect which results maximum plant height, highest yield attributing characters, high weed control efficiency (WCE %) and economics than all other treatments tested except weed free check. It is therefore recommended that pre emergence application of pendimethalin @ 1.0 kg/ha + one hand weeding will be optimal for okra production in kharif season.

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