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Effect of Planting Systems and Rates of Force Top® on Weed Suppression and Okra (*Abelmoschus esculentus* (L.) Moench) Performance in Port Harcourt, Rivers State, Nigeria

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Abstract: A trial was conducted at the Teaching and Research Farm of the University of Port Harcourt, Choba during 2019 cropping season to determine the appropriate planting system and rates of Force Top® on weed suppression and performance of okra (*Abelmoschus esculentus* (L.) Moench). The trial was laid out in a 2 x 5 factorial scheme fitted in a randomized complete block design (RCBD) with three replications. The planting systems used were: flat (control) and raised bed while the Force Top® rates were: .0 L/ha, 3.5 L/ha, 3.0 L/ha, 4.0L/ha including weeding twice at 3 and 7 Weeks After Sowing (WAS) and no weeding which serve as checks. Results showed that weed suppression and okra performance were better in a raised bed system of planting than in a flat system. Among the various rates of Force top® used, Force Top® at 4L/ha had more effective weed control and better okra performance than other rates. Plots hoe weed twice also gave effective weed control and high okra performance when compared to Force Top® at 4L/ha. The weedy check had poor weed control and poor okra performance. On the interaction, plots hoe weeded twice with raised bed planting system was more weed suppressive and had a better okra performance than the other treatments combination. The highest profit was recorded when a raised bed system of planting was combined with Force Top® application at 4L/ha. Although a higher benefit – cost ratio was obtained in a flat system with a combination of Force Top® at 4 L/ha but in terms of economic returns, farmers in the area of study should be encouraged to use Force Top® at 4L/ha on raised-bed system because of the high-profit margin obtained from it when compared to the other treatments combination.

Key words: Planting System · Force Top® · Weed Suppression · Okra Performance · Economic

INTRODUCTION

Okra (*Abelmoschus esculentus* (L.) Moench) of the Malvaceae family is one of the most useful fruit vegetable crops cultivated in almost all parts of the world. In Africa, including Nigeria, Okra production is extensively practiced due to its usefulness to the national and international economy and source of vegetable fruit for human consumption. Globally, India is the leading Okra producer with 5, 507, 000 tons yearly production while Nigeria is the second producer with 1, 978, 286 tons [1]. In 2017, out of 17, 222, 288 tons of okra fruit produced globally, Nigeria produced 2060 280 tons of it FAOSTAT [2].

Among the vegetable crops in Nigeria okra is rated in the third position after tomato and pepper, in terms of production and consumption [3]. The yield of okra in Nigeria is presently very low about 2000 kg ha^{-1} [4] due to many factors among these factors are improper planting system and herbicide application. Adejonwo *et al.* and Melifonwu [5, 6] noted that unchecked weed growth throughout okra life history reduced the fruit yield between 88 and 90 percent when compared with weed-free check. Conventionally, a minimum of two hoe weeding is required within the first 6 weeks after sowing (WAS) to reduced loss in yield caused by weed interference. Herbicides usage tends to be a better option currently on a large scale as a result of scarcity and high cost of

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labour. Buhler and Daniel [7] noted that tillage destroys rooted weeds and also provide an environment which promotes the uptake of herbicides by weeds. Other benefits of tillage are: loosening compacted soil, seedbed preparation, prevention of soil erosion and conservation of water and soil. Tillage operations influence the efficacy of herbicides particularly pre-emergence herbicides in the tropic including Nigeria [8, 9]. Various methods of tillage are practiced by farmers in Nigeria during land preparation for different crops to provide suitable conditions for the growth of crops. Besides the seedbed preparation, farmers devout their incomes and time in weed control. Weed control and tillage operation in crop production are inextricable [10]. Gill *et al.* [11] reported that there ought not to have been tillage if weeds are appropriately controlled.

The performance and nonperformance of the crop production system depends on many factors among these factors is the seedbed environment [12]. A good seedbed environment enhances weeds control effectiveness which in turn promotes the yield of crops as well as decrease the production cost of that crop [10]. Nigerian farmers and perhaps farmers in the same continent or the same geographical locations require adequate information on the effect of tillage on herbicides efficacy. Hence, the objective of this study was to determine the effect of planting systems and rates of Force Top® on weed suppression and okra performance.

