Performance of Okra (*Abelmoschus Esculentus* (L) Moench) under varying soil moisture regimes and palm fruit residue ash in Port Harcourt, Nigeria

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Abstract
An experiment was conducted at the Rivers State University of Science and Technology Research farm, *Nigeria, to investigate okra's performance under varying soil moisture regimes and palm fruit residue ash during the dry season. Treatments consisted of 4 and 6 t/ha palm fruit residue ash (PFRA), combined with 4, 8, and 12 days irrigation intervals, and a control, laid out in a randomized complete block design with three replications. Results indicated that the plots treated with 6 t/ha PFRA combined with 4 days irrigation interval produced the highest average percentage germination, plant height and pod weight. For leaf area and stem girth, the plots treated with 6 t/ha PFRA and 8 days irrigation interval produced the largest. All the plots that had doses of PFRA and irrigation performed better than the control. It is therefore recommended that okra should be treated with 6 t/ha PFRA combined with 4 days irrigation interval under the existing agroclimate.*

Keywords: Okra performance, Soil moisture, Palm fruit residue ash, Dry season.

Introduction

Okra is a flowering plant that is valued for its edible green fruits. It is widely grown and consumed in Nigeria for its mucilage content (Chukwunda et al,.2006). The oil content of the seed is about 20%. According to Abanzukwe (1989), okra contains very high amount of protein (about 42.7%). It is also used as a source of gum. Its main use, however, is as a soup thickener especially in the Southern part of Nigeria where it is called okro. Despite its nutritional and commercial values, this crop is still produced at the subsistence level because of the two major growth-limiting factors of inadequate soil moisture and poor soil quality.

Rainfall in Port Harcourt, which lies in the Niger Delta region of Nigeria, is seasonal. As farmers in this region depend entirely on rainfed agriculture, cropping activities are skewed towards the rainy season, when the high amount of rainfall is believed to be adequate to supply crop water needs (Ayotamuno et at., 2007). However, in the Niger Delta region, the movement of gravitational water into the soil is usually very slow as a result of the poor permeability of the soils. There is also high evaporation which is about one-half of the rainfall (Fubara, 1983). All these lead to a scenario in which only a small fraction of the observed rainfall actually infiltrates and percolates into the root zone to sustain plant growth. The situation is even more precarious during the dry season. This assertion is supported by Adenkule (2013). There is therefore a need for the modification of the soil moisture regime through irrigation so as to enhance crop growth, especially in the dry season.

Okon and Amalu (2003) posit that the mean pH range of the soils of the Niger Delta does not favour the cultivation of many arable crops except some tolerant tree crops. Gutteridge and Shelton (1994) also aver that decline in soil fertility is especially serious in tropical regions where the soil lacks adequate plant nutrients and organic matter due to leaching and erosion of top soil by intense rainfall. In order to rehabilitate these soils, lime has often been used traditionally. However, because of the impoverished status of farmers in this region, coupled with the high cost and low availability of lime, the use of locally available organic materials and manures should be a welcome and viable alternative. Okon et al., (2005) also advocate the incorporation of crop residues (organo-mineral fertilizers) and other locally available plant nutrients into soils. Apart from the need to reduce costs of fertilizing crops, other important considerations for advocating use of organic materials are improvement of environmental conditions and public health (Seifritz, 1982). Shanmugan et al., (1996) and Omueti et al., (2000) reported that meaningful contributions to soil nutrient pool and beneficial effects on subsequent crops were observed when crop residues were returned to farmland and especially if the residues are of immediate utilizable form. Omueti et al., (2000) also stated that organic matter has liming effect on soil, while Webster and Wilson (1980) asserted that oil palm bunch is a cheap source of calcium, magnesium, potassium and available phosphorus. There is, however, a dearth of literature on the use of oil palm fruit ash for the cultivation of crops, especially okra. The aim of this study, therefore, was to determine the effect of the application of palm fruit residue ash and varying soil moisture regime on the growth and yield of okra.

