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Nutrient Availability and Nutrient Uptake by Crop and Weed as Influenced by Stale Seedbed, Mulching and Mechanical Weeding in Okra

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ABSTRACT

Background: Weeds are the major biological constraint in okra due to its slow initial growth and wider row spacing. Due to severe crop weed competition, weeds removed considerable amount of nutrients from the soil. Competition exists between the crop and weed for nutrients results in nutrient deficiencies in crop. Hence the present experiment is formulated to assess the effect of stale seedbed, mulching and mechanical weeding on nutrient availability, nutrient uptake by crop and weed in okra.

Methods: Experiment was conducted at Coconut Research Station, Balaramapuram, Thiruvananthapuram, Kerala during *Rabi* 2020-21. Design adopted for the study was RBD with two factors. The first factor was seedbed preparation (S) and the second factor was weed management (W). Stale seedbed (S_1) and normal seedbed (S_2) were the two different seedbed preparation methods and dried banana leaf mulch @10 t ha^{-1} alone (W_1), dried banana leaf mulch @10 t ha^{-1} *fb* wheel hoe weeding at 30 and 45 DAS (W_2), dried banana leaf mulch @10 t ha^{-1} *fb* hand weeding at 30 and 45 DAS (W_3), wheel hoe weeding at 15, 30 and 45 DAS (W_4), hand weeding at 15, 30 and 45 DAS (W_5) and weedy check (W_6) were the six different weed management options tried. Soil samples were collected after the harvest of the crop to determine the nutrient availability. Weed samples at 30 and 60 DAS and plant samples at harvest were analyzed to determine the NPK content and respective uptake of nutrients were calculated by multiplying the nutrient content with DMP.

Result: Stale seedbed significantly enhanced the dry matter production and nutrient uptake by okra at harvest and lowered the nutrient removal by weeds at 30 and 60 DAS. Compared to non-stale, stale seedbed recorded significantly higher fruit yield. Among the weed management, wheel hoe weeding at 15, 30 and 45 DAS, recorded the lowest total weed dry weight at 30 and 60 DAS and resulted in the highest NPK uptake by crop and fruit yield. Uncontrolled weed growth resulted in a loss of 81.33, 18.16 and 50.84 kg N:P:K ha^{-1} at 30 DAS and 102.09, 57.90 and 55.31 kg N:P:K ha^{-1} at 60 DAS, respectively. Nutrient removal by weeds was the lowest in wheel hoe weeding at 15, 30 and 45 DAS and the highest in weedy check. It could be concluded that, wheel hoe weeding at 15, 30 and 45 DAS was the best option for the management of weeds, higher nutrient availability and uptake and yield in okra.

Key words: Banana leaf mulching, Nutrient availability, Nutrient uptake, Stale seedbed.

INTRODUCTION

Okra [*Abelmoschus esculentus* (L.) Moench] is a major vegetable crop grown in tropical, subtropical and warm temperate climate all over the world. Immature fruits are rich source of vitamins and minerals. A major constraint in the cultivation of okra is heavy infestation of weeds which might be due to wider spacing, slow initial growth and poor canopy coverage. Due to their vigorous growth habits, weeds removed a significant amount of nutrients from the soil. In every crop field, weeds and crops compete for nutrients, resulting in nutrient deficiency in the crops. Weeds remove significant amount of nutrients and adversely affect the crop growth and yield (Kumar *et al.* 2005; Sannagoudar *et al.*, 2012a). Hand weeding twice at 20 and 40 DAS resulted in the lowest weed uptake and the highest nutrient uptake in cowpea (Kujur *et al.*, 2015). Satyareddi *et al.* (2015) conducted a study to determine the effect of non-chemical weed control methods on nutrient uptake in sunflower and found that the treatment hand weeding twice at 25 and 45 DAS had the highest nutrient uptake by crop (81.0, 11.7 and 47.4 kg N, P and K ha^{-1}) and was statistically on par with the treatment weeding with manually operated weeder at 25 DAS. Sinchana (2020) observed that mulching with dried banana leaves @ 10 t ha^{-1} significantly reduced the nutrient uptake by weeds in vegetable cowpea, compared

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to weedy check. Therefore, present study was carried out to find out the effect of stale seedbed, mulching and wheel hoe weeding on nutrient availability, nutrient uptake by crop and nutrient uptake by weeds in okra.

