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IMPACT OF SPACING AND HARVESTING INTERVALS ON THE PERFORMANCE OF OKRA (*Abelmoschus esculentus L. Moench*) IN MUBI NORTHERN GUINEA SAVANNA OF NIGERIA

A.I. Omar[1], K.N. Futuless[2], I.D. Bake[2] and Anil Kumar[3]

[1]Agricultural production Technology Department, Federal Polytechnic, P.M.B 35 Mubi Adamawa State Nigeria, [2]Department of Crop Science, Faculty of Agriculture, Adamawa state University P.M.B 25 Mubi Adamawa state Nigeria and [3]High Mountain Arid Agriculture Research Institute SKUAST-K, Leh-194101, Corresponding Author: Anil Kumar

Abstract: *Field trials were conducted during the 2014 and 2015 rain fed cropping seasons at the Food and Agricultural Organization/Tree Crop Plantation (FAO/TCP) Teaching and Research Farm of the Department of Crop Science, Faculty of Agriculture, Adamawa State University Mubi with objective to determine the optimum spacing and harvesting interval on the growth and pod yield of okra in Mubi northern guinea savanna. The experiment was laid out in a split plot design with spacing viz:S_1(60X30cm),S_2(60x40cm),S_3(60x50cm) and S_4 (60x60cm) as main plots while harvesting interval viz:D_1(1day interval),D_2(two days interval),D_3(three days interval) and D_4(four days interval) as sub plot treatment replicated three times. Data were collected on the following parameters; plant height(cm), number of leaves, number of branches, crop growth rate, days to 50% flowering, pod yield per plot (t/ha) and 100 seed weight (g). Data were subjected to analysis of variance (ANOVA) appropriate for split plot design and means were separated according to Multiple Range Test (DMRT).Plant height was significantly different at 6WAS 1n 2014 and 2015.Significant difference was recorded for number of leaves at 6WAS and 9WAS in 2014 and 2015.Number of branches and crop growth rate recorded significant difference in 2014 and 2015, contrary to picking interval that showed no significant difference.*

Keywords*: Impact, Harvesting intervals, Okra, spacing and northern guinea savanna.*

Introduction: Okra (*Abelmoschus esculentus L.Moench*) is an economically important and widely grown vegetable that belongs to the family Malvacea. Okra is predominantly grown in Nigeria during the wet season but is limited to the irrigation sites during the dry season especially in the Fadama [1]. Observed that, Okra can tolerate wide range of soil type with potential hydrogen (PH) values of about 6-6.8 and a fertile sandy loam soil with high nutrient content will give a good yield [2]. In Nigeria many local varieties of okra are grown which differ in flowering habit, fruit texture, plant height, fruit size and fruit colour at maturity [3]. Okra is a warm season crop and its rate of germination and growth is markedly influenced by temperature. It grows well at day temperature between 25 0C-45 0C with night temperature over 22 0C.It is a crop of lower altitude and does well in humid condition but susceptible to drought and low night temperature [4]. In order to create a favorable environment for its growth, the land should be well ploughed and harrowed. The root system is shallow and extensive. The fruit is elongated with relatively large pod when matured. The pod is hard and woody [5]. Okra is cultivated mainly for its immature fresh pods which are used as vegetable in making soup or dried and milled to powder for use as flavoring [6]. Viewed that, okra is a nutritious rich vegetable which provides an important source of carbohydrate, protein, vitamin A,B and C, calcium, potassium, dietary fiber and mineral matter [7].

The planting density plays a significant role in okra. Lack of optimum plant spacing results in poor growth, low yield and poor quality fruits while high plant density may lead to vigorous growth, poor quality fruits and low yield due to intra specific competition [8]. They also stated that, a significant decrease of pod yield per plant with increasing plant density was