MATERIALS AND METHODS

Experimental Site: The field experiment was conducted at the Faculty of Agriculture Teaching and Research Farm of the University of Port Harcourt during the early cropping season between April to July 2019 in a humid forest agro-ecology with latitude 04°54^{I} 538^{I}N and longitude 006°55^{I} 329^{I}E with an elevation of 17 metres above sea level. The area has an average temperature of 27°C, relative humidity of 78% and average rainfall that ranges from 2500-4000 mm [13]. The area had distinct wet and dry seasons. The wet season has double rainfall peaks. There are two cropping seasons early from March to July and late from August to December. The experimental site was left fallow for seven years before the commencement of the study. Weeds such as *Chromolaena odorata, Aspilia africana, Commelina benghalensis, Panicum maximum* and *Cyperus* spp. dominated the vegetation.

Soil Analysis: Soil auger was used to collect the soil at a depth of 0 – 15cm at 10 points from the experimental area. The soil samples were bulked to form a composite sample and sent to the laboratory for physcio-chemical analysis using standard methods [14].

Source of Planting Material: Okra seeds were bought from the Agritopic office in Port Harcourt in Rivers State.

Treatments and Experimental Design: The experiment was conducted as a 2x5 factorial scheme laid out in a Randomized Complete Block Design (RCBD). Planting system and force top rate constituted the factors. The two tillage systems used were: flat (no tillage) and raised bed while the Force top® rates were 3.0 L/ha, 3.5 l/ha 4.0 l/ha, weeding twice and no weeding served as check.

Cultural Details: The experiment occupied a total land area of 8.7m x 29m (252.3m^2) which was approximately 0.03ha. The experimental area was manually cleared using cutlass and the debris was packed. The experimental area was pegged into plots of 2.4m x 2.4m with an alleyway of 0.5 m between blocks and replicates the beds were prepared with hoes to a height of 30cm per plot.

Sowing was done on the 14th of May 2019, the okra seeds were planted at a spacing of 60 cm x 30 cm to give a plant population 32 stands / plot. Plots labeled with the different rates of Force Top® at the same day of sowing were sprayed immediately after sowing using a CP3 knapsack sprayer at a pressure of 2.1 kg/ cm^3 in a spray volume of water 250 L /ha using green deflector nozzle. Hoe weeding was done at 3 and 7 WAS . Basal application of urea fertilizer at 2.5 kg/ha was carried out 3 WAS.

Planting was done on the 14th of May 2019, the okra seeds were planted at a spacing of 60 cm x 30 cm to give a plant population 32 stands / plot. Some plots were manually weeded at 3 and 7 WAS. Basal application of urea fertilizer at 2.5 kg/ha was carried out at 3 WAS. This was done because the soil sample from the experimental area was found to be deficient of nitrogen (0.08%) when compared to that of the critical level of nitrogen 0.15% of southeastern soil established by Ibedu, Unamba and Udealor [15].

Data Collection

Weed Growth Characteristics

Weed Density: This was determined by using two quadrats of 50cm x 50 cm and placing them randomly in each plot at 6 and 9 WAS. The weeds were pulled from the soil surface, counted in each quadrat and expressed in no/m^2.

Weed Dry Weight: Weed dry weight was determined at 6 and 9 WAS by the same quadrat sampling techniques as used in weed density. The weeds were carefully washed to remove soil contamination thereafter the weeds were oven-dried 70ºC for 72 h weighed and expressed in g/ m^2.

Weed Control Efficiency: Weed control efficiency was determined by using the method of Subramanian , Ali and Kumar [16] as:

$$\text{WCE (\%)} = \frac{DWT\ of\ no\ weeding\ plot - DWT\ of\ treated\ plot}{DWT\ of\ no\ weeding\ plot} \times 100$$

where:
WCE (%) = Weed control efficiency
DWT= Dry weight

$$\text{WI} = \frac{Yield\ of\ romweed\ free\ check - yield\ from\ treated\ plot}{Yield\ from\ the\ weed\ free\ check} \times 100$$

where: WI = weed index

Okra Growth and Yield Characteristics: Crop vegetative parameters were collected by random selection and tagging of six plants from each treatment plot from the net plot, they were tagged by placing labeled pegs beside them to facilitate the identification.

Plant Height: Plant height was measured at 6 and 9 WAS by using a measuring tape from the soil surface to the tip of the plant.

Leaf Area Index: The leaf area index was calculated by dividing the total leaf area per plot by gross plot area [17].

Pod Yield: Tender, green pods were harvested at five - day intervals. The pods were weighed with electronic balance and the yield was expressed per plant (g) and then extrapolated to kg/ha by multiplying by the total plant population per hectare.