MATERIALS AND METHODS

The study was carried out at coconut research station, Balaramapuram, Thiruvananthapuram district, Kerala situated at 8° 22′ 52′ North latitude and 77° 1′ 47″ East longitude and at an altitude of 9 m above MSL during Rabi 2020. The soil was strongly acidic (pH 4.71), normal in EC (0.1 dS m^{-1}), low in available N, (163.07 kg ha^{-1}) high in available P (33.5 kg ha^{-1}) and medium in available K (134.4 kg ha^{-1}). High yielding and yellow vein mosaic resistant variety Anjitha (120 days), released from Department of Plant breeding and Genetics, College of Agriculture, Vellayani was used as the test crop.

The experiment was conducted in RBD with two factors, first factor being seedbed preparation (S), *viz.*, stale seedbed (S_1) and normal seedbed (S_2) and weed management as second factor (W) *viz.*, dried banana leaf mulch @10 t ha^{-1} alone(W_1), W_1 *fb* wheel hoe weeding at 30 DAS and 45 DAS (W_2), W_1 *fb* hand weeding at 30 and 45 DAS (W_3), wheel hoe weeding 15 DAS, 30 DAS and 45 DAS (W_4), hand weeding at 15 DAS, 30 DAS and 45 DAS (W_5) and weedy check (W_6). Stale seedbed (SSB) was prepared by ploughed the field with a power tiller twice and 18 experimental plots each measuring 6.0 m × 4.05 m were laid out. Small bunds were taken around each treatment plot. After that one irrigation was given and the experimental plots were left alone for 14 days to allow the weeds to germinate. Weeds that emerged were uprooted by gentle raking with minimum soil disturbance. Field preparation of non-stale seedbed was started 10 days after the SSB. The land preparation was done as in the case of SSB. Eighteen treatment plots with a gross plot size of 6.0 m × 4.05 m were taken. Lime @ 250 kg ha^{-1} was uniformly applied to the plots at the time of final ploughing. Farm yard manure was uniformly applied to all plots @ 20 t ha^{-1} and NPK was applied @ 110: 35: 70 kg ha^{-1}. Half N and full P and half K were applied basally and remaining dose were applied as 3 splits on 30, 45 and 60 DAS. Okra seeds were dibbled two seeds per pit (60 cm × 45 cm) on 15/12/2020. Gap filling was carried out in those pits where no germination was observed. Weed management were done as per the treatments. Dried banana leaves free from sigatoka disease were laid in the treatment plots @ 10 t ha^{-1}. After laying, dried banana leaf mulch was drenched with copper oxychloride @ 3 g L^{-1} and chlorpyriphos @ 3 ml L^{-1}. Wheel Hoe Weeder (WHW) was a manually operated push-type machinery with a single wheel and weeding blade for weeding (design patent no. 346280-001 dated 14/7/2021).

Fruits weight from the net plot area of each treatment were recorded at every harvest, pooled and expressed in kg ha^{-1}. For recording the weed dry weight, weeds were uprooted from the quadrat area at 30 and 60 DAS by placing a quadrat of size 0.25 m × 0.25 m randomly at two spots in each treatment plot. Uprooted weeds were shade dried for two days and then oven dried at 65±5°C till reached a constant weight and was expressed as g m^{-2}. The N, P and K content of fruits and plant samples at final harvest and weed samples at 30 and 60 DAS were determined using standard procedures. The total N, P and K uptake by crop and weeds were calculated by multiplying the nutrient content with the respective DMP. Total N, P and K uptake by crop was computed by adding the respective haulm and fruit uptake and expressed in kg ha^{-1}. For estimating the total available soil N, P and K, composite soil samples were collected from each treatment after the harvest of the crop and analysis were carried out as per the standard procedures. Data were statistically analysed using the analysis of variance for randomized block design with two factors and the treatment means were compared at 5 per cent probability.

RESULTS AND DISCUSSION

Effect on weed dry weight

Stale seedbed (SSB) resulted in the lowest weed dry weight of 4.57 and 7.81 g m^{-2} at 30 and 60 DAS, respectively (Table 1). The percentage reduction in total weed dry weight due to the adoption of SSB compared to normal seed bed was 64. 98 and 40.15 per cent, respectively at 30 and 60 DAS. Lower weed dry weight observed in SSB might be due to the depletion of weed seed bank in the surface soil owing to the removal of germinated weeds prior to sowing of okra seeds. Depletion of weed seeds in the seedling zone reduced the weed pressure in crop. Ranjit (2007) also stated that adoption of SSB caused significant reduction in weed count (18.8-34.1%) and dry weight (21.3%) as compared to normal seedbed.