observed. Plant spacing is a major problem faced by farmers in its production. Observed that, most small holders of okra farmers produce it at low standard of crop husbandry and rarely care about the spacing [9]. Reported that, spacing of 90x30cm and application of NPK 15:15:15 fertilizer at 150kg/ha gives the highest yield of okra [10]. Plant spacing varies from one variety to another and thus, must strictly be controlled to prevent overcrowding which may in turn affect growth, development and yield of cultivated crops. Plant population is usually quantified in terms of the number of the optimum plant population of healthy plants in the most suitable arrangement pattern and that is the foundation of a successful crop production system [11]. Observed that, adequate spacing of crop is important for good yield, spacing the crop optimally reduce interplant competition for sunlight, moisture and nutrient [12]. They further stated that, wide or narrow row spacing lead to reduction in yield. The production and productivity of okra are also seriously affected due to the use of local varieties (low yielding), sub or supra-optimal plant density (improper inter and intra row spacing), inappropriate planting dates, soil nutrients, and severe attack of several insect pests, diseases and weeds [13]. The importance of spacing and harvesting interval cannot be over looked as it affects different plant characters. Spacing of any crop depends on soil productivity, location and time of planting on fertile moist soils; closer spacing will give better result than on poor sandy soil. Plant spacing varies from one species to another and thus must be strictly controlled to prevent overcrowding which may in turn affect growth, development and yield of cultivated crops [14]. Reported that, okra should be spaced at 30-60cm intra and inter row spacing and that seed to be sown at 3-4 per hole [15]. Argued that, spacing of okra should be 60 x80cm between rows and 20 x30 cm between plants and that the appropriate seed rate is 8 to 19 kg required per hectare for sole crop [16]. Overcrowding of seeding or plant in a particular area or spot may iead to competition among the plant for essential growth resource like sunlight, space, water and nutrient which may affect plant performance and yield [17]. Also reported that, wider spacing produce more healthy plant than closer spacing [18].

Okra must be harvested on a regular basis for better yield returns. If the fruits are allowed to mature on the plant then flowering will be reduced and further fruiting will be hindered. Among the constraints in production of okra, conventional methods such as sowing dates and proper plant spacing are important issues to handle; each and every crop needs a proper sowing date depending upon climatic conditions, soil and variety so that its critical stage should coincide with favorable weather conditions. If good cultivar is sown at proper time, at a proper location with optimum spacing, it may give maximum yield. A number of scientists have conducted trials and cited the importance of plant spacing and harvesting intervals on adequate plant growth, yield and quality performance of okra. Most of the small and marginal farmers with small holdings produce okra at low standard of crop husbandry and rarely care about the spacing. This either reduced the number of plants per hectare or causes overcrowding. Hence it is imperative to maintain proper optimum spacing to get good and quality yield of okra.. Picking interval can influence the yield of okra since it is a quick growing crop [19]. Earlier picking depresses yields because of low fruit weight, but delayed picking depresses marketable yield because of over aged fruits become fibrous. Reported that, differences in seed yield has been found [20] if no picking of fruit is done or only one or two pickings are made [21]. There are also reports that fruit setting in okra increase with a higher frequency of picking fresh fruit [22, 23]. Picking of green fruits encourages vegetative growth, fruit character and ultimate seed yield and seed quality in okra. The regular removal of young fruit permit sustained vegetable growth and flowering prolonging the production period. State that, when young fruits are removed, plant will produce new flowers leading to more fruit [24]. The optimum number of picking is twice or three times a week. Fewer picking depresses yield because of low fruit weight, delayed picking depresses marketable yield because of over age. Fruit become fibrous; okra is therefore harvested at interval of 2-3days.

The farmer's low yield in the study area is further compounded by the utilization of inappropriate spacing which results in relatively low yield and poor quality fruit. Research efforts in improving crop yield are mainly in area of okra growth, spacing and maturing. There is currently paucity of empirical evidence on cultural manipulations for improving the productivity of okra in Mubi, northern guinea savanna. There is the need there fore to conduct some systematic studies on okra in order to

address specific issues like appropriate spacing and harvesting intervals for optimum yield.