Statistical Analysis: Data generated were subjected to statistical analysis of variance (ANOVA) using GENSTAT programme, version 8.1 [18]. The least significant differences (LSD) test was used to detect significant differences between treatments means at 5% probability level.

Economic Analysis: Economic analysis was done using partial budgeting [19]. The mathematical expression of it is given as:

GM = TR – VC
TR = (Y_S x P_S)
VC = M x L

where;
GM = Gross margin/ha
TR = Total revenue (naira)
VC = Variable cost (naira)
Y_S = Okra yield/ha
P_S = Price of okra yield
M = Value of material inputs (seeds, fertilizers, Force Top®)
L = Value of labour (land preparations, planting, herbicide application, harvesting, transportation).

RESULTS AND DISCUSSION

Soil Analysis: Table 1 shows the physico – chemical properties of the soil before planting at the experimental site. The soil was sandy loam and moderately acidic with a P^H of 5.7. The total organic carbon of the soil was adequate when compared to it critical level. The soil was low in nitrogen (N)–and adequate in phosphorus (P), magnesium (Mg) and calcium (Ca), potassium (K) and sodium (Na) when compared to their critical levels.

Weed Suppression

Weed Density: The effect of planting system and Force Top® on weed density of okra is presented in Table 2. There were no significant differences in the planting system, Force Top® rates and their interaction at the two sampling periods. Weed density was significantly lower in the raised bed system than in the flat system. This finding is similar to that of Adeyemi, Smith and Ojeniyi [10] who noted that a flat system of planting had a higher weed density than other planting systems. Nitant and Singh [20] reported a low weed population when soil is tilled for seedbed preparation. Apart from reducing weed population, tillage also provides an environment for the interaction between herbicide and weeds where weeds and herbicides can interact [7]. Akobundu [21] also noted similar finding that decreased in weed population in raised bed system might be as a result of weeds seed burial and exposure of seeds to the soil surface to sunlight penetration which could cause desiccation. The high weed density was observed in the weedy check when compared to the various rates of force op and plots hoe weeded twice in both sampling intervals.

Table 1: Physico - chemical properties of the experimental site before plant

Soil composition	Value	Critical levels*
Physical properties		
Sand (%)	83.5	
Silt (%)	10.4	
Clay (%)	6.1	
Textural class	Sandy loam	
Chemical properties		
PH (H_20)	5.7	-
Total organic carbon (%)	1.27	1.16
Total Nitrogen (%)	0.08	0.15
Available phosphorus (mg/kg)	17	8.50
Ca (cmol/kg)	3.30	1.50
Mg (cmol/kg)	0.30	0.28
Na (cmol/kg)	1.14	0.10
K (cmol/kg	1.38	0.16

*[15]

Table 2: Effect of planting system and Force Top® on weed density (no/m^2) of Okra

	Rates of Force Top® (L/ha) (RF)						
Weeks after sowing	Planting system (PS)	3.0	3.5	4.0	Weeding twice	No weeding	Mean
6	Flat	28.33	27.33	26.33	17.67	63.33	32.60
	Raised bed	25.33	24.33	23.33	16.00	48.33	27.47
	Mean	26.83	25.83	24.83	16.83	55.83	
	LSD (P=0.05)						
	PS =		0.379				
	RF =		0.599				
	PS x RF =		0.847				
9	Flat	33.00	32.00	30.67	21.33	85.00	40.40
	Raised bed	28.67	27.67	26.67	18.00	71.67	34.53
	Mean	30.83	29.83	28.67	19.67	78.33	
	LSD (P=0.05)						
	PS =		1.594				
	RF) =		2.521				
	PS x RF =		3.565				

There was no significant difference among the various rates of Force Top® on weed density at 9 WAS but at 6 WAS there were significant differences among the various rates of Force Top®. The hoe weeded twice plots had weed density that was significantly lower than other rates of Force Top®. Although plots hoe weeded twice tends to have the lowest weed density, it was statistically similar to that of herbicide treated plots at 4.0 l/ha at 9 WAS. [11] reported that hand weeding with hoe and herbicide application reduced the weed density in maize. The highest weed density was obtained in plots that had a combination of flat system and no weeding in both sampling time while the lowest was from the combination of raised bed system and weeding twice. The high weed density observed in the weedy plots might be attributed to no application of treatments. The low weed density that was observed plot hoe weeded twice and plots treated with different rates of herbicides plots might be attributed to better and efficient weed control methods of these treatments. The reduction of the weed population as a result of applying different rates of herbicide has been reported by Khali *et al.* [22].