Among the weed management, the lowest weed dry weight was observed in wheel hoe weeding at 15, 30 and 45 DAS (W_4) at 30 DAS and it was on par with W_1 and W_2 (Table 1). At 60 DAS also, the lowest weed dry weight was recorded in W_4 (2.54 gm^{-2}), which was significantly superior to all other treatments. The treatment W_4 was followed by W_2 and it was statistically on par with W_3 and W_5. At 30 and 60 DAS, weedy check resulted in the highest weed dry weight (23.67 and 33.23 g m^{-2}, respectively). Wheel hoe weeding at 15, 30 and 45 DAS (W_4) very effectively eliminated the weeds and created a condition congenial for the crops to grow vigorously and smother the weeds and resulted in the lowest weed biomass. Mynavathi *et al.* (2008) observed that wheel hoe weeding was effective in lowering the weed density and weed dry weight in maize. Mulching with dried banana leaf mulch alone (W_1) or *fb* wheel hoe weeding at 30 and 45 DAS (W_2) also registered lower weed dry weight. This was due to the beneficial effect of dried banana leaf mulch in hindering the weed emergence and the favourable environment provided for the crop to grow

Table 1: Effect of seedbed preparation and weed management on total weed dry weight and nutrient uptake by weeds at 30 and 60 DAS.

Treatments	Total weed dry weight (g m^{-2})				Nutrient uptake by weed at 30 DAS						Nutrient uptake by weeds at 60 DAS					
	30 DAS		60 DAS		N (kg ha^{-1})		P (kg ha^{-1})		K (kg ha^{-1})		N (kg ha^{-1})		P (kg ha^{-1})		K (kg ha^{-1})	
Seedbed preparation (S)																
Stale seedbed (S_1)	2.22	(4.57)	2.67	(7.81)	2.78	(9.17)	2.19	(4.36)	2.85	(7.89)	3.88	(20.28)	3.16	(12.65)	3.62	(14.81)
No stale (S_2)	2.75	(13.05)	3.40	(13.05)	3.91	(25.09)	2.90	(8.55)	4.02	(20.25)	5.00	(34.68)	4.40	(22.26)	4.00	(19.23)
SEm (±)	0.03		0.04		0.05		0.04		0.06		0.06		0.04		0.04	
LSD (p=0.05)	0.100		0.114		0.151		0.118		0.161		0.173		0.117		0.115	
Weed management (W)																
Mulching with dried banana leaf @ 10 t ha^{-1} (W_1)	1.93	(2.73)	3.99	(15.13)	1.92	(2.74)	2.35	(4.52)	2.67	(6.16)	6.24	(38.95)	4.70	(21.30)	4.53	(20.01)
W_1 *fb* WHW at 30 and 45 DAS (W_2)	1.98	(2.94)	2.12	(3.59)	2.10	(3.40)	1.97	(3.00)	2.79	(6.99)	2.67	(6.78)	2.32	(5.25)	2.40	(4.78)
W_1 *fb* HW at 30 and 45 DAS (W_3)	2.20	(3.91)	2.23	(4.07)	2.73	(6.56)	2.92	(7.75)	3.04	(8.36)	2.60	(5.82)	2.56	(5.86)	2.57	(5.78)
WHW at 15, 30 and 45 DAS (W_4)	1.86	(2.48)	1.83	(2.54)	2.34	(4.61)	1.63	(1.68)	2.40	(4.85)	2.41	(5.15)	2.23	(4.98)	2.43	(5.10)
HW at 15, 30 and 45 DAS (W_5)	2.06	(3.40)	2.23	(3.99)	2.26	(4.13)	2.11	(3.61)	2.85	(7.24)	2.66	(6.09)	3.22	(9.45)	3.48	(11.14)
Weedy check (W_6)	5.77	(32.37)	5.80	(33.23)	8.72	(81.33)	4.32	(18.16)	6.87	(50.84)	10.07	(102.09)	7.61	(57.90)	7.43	(55.31)
SEm (±)	0.06		0.07		0.09		0.07		0.10		0.10		0.07		0.07	
LSD (p=0.05)	0.173		0.196		0.260		0.205		0.279		0.299		0.202		0.199	

Values in parentheses are original values, values are subjected to square root transformation ($\sqrt{(x+1)}$, WHW: Wheel hoe weeding, HW: Hand weeding.

and smother the weeds due to the beneficial effects of dried banana leaf as mulch in moisture conservation, regulation of soil temperature and addition of organic matter to the soil. Beneficial effect of dried banana leaf mulch in reducing the weed biomass was reported by Sinchana (2020).