Materials and Methods

Field trials were conducted during 2014 and 2015 rain fed cropping seasons at the Food and Agricultural Organization/ Tree Crop Plantation (FAO/TCP) Teaching and Research Farm of Department of Crop Science, Faculty of Agriculture. Adamawa State University Mubi. Mubi is located within latitude 10^0 8N and 10^0 30N longitude 13^0 11'E and 13^0 25'E. Syria Mubi variety of okra seeds was obtained from local farmers in Mubi open market. A split plot design was used with four spacing viz: S_1=(60x30cm), S_2=(60x40cm),S_3=(60x50cm) and S_4 =(60x60cm) as main treatment and four harvesting intervals viz:D_1=(1 day), D_2=(2 days), D_3=(3 days) and D_4=(4 days) as sub plots which was replicated three times. Unit plot size was 3.6m x3m= (10.8m^2), total land area was 50.7m x14.5m = (35.2m^2) with 1m path way between the replication and 0.5m between the plots respectively. The land for the trial was ploughed, harrowed and leveled to get a fine tilt before sowing okra seeds. The seeds were treated with Apron plus-DS at the rate of 30kg of seed per sachet before sowing in order to protect the seed against soil-borne diseases. Sowing was done on flat land at the rate of 3-4 per hole and later thinned to two plants per stand. The crop was sprayed with karate at the rate of 2.5 liters per hectare at two weeks intervals beginning from 50% flowering to protect the crops from insect attack. Weeding was done with a simple hoe as when necessary to keep the plots neat.

Data were collected on the following parameters: plant height (cm), number of leaves per plant, days to 50% flowering, number of branches, fresh fruit weight (g), dry weight of fruit (g), 1000 seed weight (g) and yield per hectare(t/ha). Data collected were subjected to analysis of variance appropriate to split plot design. Means were separated using Duncan's Multiple Range Test (DMRT) as reported by Biometric (1:11:42).

Results

The texture of the experimental site was sandy loam. The soil has normal P^H (6.20 in 2014 and 6.50 1n 2015) with low available nitrogen of 0.20 N (%) 2014 and 0.21gNkg-1 2015, medium available phosphorous of 7.21mg/100g 2014, 6.81mg/100g 2015 and available potassium of 0.50 Cmolkg-1 in 2014 and 0.45Cmol kg-1 2015.The effect of spacing and harvesting interval on plant height and number of leaves at 6 and 9WAS is presented in Table,2.Analysis of variance revealed that, at 6WAS plant spaced 60x30cm (s_1) recorded the tallest plant height which differed significantly from the other spacing in 2014 and 2015 .At 9WAS in both years S_1(60x60cm) exhibited appreciable taller plants height than the other 3 spacings. However, there was no significant effect recorded. In nature, competition effect may be completely absent until population density reaches some threshold at which resource become limited. At 6WAS, no significant difference was noticed among the treatments in both years for harvesting interval. D_3(3days interval) had significantly taller plant height of 20.97cm, while D_4(4 days interval) had the shortest plant height of 18.9cm.No significant effect of plant height due to harvesting interval was recorded at 9WAS.At 6WAS in 2014,S_4 had the highest number of leaves 15.33 which differed significantly from the other spacing. In 2015,S_2 recorded significantly higher number of leaves than other spacing, with S_4 having the least number of leaves. In respect of harvesting interval at 6 and 9WAS, there was no significant difference in both years.

Table 3 shows the effect of spacing and harvesting interval on number of branches, crop growth rate and days to 50% flowering. S_3 significantly recorded more number of branches in 2014 and 2015 than other treatments. The influence of spacing and harvesting interval on number of branches were clearly noticed. Result indicated that in 2014 and 2015 there was significant effect of spacing on crop growth rate .However in 2015, spacing exhibited significant effect where S 2 (60x40cm) recorded the higher crop growth rate of 3.15g compared to other treatments. The result of harvesting interval on crop growth rate in both years showed no significant effect. Days to 50% flowering in 2014 and 2015 indicated that,S_2 had the lest days to 50% flowering in comparison to S1, S3 and S4 while S1had the highest days to 50% flowering. Same trend was followed in 2015 where S2 recorded the least days of 54.00 and A1 the highest days of 58.42.Statistically there was no significant difference observed in both years.

