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Response of weed management practices in okra (*Abelmoschus esculentus*) under foothill condition of Nagaland

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ABSTRACT

A field experiment was conducted at Experimental Farm, SASRD, Nagaland University, Medziphema, Nagaland in summer season of 2017 to study the response of weed management practices on growth, yield, quality and economics of okra under foothill condition of Nagaland. Eight treatments were evaluated in randomized block design with three replications. Results revealed that the black polythene 30 micron mulching (T_8) gave the maximum plant height (130.1 cm), number of leaves plant^{-1} (65.3), leaf area index (13.8), length of pod (11.5 cm), number of seeds pod^{-1} (46.0), number of pods plant^{-1} (45.6), fresh weight of pod (12.0 g), pod yield (307.40 q ha^{-1}), protein content (1.3%), dry matter (13.3%) and minimum weed density (5.0). However, the maximum vitamin C (12.41 mg 100 g^{-1}) was recorded in pendimethalin @ 1kg ha^{-1} (PE) + 1 hand weeding. The highest net income (profit) of ₹ 5,00850 along with a cost: benefit ratio of 4.39 was recorded in the treatment black polythene 30 micron which was followed by weed free check (2 hand weeding). Thus, from the results it can be concluded that black polythene 30 micron thickness found to be most effective in reducing weed density and increasing the growth, yield and quality of okra under foothill condition of Nagaland.

Keywords: Weed management, okra, growth, yield, quality, economics

INTRODUCTION

Okra (*Abelmoschus esculentus*) belongs to the family Malvaceae. Okra has its chromosome number 2n = 130 and is originated from Tropical region of Africa. India produced 6.34 million tonnes of okra from an area of 5.85 million hectares (Anon., 2017). Immature fruits are consumed in the form of fry, boiled, curries etc. The stems and roots are used in clearing of cane juice and also in paper making. The tender pods possess some important medicinal properties which are used to treat inflammation of a mucous membrane, especially of the respiratory tract, accompanied by excessive secretions. Okra juice is used to treat sore throat associated with coughing. Decoction of okra leaves, fruits and leaves are used to treat urinary problems including gonorrhea and syphilis. Okra is rich in fibre that absorbs water and improves the bulk of stool. Okra's mucilage (sodium glycosides) binds with cholesterol and bile acids and expelled through stool from the body. Okra helps in lowering the blood sugar level by blocking the absorption of sugar in the intestinal tract. Okra fruits are reservoir of iodine which is used against goitre (Kanaujia *et al.,* 2017). The diverse agro-climatic conditions, varied soil types and abundant rainfall under foothills condition of Nagaland enable the favourable cultivation for okra. In spite of having optimum growing conditions, the production level of okra is low due to common agronomic practices. Among all the agronomic practices, weed management is serious problem as weeds causes a loss of as much as 70% in pod yield in okra (Sharma and Patel, 2011). Weeds serve as a source of resting inoculums of diseases and alternate host for pests and compete for space, nutrition, light, moisture with the main crop and thus reducing the yield and quality of crop produce and increasing the cost of cultivation (Singh *et al.,* 2016). Though manual weeding is the effective method of weed control in okra, but it is becoming cumbersome and uneconomical due to hike in wages and labour scarcity in these days. But no information is available about the economically feasible weed management practices of okra in North Eastern region including Nagaland in particular. In keeping view of the above situation, the present investigation was conducted to find out the best weed management practices in okra that is economically feasible to the farmers of Nagaland.