Interaction between seedbed preparation and weed management had considerable impact on weed dry weight. The treatment combination, S_1W_4 resulted in the lowest weed dry weight at 30 and 60 DAS. This was due to the favourable influence of mulch and wheel hoe weeding in reducing the weed density and biomass. The highest weed dry weight was observed in S_2W_6 at 30 and 60 DAS.

Nutrient uptake by weeds

Stale seedbed recorded significantly lower total N, P and K uptake by weeds (Table 1). Adoption of SSB caused a reduction in N, P and K uptake by weeds to a tune of 63.45, 49.01 and 61.04 per cent respectively at 30 DAS and to a tune of 41.52, 43.17 and 22.98 per cent, respectively at 60 DAS. Significant reduction in the nutrient removal by weeds in SSB at 30 and 60 DAS was due to lower weed biomass recorded in the treatment. Gaurav *et al.* (2018) opined that, weeds usually grow faster than the associated crop plants and draw available nutrients in higher amounts leading to the deficiency of nutrients in crop plants. Competition for nutrients was found to be more when the root system of crop and weeds overlap in the soil profile for exploring nutrients.

Wheel hoe weeding at 15, 30 and 45 DAS (W_4) registered the lowest P and K uptake and N uptake in dried banana leaf mulching @ 10 t ha^{-1} at 30 DAS (Table 1). However, at 60 DAS, the lowest N and P uptake by weeds was noted in wheel hoe weeding (W_4) and K uptake in W_2 (dried banana leaf mulching *fb* wheel hoe weeding at 30 and 45 DAS). This was due to lower dry matter accumulation in weeds and respective nutrient content. Parameswari and Srinivas (2014) reported that nutrient depletion by weeds was found to be lower in cono weeding treatment. Weedy check registered higher amount of nutrient removal by weeds owing to higher weed biomass registered in the treatment. Similar results were also reported by Mahadevaiah and Karunasagar (2014) in baby corn and Sinchana (2020) in bush type vegetable cowpea.

Interaction was found to significant at both 30 and 60 DAS (Table 2). The treatment combination in S_1W_1 resulted in the lowest N uptake by weeds and P and K uptake by weeds were recorded the lowest in S_1W_4. At 60 DAS, the treatment combination S_1W_4 resulted in the lowest nutrient uptake/removal by weeds. The result is in conformity with the observations of Sinchana (2020) and Sannagoudar *et al.* (2012b).

Nutrient availability

Stale seedbed recorded higher values of N, P and K content in soil than normal seedbed (Table 3). This was due to reduction in the depletion of nutrients by weeds (Table 1).

Table 2: Interaction effect of seedbed preparation and weed management practices on weed dry weight and nutrient removal by weeds at 30 and 60 DAS.

Treatments	Total weed dry weight ($g\ m^{-2}$)		Nutrient uptake by weed at 30 DAS			Nutrient uptake by weeds at 60 DAS		
	30 DAS	60 DAS	N ($kg\ ha^{-1}$)	P ($kg\ ha^{-1}$)	K ($kg\ ha^{-1}$)	N ($kg\ ha^{-1}$)	P ($kg\ ha^{-1}$)	K ($kg\ ha^{-1}$)
S_1W_1	1.80 (2.24)	3.62 (12.13)	1.70 (1.88)	2.25 (4.04)	2.52 (5.38)	5.30 (27.18)	4.46 (18.90)	5.23 (26.38)
S_1W_2	1.79 (2.21)	1.80 (2.25)	2.17 (3.71)	1.63 (1.65)	2.36 (4.59)	1.88 (2.52)	1.41 (0.98)	2.47 (5.12)
S_1W_3	2.01 (3.08)	1.96 (2.86)	2.48 (5.17)	2.48 (5.18)	2.77 (6.74)	2.86 (7.21)	2.09 (3.39)	2.25 (4.07)
S_1W_4	1.68 (1.81)	1.41 (1.03)	2.01 (3.05)	1.42 (1.02)	2.13 (3.55)	1.82 (2.31)	1.26 (0.60)	2.02 (3.07)
S_1W_5	2.03 (3.12)	2.14 (3.57)	2.12 (3.49)	1.77 (2.14)	3.60 (5.76)	2.65 (6.00)	3.08 (8.46)	3.33 (10.12)
S_2W_6	3.99 (14.96)	5.09 (24.99)	6.22 (37.70)	3.62 (12.12)	4.72 (21.32)	8.80 (76.48)	6.68 (43.60)	6.41 (40.09)
S_2W_1	2.05 (3.21)	4.37 (18.12)	2.14 (3.60)	2.45 (5.00)	2.81 (6.94)	7.19 (50.73)	4.97 (23.70)	3.83 (13.65)
S_2W_2	2.16 (3.67)	2.43 (4.93)	2.02 (3.09)	2.31 (4.35)	3.22 (9.38)	3.46 (11.04)	3.24 (9.52)	2.33 (4.43)
S_2W_3	2.39 (4.73)	2.51 (5.29)	2.98 (7.95)	3.36 (10.32)	3.31 (9.99)	2.33 (4.44)	3.0 (8.33)	2.89 (7.49)
S_2W_4	2.04 (3.15)	2.25 (4.07)	2.68 (6.17)	1.83 (2.35)	2.67 (6.15)	2.99 (7.98)	3.22 (9.39)	2.85 (7.14)
S_2W_5	2.09 (3.40)	2.33 (4.41)	2.39 (4.76)	2.46 (5.09)	3.10 (8.71)	2.68 (6.18)	3.38 (10.45)	3.63 (12.17)
S_2W_6	5.77 (32.37)	6.51 (41.46)	11.22 (124.96)	5.02 (24.02)	9.01 (80.35)	11.34 (127.71)	8.56 (72.20)	8.46 (70.53)
SEm (±)	0.08	0.09	0.13	0.10	0.13	0.14	0.10	0.10
LSD (p=0.05)	0.245	0.278	0.370	0.289	0.395	0.423	0.286	0.281