Materials and Methods

1. Site Description

The study was conducted at the Teaching and Research Farm of the Rivers State University of Science and Technology, Port Harcourt, Nigeria during the dry season between November 2012 and February, 2013. The soil at the site has been described as coastal plain sands (Ayolagha and Onuegbu, 2001), and also classified as ultisols (USDA classification).

Port Harcourt has a tropical humid climate with distinct wet and dry seasons. It is characterized by high humidity ($\geq$ 80%) and moderately high temperature (25-30^{0}c). The area is also characterized by heavy rainfall with total annual rainfall ranging from 2000mm to 2484mm, occurring mostly in the months of June through September.

2. Experimental Design

The experiment was laid out in a randomized complete block design with seven treatments replicated three times. Plot size was 4 x 4m, with shallow drain between each plot to prevent treatment flowing from one plot to another either by surface runoff or interflow.

3 Planting Material

A new hybrid of okro variety, NHAe-47-4N, obtained from the Rivers State Agricultural Development Programme (ADP) in Port Harcourt, was used for the experiment. This variety is early and high yielding, and has high resistance to disease attack. Four seeds were planted per hole at a spacing of 0.6 x 0.3m, but later thinned to 2 plants per stand, three weeks after planting (3 WAP).

4 Laboratory Analysis

Composite soil samples were randomly collected with auger at 0-15cm depth for physico-chemical analysis. The properties determined were particle sizes, pH, organic carbon, and total nitrogen. Others were available phosphorus, exchangeable cations (Ca, Mg, Na, K), base saturation, electrical conductivity, and bulk density. Procedures adopted were those outlined in relevant literatures such as Day (1965); Peech (1965); walkey and Black (1934); Bremner and Mulvaney (1982); Bray and Kurtz (1945). Some chemical properties of the palm fruit residue ash were also determined.

5 Treatments

Treatments consisted of 4, and 6 t/ha of palm fruit residue ash (PFRA) and 4, 8, and 12 days irrigation intervals. The application depth was 4 mm. There was also a control that had neither PFRA nor irrigation.

The PFRA was applied two weeks before planting. It was uniformly spread on the plots and lightly worked into the soil with hoe, immediately after which the first irrigation was applied.

6 Cultural Practices

The site was first slashed, ploughed and harrowed. The plots were weeded manually whenever necessary.

7 Data Collection

For each plot, the middle five plants were selected for data collection. Growth and yield parameters measured were percentage germination (7 days after planting), plant height, leaf area and stem girth (at intervals of 2 weeks after planting), including the weight of fresh pods (from 7 to 12 weeks after planting).

8 Data Analysis

The mean growth and yield data were subjected to analysis of variance (ANOVA), while the means for treatment effects were compared using Duncan Multiple Range Test (DMRT) at 5% level of significance. The procedures adopted were those outlined by Gomez and Gomez (1984)**.**

Results

The physico-chemical properties of the soil before the experiment are shown in Table 1. The soil is loamy sand, with a pH that indicates that it is acidic. The soil is low in almost all the essential nutrients. Apart from exchangeable Ca and Mg, all the other essential elements such as total N, available P, exchangeable K and Na are below the critical levels recommended for crop production in the ecological zones of Nigeria (Akinrinde and Obigbesan, 2000). The soil moisture content is also low, thus resulting in low available water. Table 2 presents some chemical properties of the palm fruit residue ash (PFRA). The table shows that the PFRA is alkaline, with high available K, exchangeable P, Ca and Na. These high nutrient values are capable of positively enhancing the soil fertility and hence the crop performance.

The percentage germination, obtained 7 days after planting (7 DAP) is presented in figure 1. The minimum germination of 75.8% occurred in the control plots that had neither organic manure nor irrigation, while the highest percentage germination (94.4%) occurred in the plots that a combination of 6 t/ha PFRA and 4 days irrigation interval.