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MATERIALS AND METHODS

The experiment was conducted at the Experimental Farm, SASRD, Nagaland University, Medziphema under Dimapur district. It is situated at an altitude of 304.8 m above mean sea level and geographically located at 25° 45′ 45′′ North latitude and 9° 53′ 04′′ East longitude, in the foot hills of Nagaland. Plot size was measured 2.4 m x 2.4 m and spacing was maintained at 60 x 30 cm. The experiments were laid out in Randomized Block Design with three replications. The treatments consisted of T_1 - Weedy check (Control), T_2- Weed free check (2 hand weeding), T_3-Pre-emergence application of pendimethalin @ 1kg ha^{-1}, T_4- Pre-emergence application of pendimethalin @ 1kg ha^{-1} + one hand weeding, T_5-Pre- emergence application of pendimethalin @ 1kg ha^{-1} + onizolphose ethyl (POE) 40-50 g ha^{-1} at 20 days, T_6- Post emergence application of metribuzin @ 525 g ha^{-1} at 20 days, T_7- Post emergence application of glyphosate @ 1kg ha^{-1} + 10g urea L^{-1} as protected spray at 25 days, T_8- Black polythene 30 micron thikness. Well decomposed FYM @ 15 t ha^{-1} was applied to the field 30 days prior to sowing during land preparation. Full dose of P and K and half dose of N were applied at the time of sowing. While remaining half dose of N was applied in split doses at 15 and 30 days of planting. Seeds were soaked in water overnight followed by shade drying then treating with Bavistin @ 3g kg^{-1} seeds. The treated seeds were sown in the well prepared beds by dibbling method where two seeds are placed at half inch depth. Tender and small pods were harvested in morning or evening hours. Harvested pods were carefully collected in labelled bags. Subsequent pickings were done at 2-3 days interval. Five plants in each plot were selected randomly for recording the observations and were duly tagged. Data were recorded on growth parameters (germination percentage, plant height, number of leaves $plant^{-1}$, leaf area index, number of branches $plant^{-1}$), yield and yield attributes (length of pods, diameter of pods, number of seeds pod^{-1}, number of pods $plant^{-1}$, fresh weight of pod, pod yield), quality characters (shelf life, protein content, vitamin C content, dry matter percentage), weed population, soil nutrient status after harvest and economics of the treatments. Protein content was determined by Kjeldhal method (Jackson, 1973). Vitamin C content was estimated by 2, 6-dichlor-ophenol indophenol methods of AOAC (1984) and expressed in mg 100 $^{-1}$g. Treatment wise economics was carried out by calculating the cost of cultivation based on prevailing rates of input and output. Gross income was calculated by yield multiplied by whole sale rate of okra @ □ 20 kg^{-1}. Net income was estimated by deducting the total cost of cultivation (fixed cost + treatment cost) from gross income of the particular treatment and cost benefit ratio was also worked out. The composite soil samples were collected before and after the experiment from the experimental plots to a depth of 15 cm with the help of screw type auger. Soil samples were analysed for available nitrogen, phosphorus, potassium and organic carbon using standard procedure (Jackson, 1973). The statistical analysis was carried out as per procedure given by Panse and Sukhatme (1978).

RESULTS AND DISCUSSION

Growth parameters

Growth parameters behaviour varied considerably under different treatments (Table 1). There were no significant differences on germination percentage under all the treatments. However, maximum germination (100%) was observed with black polythene 30 micron. Variation in plant height among the treatments was statistically significant at 30, 60 and 90 days after sowing. There was appreciable increase in plant height with the advancement of days in the different treatments. Black polythene 30 micron recorded maximum plant height of 61.9, 101.9 and 130.1 cm which was at par with pendimethalin @ 1kg ha^{-1} (PE) + onizolphose (POE) ethyl 40-50 g ha^{-1} at 20 days *i.e*. 51.0, 97.2 and 129.1 cm at 30, 60 and 90 days after sowing, respectively. The minimum plant height was recorded in weedy check with 20.0, 34.1 and 44.6 cm at 30, 60 and 90 days after sowing, respectively. The significant difference in plant height might be associated with the treatment characteristics which are similar with the findings of Sharma and Patel (2011) who concluded that mulching with black polythene sheet greatly increased the plant height in okra. Number of leaves varied significantly among the treatments. The maximum number of leaves 39.3, 53.0 and

65.3 at 30, 60 and 90 days after sowing, respectively was recorded from treatment black polythene 30 micron followed by weed free check *i.e*. 21.0, 30.6 and 39.6 at 30, 60 and 90 days after sowing, respectively. The minimum number of leaves was recorded from weedy check *i.e*. 9.0, 13.0 and 18.3 at 30, 60 and 90 days after sowing, respectively. More number of leaves may be due to vigorous growth of the crop under less interference of weed. These results are in accordance with the findings of Baraiya *et al.* (2017). There were no significant differences in number of branches plant^{-1} under all the treatments. The value of leaf area index ranged from 1.37 to 13.82. Black polythene 30 micron recorded the maximum LAI with 13.82 which was followed by weed free check with 4.83 and pendimethalin @ 1kg ha^{-1} (PE) + onizolphose (POE) ethyl 40-50 g ha^{-1} at 20 days *i.e*. 4.56. The minimum LAI (1.37) was recorded from weedy check. The highest LAI produced with black polythene 30 micron indicates that the photosynthetic leaf surface perfectly covers the ground area which signifies the effective utilization of cropped area for photosynthetic activity. This result was well supported by Kumar *et al.* (2014) who concluded that leaf area index of okra was significantly different between various weed control methods.