Table 3: Effect of seedbed preparation and weed management on nutrient availability in soil.

Treatments	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})
Seedbed preparation (S)			
Stale seedbed (S_1)	179.49	22.70	173.04
No stale (S_2)	164.20	20.18	158.79
SEm (±)	4.25	0.44	3.63
LSD (p=0.05)	12.546	1.301	10.733
Weed management (W)			
Mulching with dried banana leaf @ 10 t ha^{-1} (W_1)	169.31	21.50	128.89
W_1 *fb* WHW at 30 and 45 DAS (W_2)	181.97	21.46	186.81
W_1 *fb* HW at 30 and 45 DAS (W_3)	172.45	19.19	165.08
WHW at 15, 30 and 45 DAS (W_4)	206.25	23.28	181.19
HW at 15, 30 and 45 DAS (W_5)	166.20	22.29	152.95
Weedy check (W_6)	134.84	20.92	180.56
SEm (±)	7.36	0.76	6.29
LSD (p=0.05)	21.730	2.254	18.591

Table 4: Interaction effect of seedbed preparation and weed management on soil available K, kg ha^{-1}.

Treatments	Soil available K, kg ha^{-1}
S_1W_1	128.14
S_1W_2	204.39
S_1W_3	182.37
S_1W_4	197.53
S_1W_5	115.42
S_1W_6	210.39
S_2W_1	129.65
S_2W_2	169.24
S_2W_3	147.79
S_2W_4	164.86
S_2W_5	190.47
S_2W_6	150.74
SEm (±)	8.91
LSD (p=0.05)	26.291

Similar observations were also reported by Tehria *et al.* (2015) and Sinchana (2020).

Higher nutrient status was recorded in weed control treatments compared to weedy check (Table 3) might be due to the better control of weeds that resulted in reduction in nutrient removal by weeds. The result is in line with the observations of Kumar *et al.* (2019) who reported that two manual hoeing registered significantly higher available P and K content in soil. Gaurav *et al.* (2018) also reported that weed management treatments recorded higher nutrient availability in soil compared to weedy check. Interaction between seedbed preparation and weed management was not significant for soil available N and P. However, interaction was significant for soil available K. The highest soil available K was recorded in the treatment S_1W_6 and it was statistically on par with S_1W_4, S_1W_2 and S_2W_6.

Nutrient uptake by crop

Adoption of SSB enhanced the total N, P and K uptake by 27.76, 19.56 and 17.11 per cent, respectively over normal seedbed. Nutrient uptake by crop is directly related to nutrient content and dry matter production. Higher uptake of nutrients registered in SSB was due to higher DMP and higher N, P and K content recorded in the treatment. Higher nutrient uptake by crop was also associated with lower total weed density and weed dry weight and higher weed control efficiency (Sannagoudar *et al.*, 2012b).