Data for plant height, leaf area, and stem girth recorded every two weeks after planting are shown in Tables 3 to 5, while pod weights obtained from 7 weeks after planting and on a weekly basis are presented in Table 6. Soil moisture content and available water determined from 4 weeks after planting (4WAP) to 12 weeks after planting (12WAP) are also presented in Table 7, while a summary of the analysis of variance (ANOVA) is shown in Table 8.

Discussion

Table 1 shows that the soil is low in nutrients and, hence, incapable of sustaining effective crop growth without any form of amendment. This view is supported by Opuwaribo et al., (1990) who further stated that soils in this region are inherently low in fertility, fragile and often highly weathered with characteristic low-activity clays and low cation exchange capacity. The situation is further aggravated by continuous cropping on the same piece of land without proper crop rotation.

The above-average percentage germination in the control plots that had neither PFRA nor irrigation can be attributed to the disease-resistant and high yielding nature of the variety used, as well as the carry-over soil moisture. The highest average germination occurred in the plots that were treated with 6 t/ha PFRA and 4 days irrigation interval, followed by the plots that had a combination of 4 t/ha PFRA and 4 days irrigation interval. The lowest average germination took place in the plots that had neither PFRA nor irrigation. This indicates that the organic manure, PFRA, in the presence of soil moisture, played a pivotal role in the enhancement of the fertility of the soil; a fact attested to by Okonmah (2011). The difference in germination between the control and other plots was highly significant at the 5% level. However, although there were also differences in germination among the plots that had organic manure and irrigation, such differences were not significant.

Except for the control (at 10 and 12 WAP), average plant height increased generally with time. This is in consonance with the findings of Okonmah (2011). At 12 WAP, the plots with treatment combination of 6 t/ha PFRA and 4 days irrigation interval produced the highest average plant height, although this was not significantly different from the treatment combinations of 6 t/ha PFRA and 8 days irrigation interval, as well as 6 t/ha PFRA and 12 days irrigation interval based on Duncan Multiple range test (DMRT) at 5% level of significance. On the whole, however, differences between the treatments were highly significant. Increases were also observed up to 12 WAP in the other parameters investigated. This observation does not totally agree with that of Akanbi et al., (2010), who posited that plant height increased gradually up to 8 WAP, and thereafter, remained unchanged, while leaf area and stem girth increased up to 8 WAP, and then decreased. The discrepancy might be attributable to the combinations of the doses of organic and inorganic fertilizers applied, as well as the fact that their experiment was performed under rainfed condition.

For leaf area at 12 WAP, the highest average value was obtained from the plots that had a combination of 6 t/ha PFRA and 8 days irrigation interval, followed by the plots that were treated with 6 t/ha PFRA and 4 days irrigation interval. However, the differences in treatment in all the plots (except the control) were not significant at 5% level (DMRT). The same trend was observed for stem girth except that at 12 WAP the combination of 6 t/ha PFRA and 12 days irrigation interval produced a bigger stem girth than that of 6 t/ha PFRA and 4 days irrigation interval. Furthermore, there was significant difference between the 4 t/ha PFRA and 4 days irrigation interval plots and the other plots that had PFRA and irrigation at 12 WAP.

For pod weight at 12 WAP, 6 t/ha PFRA and 4 days irrigation interval produced the highest value, followed by 6 t/ha PFRA and 12 days irrigation interval. There was however no significant difference amongst the plots treated with 6 t/ha PFRA and 4days irrigation interval, 6 t/ha PFRA and 8 days irrigation interval and 6t/ha PFRA and 12 days irrigation interval. Although the difference between these latter plots and the other plots was significant, there was no significant difference between the plots treated with 4 t/ha PFRA and 4 days irrigation interval, 4 t/ha PFRA and 8 days irrigation interval, and 4 t/ha PFRA and 12 days irrigation interval.