Table 1: Effect of weed management practices on growth attributes of okra

Treatments	Germinat-ion (%)	Plant height (cm)			Leaves plant^{-1}			Branches plant^{-1}			Leaf area index	Weed density 0.5 m^{-2}	
		30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS		40 DAS	60 DAS
T_1	87.5	20.0	34.1	44.6	9.0	13.0	18.3	0.3	2.3	4.0	1.37	193.6	130.0
T_2	93.0	45.2	86.	117.3	21.0	30.6	39.6	1.3	3.0	5.3	4.83	85.0	30.3
T_3	94.4	37.9	81.3	112.8	13.3	20.0	27.3	0.6	2.6	4.0	3.70	6.3	7.0
T_4	91.6	44.4	88.4	120.9	19.0	27.6	37.6	1.0	3.3	5.0	5.55	16.3	5.6
T_5	93.0	51.0	97.2	129.1	13.3	20.6	28.6	0.6	2.6	4.6	4.56	9.0	7.0
T_6	88.2	28.5	51.2	75.7	11.6	17.0	23.3	0.3	2.3	4.3	3.37	19.0	14.0
T_7	91.6	29.9	48.8	68.3	9.3	14.6	22.6	0.6	2.6	5.0	1.74	110.6	97.3
T_8	100	61.9	101.9	130.1	39.3	53.0	65.3	1.6	4.0	7.0	13.82	5.0	5.0
SEm ±	3.66	3.97	4.78	4.47	2.83	3.31	3.23	0.31	0.42	0.62	0.16	3.1	3.39
CD (P = 0.05)	NS	12.04	14.51	13.57	8.58	10.04	9.8	NS	NS	NS	0.48	9.43	10.27

T_1 weedy check, T_2 weed free check (2 hand weedings), T_3-Pendimethalin @ 1kg ha^{-1} (PE), T_4-Pendimethalin @ 1kg ha^{-1} (PE) + 1 hand weeding, T_5-Pendimethalin @ 1kg ha^{-1} (PE) + onizolphose ethyl (POE) 40-50 g ha^{-1} at 20 days, T_6-Metribuzin @ 525 g ha^{-1} (POE) at 20 days, T_7-Glyphosate @ 1kg ha^{-1} (POE) + 10g urea L^{-1} as protected spray at 25 days, T_8-Black polythene 30 micron

Yield attributes and yield

Weed management practise of using black polythene mulch increased the yield attributes of the okra plants (Table 2). Length of pod varied significantly among the treatments. Black polythene 30 micron recorded maximum length of pod of 11.5 cm which was at par with pendimethalin @ 1kg ha^{-1}(PE) + onizolphose ethyl (POE) 40-50 g ha^{-1} at 20 days with 11.1 cm.While the lowest length of pod (8.4) cm was recorded in weedy check. The superiority of black polythene 30 micron over other treatments might be due to efficient catalytic ancactivity of starch deposition (photosynthates) on pods of the okra plant under minimal weed. Baraiya *et al.* (2017) reported that there was a significant difference among various treatments for length of pod in okra plants. There were no significant differences in diameter of pod and number of seeds pod^{-1} under all the treatments. Variation in number of pods plant^{-1} among the treatments was found statistically significant. Black polythene 30 micron recorded maximum number of pods plant^{-1} (45.6) followed by weed free check:2 HW (33.3), pendimethalin @ 1kg ha^{-1} (PE) + 1 HW (31.6) and pendimethalin @ 1kg ha^{-1} (PE) + onizolphose ethyl (POE) 40-50 g ha^{-1} at 20 days (31.6). However, the minimum number of pods plant^{-1} (18.6) was recorded from weedy check. The increased number of pods plant^{-1} with black polythene 30 micron over the other treatments might be due to the reduced competition for moisture, nutrients and space with the weed plants thereby giving efficient weed management which leads to increased plant vigour which ultimately gave better yield. Singh *et al.* (2016) referred that there were significant differences in number of pods plant^{-1} among various treatments. Fresh weight of pod

showed a significant difference among the different treatments. The fresh weight of pod of okra ranged from 8.8 g to 12.0 g. The maximum fresh weight of pod (12.0 g) was recorded from black polythene 30 micron followed by metribuzin @ 525 g ha^{-1} (POE) at 20 days (11.2 g) and weed free check:2 HW (11.1g). Black polythene 30 micron was found to be significantly higher in fresh weight of pod over other treatments, whereas, the least fresh weight of pod (8.8 g) was recorded from weedy check. Similar findings were also reported by Sakshi *et al.* (2016) and Shamla *et al.* (2017).