Weed Dry Weight: The effect of planting systems and Force Top® on weed dry weight is presented in Table 3 Weed dry weight was significantly lower in raised bed system than in flat system at both sampling period probably as a result lower emergence of weeds and larger leaf area index. Larger leaf index is an indication of better canopy formation which helps to shade out the light from penetrating the soil for weed growth. Higher weed dry weight on no-tillage has been reported by Arift *et al.* [23]. Among the force top rates, plot hoe weeded twice and plots treated with force top had the lowest weed dry weight at two sampling intervals. Tunku, Ishaya and Haruna [24] had similar observation of low weed dry

Table 3: Effect of planting system and Force Top® on weed dry weight (g/m^2) of okra

	Rates of Force Top® (L/ha) (RF)						
Weeks after sowing	Planting system (PS)	3.0	3.5	4.0	Weeding twice	No weeding	Mean
6	Flat	19.20	18.33	16.00	13.33	97.93	32.96
	Raised bed	14.00	10.33	10.83	8.67	93.33	27.43
	Mean	16.60	14.33	13.42	11.00	95.63	
	LSD (P=0.05)						
	PS =		3.20				
	RF =		5.00				
	PS x RF =		7.156				
9	Flat	21.0	19.5	17.0	14.3	102.5	34.9
	Raised bed	15.0	11.3	11.8	9.0	71.3	23.7
	Mean	18.0	15.4	14.4	11.7	86.9	
	LSD (P=0.05)						
	PS =		3.20				
	RF =		5.00				
	PS x RF =		7.156				

weight in maize due to herbicide application at various rates. On the interaction, plots that had a combination of flat system and no weeding had the highest weed dry weight in both sampling times while the lowest was from the combination of raised bed system and weeding twice.

Weed Control Efficiency: The effect of planting systems and Force Top® on weed control efficiency is presented in Table 4. There was no significant difference between the planting systems at both sampling intervals though the raised bed system tends to have the highest weed control efficiency. There were no significant differences among the various rates of Force Top® and hoe weeded plots on weed control efficiency at both 6 and 9 WAS though the weeding twice plots tend to have the highest weed control efficiency probably because of better weed suppression as a result of larger leaf area index. The interactive effect of the two planting system and Force Top® rates including the hoe weeded twice plots were not significant at both times of sampling though treatment combination raised bed system and weeding twice tend to have the highest weed control efficiency.

Okra Performance

Plant Height: The effect of planting systems and Force Top® on plant height of okra is presented in Table 5. At 6 and 9 WAS, there were significant differences between the two planting systems. Okra plants on raised bed systems grew taller than that flat system probably because the raised bed system was able to conserve more moisture and nutrients that facilitated the increase in height of okra [25] reported that a well-prepared seedbed encourages moisture reserve Plots that were hoe weeded twice and treated with various rates of herbicide grew taller when compared to weedy check probably they were more weed suppressive. The shorter plants observed in weedy plots might be attributed to severe weed competition with the plant for sunlight, water, nutrients, carbon dioxide and space. Shorter plants in weedy plots as a result of weed competition have been reported by several authors [22, 26]. On the interaction, plots that were hoe weeded twice combined with raised bed had produced plants that were taller than the rest treatments combination.

Leaf Area Index: The effect of planting systems and Force Top® on the leaf area index of okra is presented in Table 6. At 6 and 9 WAS there was a significant difference in leaf area index between the two planting systems. Okra plant grew on raised bed had a larger leaf area index than the flat probably due to more moisture and nutrient. Plots treated with the various rates force top and hoe weeded produced a lager leaf index than the weedy check probably as a result of efficient control. The weedy plots had smaller leaf area index probably because of weed competition with plants for available growth resources. Law-Ogbomo, Osaigbovo and Ewansiha [27] also reported a similar finding of larger leaf area index in plots that were hoe weeded and smaller leaf area index in weedy check plots. On the interaction, plots hoe weeded twice combined with raised bed had a larger leaf area index when compared to the other treatment combination.

Number of Pods: The effect of planting systems and Force Top® on number of pods of okra is presented in Table 7. The raised bed produced significantly more number of pods than the flat system. The variation in the number of pods is due to treatments application.