On the whole, the analysis of variance (ANOVA) indicated that the differences in germination, plant height, leaf area, stem girth, and pod weight due to the treatment applications were highly significant. This implies that the application of PFRA and irrigation resulted in both increase in soil fertility and soil moisture that adequately induced significant differences in the parameters investigated.

In terms of growth and yield performance, the combination of 6 t/ha PFRA and 4 days irrigation interval produced the highest germination, plant height, and pod weight. However, the combination of 6 t/ha PFRA and 8 days irrigation interval gave the best performance in terms of leaf area and stem girth.

The soil moisture regime as displayed in Table 7 shows that the highest moisture content and, hence, available water occurred in the plots treated with 6 t/ha PFRA and 4 days irrigation interval, followed by the combination of 6 t/ha PFRA and 8 days irrigation interval. This implies that 6 t/ha PFRA introduced the highest nutrients to the soil, while 4 and 8 days irrigation intervals produced soil moisture at the readily available level for crop growth. This is predicated on the performance of okra under these organic matter and water combinations. The ability of PFRA, an organic manure, to enhance soil moisture should also not be underestimated. On the whole, the choice for the best combination will tilt in favour of 6 t/ha PFRA and 4 days irrigation interval.

Conclusion

There is dearth of literature on the growth response of okra to varying soil moisture regimes in combination with palm fruit residue ash (PFRA) as soil amendment. This study has shown that combining 6t/ha PFRA with 4 days irrigation interval produced the highest okra performance in terms of percentage germination, plant height, and pod weight, while for leaf area and stem girth, the combination of 6t/ha PFRA and 8 days irrigation interval performed best. If, however, the importance of the five plant parameters measured were to be scaled, the preferred combination would certainly be 6t/ha PFRA and 4 days irrigation interval.

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References

Adekunle O. O. (2013). The effect of combined application of poultry manure and sawdust on the growth and yield of okra. Journal of Agricultural Science, Vol. 5, No. 10, 169-175.

Akanbi W. B., Togun A. O., Adediran J. A., & Ilupeju E. A. O.(2013). Growth, dry matter and fruit yields components of okra under organic and inorganic sources of nutrients. Am. Eurasian J. Sustain. Agric., 4(1), 1-13.

Akirinde E. A. & Obigbesan G. O. (2000). Evaluation of the fertilizer status of selected soils for crop production in five ecological zones of Nigeria. Proceeding, 26th annual Conference of Soil Science Society of Nigeria, Ibadan, Nigeria. 279-288.

Ayolagha G. A. & Onuegbu B. A. (2001). Soils of Rivers State and their uses. In: Land and people of Rivers State. Department of Crop/Soil science and Forestry, Faculty of Agriculture, Rivers State University of Science and Technology, Port Harcourt, Nigeria. 12 – 14.

Ayotamuno J. M., ZUOFA K., Ofori S. A. & Kogbara R. B. (2007). Response of maize and cucumber intercrop to soil moisture control through irrigation and mulching during the dry season in Nigeria. Afr. J. Biotechnol. Vol. 6(5), 509 – 515.

Bray R. H. & Kurtz L. T. (1945). Determination of total, organic and available forms of phosphorus in soils. Soil Science, 59, 39 – 45.

Bremner J. M. & Mulvaney C. S. (1982). Total nitrogen. In: methods of soil analysis. American Soc. of Agronomy 9, 595-624.

Chukwunda A. F., Atanaga A. E. & Ukoima H. U. (2006). Effect of Culture filtrate of curvularia lunata on seedling diseases of okra (Abelmoschus esculentus (L) Moench). Acta Agronomica Nigeriana, 7 (1), 65 – 68.

Day P. R. 1965. Particle size analysis. In: Black C. A. (ED), Methods of soil analysis. American Society of Agronomy. Madison, Wisc., 1, 545 – 566.

Fubara D. M. J. 1983. Physical conquest and development of the Niger Delta. Commemoration lecture, Rivers State University of Science and Technology, Port Harcourt, Nigeria.