Table 2: Effect of weed management practices on yield and quality attributes of okra

Treatments	Length of pods (cm)	Diameter of pod (cm)	Number of seeds pod^{-1}	Number of pods $plant^{-1}$	Fresh weight of pod (g)	Pod yield (q ha^{-1})	Shelf life (days)	Protein content (%)	Vitamin C content (mg 100 g^{-1})	Dry matter (%)
T_1	8.4	1.0	30.6	18.6	8.8	92.59	4.0	0.90	9.20	10.8
T_2	8.7	1.2	30.3	33.3	11.0	205.55	4.0	1.03	10.69	10.1
T_3	8.6	1.0	42.6	27.3	9.6	146.29	3.3	1.20	11.89	11.3
T_4	9.0	1.1	37.6	31.6	11.0	194.44	3.6	1.20	12.41	10.9
T_5	11.1	1.2	38.0	31.6	10.9	190.73	3.6	1.13	12.06	12.0
T_6	9.7	1.0	40.6	23.3	11.2	124.76	3.6	1.30	11.91	10.1
T_7	9.1	1.3	31.3	22.0	10.4	129.63	4.0	1.04	9.83	10.2
T_8	11.5	1.4	46.0	45.6	12.0	307.40	4.0	1.37	12.25	13.3
SEm ±	0.44	0.10	5.05	1.98	0.18	14.12	0.25	0.08	0.44	0.12
CD (P=0.05)	1.32	NS	NS	6.00	0.54	42.28	NS	0.24	1.33	0.35

Pod yield showed a significant difference among the different treatments. The maximum pod yield (307.40 q ha^{-1}) was exerted by black polythene 30 micron followed by weed free check: 2 HW (205.44 q ha^{-1}) and Pendimethalin @ 1kg ha^{-1}(PE) + 1 HW (194.44 q ha^{-1}). Minimum pod yield (92.59 q ha^{-1}) has been recorded in weedy check. Black polythene 30 micron was found to be the potential yielder. Medium yielder were weed free check:2 HW, Pendimethalin @ 1kg ha^{-1}(PE) + 1 HW and Pendimethalin @ 1kg ha^{-1} (PE) + onizolphose ethyl (POE) 40-50 g ha^{-1} at 20 days. The highest pod yield exerted by treatment Black polythene 30 micron might be due to the reduced competition for moisture, nutrients and space with the weed plants which gives efficient weed management which leads to increased in plant vigour which ultimately gave better yield whereas weeds compete indiscriminately with the crop plants for moisture, nutrients and space in weedy check thereby reducing the yield of the crop when grown under same agro-climatic conditions. Similar findings were also presented by Baraiya *et al.* (2017), Rajasree *et al.* (2017) and Sen *et al.* (2017).

Quality

The data (Table 2) revealed that there was no significant difference with regard to shelf life among the different treatments. Protein content varied significantly among the treatments and maximum protein content (1.3%) was recorded from black polythene 30 micron. The minimum protein content 0.9 % was recorded from weedy check. These findings were well supported by Sen *et al.* (2017). Vitamin C content showed a significant difference among the different treatments. The maximum vitamin C content (12.41 mg 100 g^{-1}) was recorded in treatment pendimethalin @ 1kg ha^{-1} (PE) + 1 HW which was at par with black polythene 30 micron). The minimum content of vitamin C (9.20 mg 100 g^{-1}) was recorded from weedy check. The highest dry matter (13.3%) was recorded from black polythene 30 micron. The lowest dry matter content (10.1%) was recorded in metribuzin @ 525 g ha^{-1} (POE) at 20 days. Black polythene 30 micron) exhibit highest dry matter content which might be due to deposition of higher soluble solids in the pod tissues. The lowest was recorded metribuzin @ 525 g ha^{-1} (POE) at 20 days which may be due to lesser soluble solids deposition. Similar findings were also supported by Singh *et al.* (2016).

Weed efficacy

The weed density at 40 and 60 DAS of okra showed a significant difference among the different treatments (Table 1). The maximum weed density was recorded from weedy check *i.e*. 193.6 and 130.0 at 40 and 60 days after sowing, respectively. The minimum weed density was recorded from black polythene 30 micron *i.e*. 5.0 and 5.0 at 40 and 60 days after sowing, respectively. Black polythene 30 micron found to be significantly superior over other treatments. The difference in weed density might be due to the restriction of weed growth under the different weed management regimes, which ultimately reduced the weed population. Black polythene 30 micron gave minimum weed density, this might be due to failure of weed seeds to germinate as complete killing of the weed seeds takes place under high temperature condition of the black polythene mulching and also inhibition of weed plants in photosynthetic activity by blocking the sun rays falling onto the weed leaves by the black polythene mulch. These results are in accordance with the findings of Singh *et al.* (2016), Rajasree *et al.* (2017) and Baraiya *et al.* (2017).