Table 4: Effect of planting system and Force Top® on weed control efficiency (%) of okra

	Rates of Force Top® (L/ha) (RF)					
Weeks after sowing	Planting system (PS)	3.0	3.5	4.0	Weeding twice	No weeding	Mean
6	Flat	80.37	81.28	83.66	86.39	0.0	66.34
	Raised bed	85.00	88.93	88.34	90.71	0.0	70.60
	Mean	82.69	85.11	86.00	88.55	0.0	
	LSD (P=0.05)						
	PS =		7.08				
	RF =		11.20				
	PSx RF =		15.83				
9	Flat	79.51	80.96	83.41	86.05	0.00	65.99
	Raised bed	78.96	84.15	83.45	87.35	0.00	66.78
	Mean	79.24	82.56	83.43	86.7	0.00	
	LSD (P=0.05)						
	PS=		6.570				
	R F =		10.487				
	PS x RF =		15.517				

Table 5: Effect of planting system and Force Top® on plant height (cm) of okra

	Rates of Force Top® (L/ha) (RF)					
Weeks after sowing	Planting system (PS)	3.0	3.5	4.0	Weeding twice	No weeding	Mean
6	Flat	10.40	12.18	19.53	20.67	7.17	13.99
	Raised bed	12.92	16.00	21.67	24.50	9.67	16.95
	Mean	11.66	14.09	20.60	22.59	8.42	
	LSD (P=0.05)						
	PS =		0.736				
	RF =		1.164				
	PS x RF =		1.646				
9	Flat	13.67	17.00	24.00	29.00	12.33	19.20
	Raised bed	19.00	27.33	31.00	36.00	16.33	25.93
	Mean	16.33	22.17	27.50	32.50	14.33	
	LSD (P=0.05)						
	PS =		0.530				
	RF =		0.838				
	PS x RF =		1.186				

Table 6: Effect of planting system and Force Top® on leaf area index of okra

	Rates of Force Top® (L/ha) (RF)					
Weeks after sowing	Planting system (PS)	3.0	3.5	4.0	Weeding twice	No weeding	Mean
6	Flat	0.18	0.29	0.42	0.65	0.09	0.32
	Raised bed	0.26	0.37	0.49	0.83	0.12	0.41
	Mean	0.22	0.33	0.45	0.74	0.11	
	LSD (P=0.05)						
	PS =		0.006				
	RF =		0.01				
	PS x RF =		0.014				
9	Flat	0.33	0.49	0.66	0.99	0.14	0.52
	Raised bed	0.43	0.50	0.75	1.16	0.23	0.61
	Mean	0.38	0.49	0.70	1.08	0.18	
	LSD (P=0.05)						
	PS =		0.011				
	RF =		0.017				
	PS x RF =		0.024				

Table 7: Effect of planting system and Force Top® on number of pods

	Rates of Force Top® (L/ha)					
Planting System (PS)	3.0	3.5	4.0	Weeding twice	No weeding	Mean
Flat	5.67	8.00	9.00	11.00	2.33	7.20
Raised bed	8.00	8.67	14.00	15.67	4.00	10.07
Mean	6.83	8.33	11.50	13.33	3.17	

LSD (P = 0.05)
PS = 0.662
RF = 1.047
PS x RF = 1.480

Table 8: Effect of planting system and Force Top® on fruit yield (kg/ha) of okra

	Rates of Force Top® (L/ha) (RF)					
Planting System (PS)	3.0	3.5	4.0	Weeding twice	No weeding	Mean
Flat	3670	4670	5330	7330	560	4310
Raised bed	4670	5670	7330	9000	950	5520
Mean	4170	5170	6330	8170	760	

LSD (P = 0.05)
PS = 518
RF= 818
PSx RF = 1, 157

Plots hoe weeded twice produced higher pod numbers than other treatment. Among Force Top® rates, the plot treated with force top at 4 L/ha had higher pod numbers than others. The least number of pods were produced in the weedy plots. On the interaction, higher numbers of pods were produced from a combination of raised bed system of planting and weeding twice while the lowest was from flat system of planting and no weeding.

Fruit Yield: The effect of planting system and Force Top® on fruit yield of okra is presented in Table 8. The raised bed planting system produced a significantly higher yield than the flat system probably because it has a good soil structure which enhanced the rooting features of the plant for nutrient uptake and better yield of okra. This finding is agreement with that of Tunku, Ishaya and Haruna [24] who reported similar observations on maize plants. Plots hoe weeded twice had significantly a higher fruit yield than other treatments. Among the various rates of Force Top®, plots treated with 4.0 L/ha had higher fruit yield than other rates. The low weed infestation in the herbicide treated plots and hoe weeded plots could be the probable reason for their high yield. An increase in crop yield as a result of low weed infestation has been reported by Tunku, Ishaya and Haruna [24]. The weedy plots had the lowest yield probably as a result of severe weed competition with the plant for available growth resources. Shah *et al.* [28] noted that weeds compete for water, light, nutrients and space with crops which invariably reduced crop yield and increase the cost of production. On the interaction, the highest fruit yield produced from raised bed system and weeding twice plots while the least was from a flat system and no weeding.