Gomez A. K. & Gomez A. A. (1984). Statistical procedures for agricultural research. 2nd Edition John Wiley and Sons, New York, pp. 680.

Gutteridge R. C. & Shelton H. M. (1994). The role of forage tree legumes in cropping and grazing systems. In: Gutteridge R. C. and Shelton H. M. (eds.) Forage tree legumes in tropical Africa. CAB International, United Kingdom.

Okon P. B. and Amalu U. C. (2003). Low-cost technologies for rehabilitation of degraded small-scale tropical farms. Proceeding of the 37th Annual Conference of the Agricultural society of Nigeria.

Okon P. B., Amalu U. C. & Ogeh J. S. (2005). Effect of rice husk ash and phosphorus on some properties of the acid sands and yield of okra. Communication in soil science and plant analysis Vol. 36 (7 & 8), 833 – 845.

Okonmah L. U. (2011). The effects of pig manure rates on some agronomic parameters of three okra (Abelmoschus esculentus (L) Moench) cultivars in Asaba agro-ecological zone. International Journal of Agric. Science Vol. 1 (7), 427 – 436.

Omueti J. A. L., Shridhar M. K. C.., Adeoye G. O., Bamiro O. & Fadare D. A. (2000). Organic fertilizer use in Nigeria: Our experience. In: M. O. Akoroda (Ed.). Agronomy in Nigeria, University of Ibadan, Ibadan, Nigeria, September, 208 -215.

Opuwaribo E. E., Enwezor W. O. , Ohiri A. C. & Undo E. J. (1990). A review of fertilizers. Federal Ministry of Agiculture, Water resources and Rural Developmkent, FPDD, 53 – 63.
Peech M. (1965). Hydrogen-ion activity. In: Method of Soil Science Analysis; Black C. C. A. Edu. No 9, part 2 , American Society of Agronomy: Madison W. I, 914 – 926.
Seifritz W. (1982). Alternative and renewable sources of energy in optimizing yield: The role of fertilizers. In proceedings of 12th IPI Congress, 153 – 163.
Shanmugan M., Rathorasanny R. & Nadaragan N. (1996). Effect of amendments on soil properties and yield parameters under maize – black gram cropping sequence in soils with surface crusting. Madras Agriculture Journal 83 (1), 24 – 36.
Walkley A. and Black T. A. (1934). An examination of the Degtjaroff method for determining soil organic matter and proposed modification of the chronic acid titration method. Soil Science 37, 28 - 38.
Webster W. C and Wilson P. N., 1980. Agriculture in the Tropics. Longman Ltd, London,
148 – 207.

Table 1. Physico-chemical Properties of the Soil (0-15cm depth) before the Experiment

Parameters	Values
pH (1:2.5 H_20)	4.80
Organic Matter (%)	1.04
Total N (%)	0.06
Available P (mg/kg)	2.12
Exchangeable K (cmol/kg)	0.09
Exchangeable Ca (cmol/kg)	2.30
Exchangeable Mg(cmol/kg)	0.85
Exchangeable Na (cmol/kg)	0.33
Effective Cation Exchanges (cmol/kg)	4.78
Exchangeable Acidity (cmol/kg)	2.28
Base Saturation (%)	61.68
Total Porosity	20.00
Bulk density (g/cc)	2.14
Moisture Content (% Volume)	12.11
Available water (%)	28.52
EC (µs/cm)	110.00
Clay (%)	11.00
Silt (%)	9.30
Sand (%)	9.70

Table 2. Some Chemical Properties of the Palm Fruit Residue Ash

pH (1:2:5 H_{20})	8.50
Total N (%)	1.10
Available P (mg/kg)	241.94
Exchangeable K (cmol/kg)	440.64
Exchangeable Ca (cmol/kg)	68.00
Exchangeable Ca (Mg (cmol/kg)	21.87
Exchangeable Na (cmol/kg)	88.00
EC (µ/cm)	260000.00