The effect of spacing and harvesting interval on pod yield and 100 seed weight is presented in table 4.There was no significant effect of spacing on pod yield in 2014, however, in 2015 S1 significantly gave a higher pod yield of 8.70 than other 3 spacings with S4 recording the lowest pod yield per plot. Pertaining to

harvesting interval, there was significant effect on pod yield in 2014 contrary to 2015.S1 significantly indicated higher 100 seed weight than other 3 spacing, followed by S4 while S1recorded the least 100 seed weight of okra. With regards to harvesting interval in both years, no significant effect was observed, although D3 had the highest 100 seed weight while D1 gave the least in 2015.

Table 1: Effect of spacing & harvesting internal on the number of branches crop growth rate & days to 50% flowering

Treatment	Number of branches		Crop growth rate		Days to 50% flowering	
	2014	2015	2014	2015	2014	2015
S_1	1.38[c]	1.27[c]	1.25[a]	2.23[b]	59.25	58.42
S_2	1.61[b]	1.80[ab]	1.02[b]	3.15[a]	54.42	54.00
S_3	1.71[a]	1.84[a]	0.94[c]	1.65[d]	54.83	54.42
S_4	1.43[bc]	1.61[b]	0.73[d]	1.76[c]	56.08	55.58
SE_1	0.480	0.119	0.067	0.648	0.47	0.44
LSD (P-0.5)	*	*	*	*	*NS*	*NS*
D_1	1.49	*1.06*	*0.93*	*1.78*	*56.08*	*55.50*
D_2	1.53	*1.68*	*0.94*	*1.71*	*55.92*	*55.25*
D_3	*1.54*	*1.75*	*1.03*	*1.92*	*55.67*	*55.58*
D_4	*1.58*	*1.56*	*1.01*	*2.17*	*56.92*	*56.08*
SE_1	*0.038*	*0.059*	*0.032*	*0.638*	*0.32*	*0.37*
LSD (P-0.5)	*Ns*	*NS*	*NS*	*NS*	*NS*	*NS*

Mean values with the same letter (s) in each treatment group are not significantly different at P≤ 0.05 (DMRT)

KEY

S_1 = 60X30cm D_1 = one day interval ns = not significant
S_2 = 60X40cm D_2 = two days interval * =significant
S_3 = 60X50cm D_3 = three days interval SE = standard
S_4 = 60X60cm D_4 = four days interval LSD = least significantly difference

Table 2: Effect of spacing and harvesting internal on plant height and number of leaves at 6 & 9 was in 2014 & 2015

Treatment	Plant height				Number of leaves			
	6 was		9 was		6 was		9 was	
	2014	2015	2014	2015	2014	2015	2014	2015
5_1	20.57[b]	22.62[a]	43.86	55.71	10.51[a]	58.42	18.82[b]	19.36[b]
5_2	21.29[a]	21.63[b]	42.53	55.11	9.68[b]	54.00	18.48[c]	20.09[a]
5_3	18.75[c]	19.74[c]	42.36	55.05	9.64[b]	54.42	18.94[a]	19.10[c]
5_4	17.84[1]	19.66[cd]	39.66	51.18	15.33[c]	55.58	15.85[d]	16.35[c]
SE_1	0.778	0.831	0.884	1.450	3.338	0.44	0.342	0.679
LSD (P-0.5)	*	*	*Ns*	*	*NS*	*NS*	*	*
D_1	*19.87*	*20.91*	*41.63*	*54.48*	*10.09*	*11.10*	*17.70*	*18.68*
D_2	*19.70*	*21.56*	*41.30*	*54.34*	*8.79*	*11.22*	*19.40*	*19.97*
D_3	*20.45*	*21.48*	*43.85*	*55.38*	*16.98*	*10.40*	*18.09*	*18.91*
D_4	*18.42*	*21.39*	*41.63*	*53.89*	*8.79*	*10.04*	*16.09*	*17.82*
SE_1	*0.697*	*1.121*	*1.218*	*0.960*	*3.339*	*0.560*	*0.232*	*0.609*
LSD (P-0.5)	*Ns*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*

Table 3: Effect of spacing and harvesting internal on pod yield per plot (t/ha) and 100 seed weight (g)