Weed Index: The effect of planting systems and force top on yield index of okra is presented in Table 9. Weed index was significantly higher in flat planting system than in raised bed system probably because the flat system had a lower leaf area index and was less weed suppressive. The weedy plots had the highest weed index when compared to other treatments. Weed index implies yield reduction. A yield reduction of 90.92 % was obtained in this study in weedy check due to uncontrolled weed growth. This finding is agreement with that Adejonwo *et al.* and Melifonwu [5, 6] who reported that uncontrolled weed growth in okra life cycle decreases okra fruit yield by 88 to 93 percent when compared with weed-free check.

Economic Assessment of Planting Systems and Rates of Force Top® on Okra Production: The Economic assessment of planting systems and rates of Force Top® is presented in Table 10.

The highest cost of production was recorded in the weeded twice plots while the lowest cost of production was in the weedy check. The highest profit was obtained in the force top 4.0L/ha treatment in both raise beds and flat. The plot treated with Force Top® 4.0 L/ha had the

Table 9: Effect of planting system and Force Top® on yield index (%) of okra

	Rates of Force Top® (L/ha) (RF)					
Planting System (PS)	3.0	3.5	4.0	Weeding twice	No weeding	Mean
Flat	49.98	36.33	26.93	0.00	92.37	41.12
Raised bed	48.18	37.10	18.87	0.00	89.47	38.72
Mean	49.07	36.72	22.90	0.00	90.92	

LSD (P=0.05)
PS = 0.255
RF = 0.403
PSx RF = 0.570

Table 10: Economic of planting system and rates of Force Top® on okra production

	Cost of production (₦)		Sale revenue (₦)		Profit (₦)		[1]BCR	
Treatments	Raised bed	Flat	Raised bed	Flat	Raised bed	Flat	Raised bed	Flat
Force top at 3L/ha	700072	352850	1401000	1101000	700928	748150	1.0	2.1
Force top at 3.5L/ha	700847	353625	1701000	1401000	1000153	1047375	1.4	2.9
Force top at 4.L/ha	701622	354400	2199000	1599000	1497378	1244600	2.1	3.5
Weeding twice	2083110	1735888	2700000	2199000	616890	463112	0.2	0.3
No weeding	694222	347000	285000	168000	-409222	-79000	-0.5	-0.5

1kg of okra is ₦ 300 at Choba market in 2019
[1]BCR = Benefit – cost ratio = Profit/ Cost of production

highest benefit-cost ratio while the lowest was obtained in weedy check. Force top applied at 4.0L/ha was more profitable in both planting systems; however, the highest profit was recorded in bed system when Force Top® at 4.0 L/ha was used in controlling the weeds. Plots that were weeded twice were not as profitable as that of Force Top® at 4L/ha because of the high cost of labor involved due to scarcity of labor at the time of carrying out this study. Adigun and Lagoke [29] noted that the cost of hoe weeding is more expensive manual hoe weeding. Kehinde and Khan *et al.* [30, 31] reported higher financial returns with the application of herbicides when compared with the other methods of weed control. Adigun *et al.* [32] also noted that the use of herbicides was more profitable than manual hoe weeding of different crop production in Nigeria.

CONCLUSION

This study showed that the bed system was more weed suppressive than the flat system. Okra growth and yield was better in bed system of planting than a flat system. Among the herbicides rates, 4.0 L/ha of Force Top® had the lowest weed density and weed dry weight and better okra performance. Generally, plots that were weeded twice were slightly better than Force Top® rate at 4.0L/ha. In terms of economic, Force Top® applied at 4L/ha had the highest profit than other treatments. Although weeding twice had the highest yield but the cost of weeding was more expensive than Force Top® at 4L/ha. For economic reasons, Force Top® at 4L/ha is recommended to both planting systems. However, the combination of Force Top® and raised bed system had more economic returns than that of a flat system and should be recommended to farmers in the study area for effective weed control and better okra performance.

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