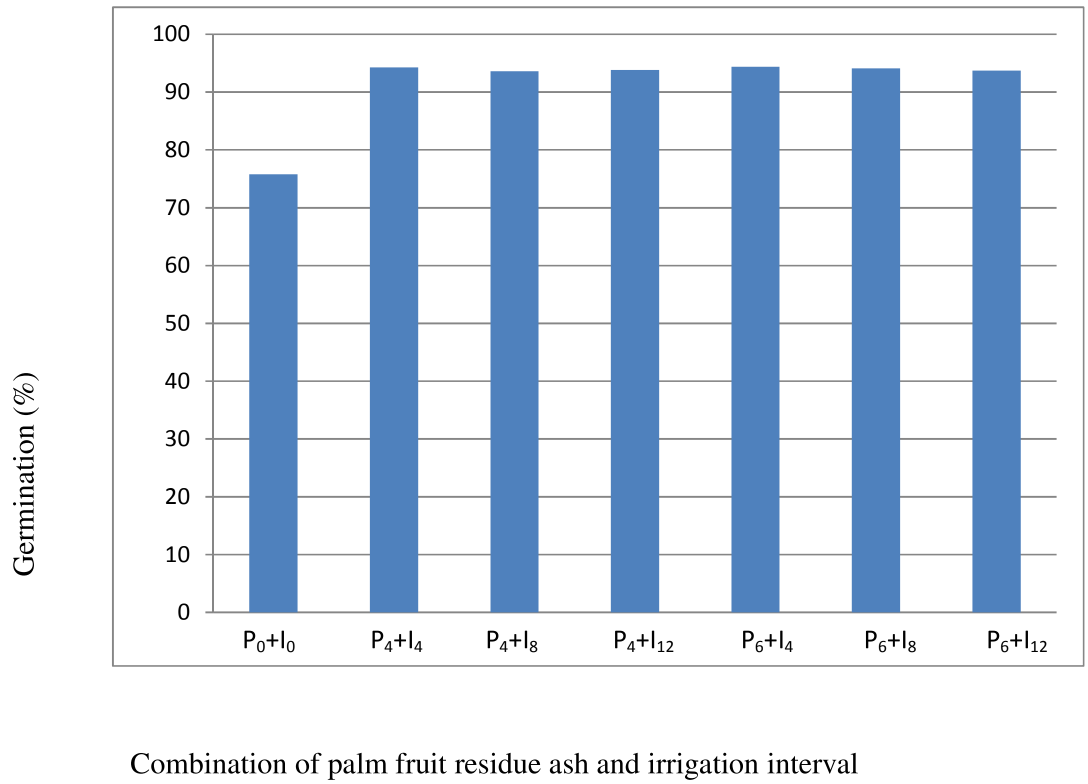

Figure 1. Effect of combined levels of palm fruit residue ash (P) and irrigation interval(I) on germination of Okra

Key: P_0+1_0 = Control: P_4+1_4 = 4 t/ha PFRA +4 days irrigation interval; P_4+1_8 = 4 t/ha PFRA + 8 days irrigation interval; P_4+1_{12} = 4 t/ha PFRA + 12 days irrigation interval; P_6+1_4 = 6 t/ha PFRA +4 days irrigation interval; P_6+1_8 = 6 t/ha PFRA +8 days irrigation interval; P_6+1_{12} = 6 t/ha PFRA + 12 days irrigation interval.