Treatment	Yield per plot		100 seed weight	
	2014	**2015**	**2014**	**2015**
5_1	8.56	8.70[a]	5.48[d]	2.23[b]
5_2	7.80	8.25[b]	5.76[c]	3.15[a]
5_3	7.63	7.78[d]	5.83[b]	5.89[a]
5_4	6.74	6.78[d]	5.83[b]	5.72[b]
SE_1	0.113	0.404	0.153	0.220
LSD (P-0.5)	*NS*	*	*	*
D_1	*7.00*[c]	*7.16*	*5.73*	*5.47*
D_2	*9.60*[a]	*8.88*	*5.57*	*5.84*
D_3	*8.15*[b]	*7.69*	*5.88*	*5.94*
D_4	*6.65*[d]	*7.48*	*5.82*	*5.86*
SE_1	*0.116*	*0.810*	*0.692*	*0.193*
LSD (P-0.5)	*Ns*	*NS*	*NS*	*NS*

Mean value with the same letter (s) in each column ace not significantly different at P≤ 0.05 (DMRT)

KEY

ns= not significant S_1 = 60X30cm D_1 = one day harvesting interval
*=significant S_2 = 60X40cm D_2 = two days harvesting interval
SE= standard error S_3 = 60X50cm D_3 = three days harvesting interval
LSD= least significant difference S_4 = 60X60cm D_4 = four days harvesting interval

Discussion

Plants that were closely spaced S_1(60x30cm) significantly produced taller plants. This could be attributed to the competition for light and other growth resources among the plant that were crowded at closer plant spacing. One can assume that, at the spacing there were insufficient light and other growth resources due to high plant density. Plant grew taller to receive maximum sunlight from the upper region. This result concurs with the work of [25, 26, 27, 28] who reported that, plant spacing produced a significant influence on plant height. This finding is corroborated [29, 30] who observed that ,over crowding of seedlings or plants in a particular area or spot may lead to competition among the plants for essential growth resources like sunlight, space, water and nutrients which may affect performance and yield. In line with the present study reported that, wider spacing produce more healthy plant than closer spacing [18]. Results of the present study are in conformity with that of who reported that, plants height increased in close spacing [31]. The present study also indicated that, plants that were planted closer (60x30cm) gave the tallest height of okra. This is in total conformity with the findings of who observed that, high density plants had greater canopy light interception than the low density [18]. Widely spaced plants produced shorter plants because of reduction in competition for growth resources. This study concurs with that of [32, 14] who reported that, plant spacing must strictly be controlled to control over crowding which may in turn affect growth, development and yield of cultivated crops. Also observed that, widest spacing or lower plant density per unit area was recorded best in case of plant height [33], leaf area and number of branches whereas the highest plant population or closest spacing produced the optimum yield. Similar results were also observed [34] with regards to plant spacing in okra. They also stated that, plant spacing had effect on vegetative growth, fruit quality characteristics and yield parameters. The non significant effect of plant spacing at 9WAS might be due to the fact that, the plant had attained its physiological maturity and growth might have ceased.

The highest yield was obtained at two days harvesting interval. This result is in total conformity of the findings of [19] who observed that, okra yield gradually decreases with increase in picking interval and the highest pod yield was obtained at two days picking interval. This variation arise because short picking interval encourage the plant to produce higher number of fruit, size and weight which in turn produce highest fruit yield per plant as well as per hectare. This variation also arises because two days picking interval encourages the plants to produce heavier fruit per plant with regards to the increase in fruit size, length, diameter and weight. This collaborates with [17] who reported that, to obtain high fruit yield, farmers will need to pick fruit regularly, since plant will direct its energy towards seed production at the expense of new growth. Also opined that harvesting is recommended at least every other day for size and quality [35].

Conclusion

On the basis of the findings, it may be concluded that spacing and picking intervals played important role in deciding the growth and yield and quality attributes of okra. Among the different spacings and picking intervals better fruit characteristics were exhibited at 60cmx30cm and two days picking intervals and all fruits were tender and very marketable. Closest spacing of 60cmx30cm and two picking intervals is therefore recommended to farmers in the study area and adjoining areas because the highest yield per hectare was recorded. However, more trials need to be conducted at different locations so as to arrive at conclusive findings for optimum spacing and picking intervals.

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