Table 3: Effect of weed management practices on nutrient status (kg ha^{-1}) in post harvest soil

Treatments	Nutrient status of soil after harvest			
	Available nitrogen	Available phosphorus	Available K_2O	Organic C
T_1	496.2	11.3	154.4	12.7
T_2	377.7	14.4	197.0	10.7
T_3	372.9	13.3	264.9	12.9
T_4	436.0	11.8	349.6	11.1
T_5	437.2	12.2	295.6	12.9
T_6	373.4	9.3	264.4	12.3
T_7	433.7	8.2	195.2	9.5
T_8	369.3	8.4	272.0	13.2
SEm ±	4.96	0.33	3.91	0.10
CD (P = 0.05)	15.05	1.00	11.87	0.30

Nutrient status in post harvest soil

The available N, P_2O_5, K_2O and organic carbon showed a significant variation among the different treatments (Table 3). Available nitrogen content ranged from 369.3 to 496.2 kg $ha^{-1}$and the highest value (496.2 kg ha^{-1}) was recorded from weedy check. The minimum available nitrogen (369.3 kg ha^{-1}) was recorded from black polythene 30 micron. Weedy check) was found significantly superior over the other treatments. Available phosphorus ranged from 8.2 to 14.4 kg $ha^{-1}$and maximum value (14.4 kg ha^{-1}) was recorded from weed free check. The minimum available phosphorus content (8.2 kg ha^{-1}) was recorded from glyphosate @ 1kg ha^{-1} (POE) + 10g urea L^{-1} spray at 25 days. Weed free check was found significantly superior over the other treatments. Available K_2O content ranged from 154.4 to 349.6. Available K_2O was recorded highest (349.60 kg ha^{-1}) from pendimethalin @ 1kg ha^{-1} (PE) + 1 HW) and the minimum (154.42 kg ha^{-1}) in weedy check. Pendimethalin @ 1kg ha^{-1} (PE) + 1 HW was found significantly superior over the other treatments. The data on organic carbon ranged from 9.5 to 13.2 g kg^{-1} and highest 13.2 g kg^{-1} from black polythene 30 micron. Black polythene 30 micron was found significantly superior over the other treatments. The minimum organic carbon (9.5 g kg^{-1}) was recorded glyphosate @ 1kg ha^{-1} (POE) + 10g urea L^{-1} as protected spray at 25 days.

Economics

The viability of any practices is evolved on the basis of experimentation and depends upon its economics. Economics of different treatments in okra was calculated and the data on B: C ratio ranged from 1.08 to 4.39 (Table 4). Net income (Rs. 5,00850.00) and B: C ratio (4.39) was recorded highest from black polythene 30 micron which was followed by weed free check: 2HW. The minimum net income (Rs. 96,230.00) and B: C ratio (1.08) was recorded from weedy check. Maximum economic return (Rs. 5,00850.00) in black polythene 30 micron may be due to higher pod yield obtained whereas, minimum economic return (Rs. 96,230.00) in weedy check may be

Table 4: Effect of weed management practices on economics of treatments

Treatments	Cost of cultivation (Rs ha^{-1})			Pod yield (q ha^{-1})	Gross income (Rs. ha^{-4})	Net income (Rs. ha^{-1})	Cost benefit ratio
	Fixed cost	Treatment cost	Total Cost				
T_1	88950	NIL	88950	92.59	185180	96230	1.08
T_2	88950	5000	93950	205.55	411100	317150	3.37
T_3	88950	1082	90032	146.29	292580	202547	2.24
T_4	88950	3582	92532	194.44	388880	296347	3.2
T_5	88950	3142	92092	190.73	381460	289367	3.14
T_6	88950	825	89775	124.76	249520	159745	1.78
T_7	88950	1057	90007	129.63	259260	169253	1.88
T_8	88950	25000	113950	307.40	614800	500850	4.39

due to least pod yield. These results are in accordance with the findings of Kumar *et al.* (2014).

On the basis of present study, it may be concluded that the black polythene 30 micron was found most effective in reducing weed density and increasing the growth, yield and quality of okra, Black polythene 30 micron was also found economically feasible to the farmers. Therefore, the use of black polythene 30 micron mulching is recommended for effective weed management in okra under foothill condition of Nagaland.

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