Table 3. Plant Height of Okra(cm)

Weeks	2	4	6	8	10	12
Treatment						
P_0+1_0	8.4	10.5	13.1	13.9	13.8	13.8
P_4+1_4	14.9	27.2	59.4	63.7	85.3	91.1
P_4+1_8	14.6	27.4	58.6	63.2	84.9	90.7
P_4+1_{12}	13.9	27.1	58.1	60.3	84.2	89.8
P_6+1_4	15.2	28.1	61.0	72.2	93.5	95.4
P_6+1_8	14.8	28.0	60.8	72.0	91.8	95.1
P_6+1_{12}	13.9	24.6	58.3	69.8	90.3	90.8

Table 4. Leaf area of Okra (cm^2)

Weeks	2	4	6	8	10	12
Treatment						
P_0+1_0	4.3	9.2	30.3	38.5	43.7	43.6
P_4+1_4	9.8	24.4	97.8	105.1	138.3	221.8
P_4+1_8	9.4	23.8	98.2	106.0	135.6	209.1
P_4+1_{12}	9.5	23.3	93.4	105.6	135.2	208.5
P_6+1_4	10.1	24.6	100.1	117.3	170.1	248.9
P_6+1_8	9.8	24.1	98.4	116.8	171.3	243.7
P_6+1_{12}	9.7	23.9	97.7	109.2	152.8	239.7

Table 5. Stem Girth of Okra (cm)

Weeks	2	4	6	8	10	12
Treatment						
P_0+1_0	1.6	2.5	4.3	4.6	4.7	5.1
P_4+1_4	2.1	5.4	9.9	13.6	15.2	19.7
P_4+1_8	2.4	5.8	12.3	15.7	20.2	25.0
P_4+1_{12}	2.3	5.5	13.0	15.6	20.5	24.4
P_6+1_4	2.5	7.0	15.7	17.5	23.5	26.4
P_6+1_8	2.5	7.1	15.3	17.7	23.5	27.3
P_6+1_{12}	2.4	7.1	15.2	16.8	23.4	26.8

Table 6. Pod Weight (g)

Weeks	7	8	9	10	11	12
Treatment						
P_0+1_0	108.8	156.5	158.3	156.7	148.2	148.9
P_4+1_4	310.1	502.7	650.2	1184.1	1210.7	1200.6
P_4+1_8	302.3	496.1	650.7	1093.3	1108.5	1191.7
P_4+1_{12}	298.8	498.6	608.1	1021.9	1003.1	1100.3
P_6+1_4	453.2	781.2	935.7	1473.5	1446.3	1388.8
P_6+1_8	420.7	778.2	929.6	1388.1	1402.3	1353.1
P_6+1_{12}	411.4	753.1	906.2	1319.8	1402.1	1361.6

Table 7. Soil Moisture Content (MC, % by Volume) and (Available Water (AW, %)

Weeks	4		8		12	
Treatment	MC	AW	MC	AW	MC	AW
P_0+1_0	12.09	28.36	12.01	27.70	11.89	26.72
P_4+1_4	17.44	72.21	17.69	74.26	18.40	80.08
P_4+1_8	17.00	68.61	17.01	68.69	16.97	68.36
P_4+1_{12}	16.80	66.97	16.62	65.49	16.71	66.23
P_6+1_4	19.75	91.15	19.91	92.46	19.96	92.87
P_6+1_8	19.57	89.67	19.66	90.41	19.67	90.49
P_6+1_{12}	18.05	77.23	18.03	77.05	18.06	77.30

Table 8. Summary of ANOVA of Okra Performance

Parameter	Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	Computed F	Tabular F 5%	Tabular F 1%
Germination	Between groups	6	851.85	141.98	489.59**	2.85	4.46
	Within groups	14	3.02	0.29			
	Total	20	854.87				
Plant Height	Between groups	6	15874.73	2645.789	4748.851**	2.85	4.46
	Within groups	14	7.8	0.557143			
	Total	20	15882.53				
Leaf Area	Between groups	6	94059.28	15676.55	15973.19**	2.85	4.46
	Within groups	14	13.74	0.981429			
	Total	20	94073.02				
Stem Girth	Between groups	6	1128.24	188.04	654.87**	2.85	4.46
	Within groups	14	4.02	0.287143			
	Total	20	1132.26				
Pod Weight	Between groups	6	3427693	571282.2	22579.05**	2.85	4.46
	Within groups	14	354.22	25.30143			
	Total	20	3428047.22				

** = Significant at 1% Level.