Wheel hoe weeding at 15, 30 and 45 DAS (W_4) recorded the highest total uptake of P and K and dried banana leaf mulch *fb* mechanical weeding with wheel hoe weeding at 30 and 45 DAS recorded the highest total N uptake. Increase in the uptake of nutrients observed in W_4 was due to increase in the availability of nutrients due to significant reduction in nutrient removal by weeds (Table 1). The result is in line with the observations of Sharma and Singh (2011) who reported that mechanical weeding twice at 15 and 30 DAS significantly enhanced the uptake of nutrients in grain and straw of wheat due to effective control of weeds and higher DMP. Weedy check recorded the lowest uptake of N, P and K by crop. This might be due to severe crop weed competition as evident from data on dry weight that restricted the crop to draw nutrients from the soil. Reduced availability of nutrients (Table 3) and higher nutrient removal by weeds (Table 1) also attributed to lower nutrient uptake by crop in weedy check (Sannagoudar *et al.*, 2021b).

Effect on yield

Stale seedbed resulted in the highest fruit yield ha^{-1} (3291 kg ha^{-1}) compared to normal seed bed (2963 kg ha^{-1}). Higher yield registered in SSB was due to the absence of early crop weed competition. It was also noted that SSB accounted for higher nutrient uptake (Table 5) in okra. Increased nutrient availability and uptake (Table 3 and 4) significantly improved the yield attributes particularly number of fruits per plant (Table 5) which finally contributed to higher yield in okra.

Among the weed management practices, the highest fruit yield ha^{-1} was recorded in W_4 (4412 kg ha^{-1}) and it was significantly superior to other treatments. The treatment

Table 5: Effect of seedbed preparation and weed management on nutrient uptake by crop and yield in okra.

Treatments	Total N uptake by crop	Total P uptake by crop	Total K uptake by crop	Yield (kg ha^{-1})
Seedbed preparation (S)				
Stale seedbed (S_1)	97.67	42.12	65.85	3291
No stale (S_2)	70.55	35.27	56.23	2963
SEm (±)	2.34	0.70	1.28	63.50
LSD (p=0.05)	6.908	2.066	3.955	187.6
Weed management (W)				
Mulching with dried banana leaf @ 10 t ha^{-1} (W_1)	74.51	39.29	60.53	2513
W_1 *fb* WHW at 30 and 45 DAS (W_2)	110.89	44.20	75.25	3936
W_1 *fb* HW at 30 and 45 DAS (W_3)	92.89	40.05	69.70	3337
WHW at 15, 30 and 45 DAS (W_4)	110.53	48.28	76.94	4412
HW at 15, 30 and 45 DAS (W_5)	76.30	37.29	51.99	2711
Weedy check (W_6)	39.55	23.06	31.83	1852
SEm (±)	4.05	1.21	2.21	155.6
LSD (p=0.05)	11.964	3.578	6.519	324.9

W_4 was followed by W_2, W_3 and W_5. The treatment W_5 was statistically on par with W_1. The lowest fruit yield ha^{-1} was recorded in W_6 (1852 kg ha^{-1}). No interaction was observed between seedbed preparation and weed management practices. Higher yield recorded in W_4 might be due to the fact that wheel hoe weeding effectively uprooted and buried the weeds into the soil resulted in significant reduction in weed biomass (Table 1). Furthermore, it improves soil aeration, root development, availability and uptake of nutrients, (Table 3 and 4) which favours crop growth, photosynthesis and assimilate partitioning from source to sink leading to the production of greater number of fruits per plant with higher fruit yield (Table 5). Akbar *et al.* (2011) observed that mechanical hoeing significantly increased the grain yield (25.1%) in rice over control due to enhancement in nutrient availability resulting from soil stirring and weed control. Interaction did not have any significant effect.

CONCLUSION

Stale seedbed technique significantly reduced the weed biomass and nutrient uptake by weeds and it also enhanced the uptake and availability of nutrients to the okra. Among the weed management practices, wheel hoe weeding at 15, 30 and 45 DAS has noticed the lowest weed biomass and nutrient removal by weeds and the highest nutrient uptake by crop. The fruit yield was also the highest in wheel hoe weeding at 15, 30 and 45 DAS. Hence, it could be concluded that stale seedbed technique significantly reduced the nutrient uptake by weeds and enhanced the nutrient uptake and yield of okra. Wheel hoe weeding at 15, 30 and 45 DAS was the best weed management option for improving the yield of okra by increasing the availability and uptake of nutrients and reducing the nutrient uptake by weeds at critical stages of okra.

Conflict of interest: None.

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