

EFFECTS OF TIME OF NITROGEN APPLICATION AND FREQUENCY OF WEEDING ON THE PERFORMANCE OF OKRA (*ABELMOSCHUS ESCULENTUS*) IN SOUTHWESTERN NIGERIA

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ABSTRACT

A two – year field experiment was carried out at the Teaching and Research Farm of the University of Ado – Ekiti, Nigeria, during 2005 and 2006 cropping seasons to evaluate the effects of time of nitrogen application, frequency of weeding and the interactions between these two treatments on the growth and yield of okra. The design was a split - plot arrangement, laid out in a randomized complete block, with three replications. Nitrogen application constituted the main – plot treatment, which were: no nitrogen (control); single dose N application at four weeks after planting (WAP); split N application, with half applied at 4 WAP, and the rest at 6 WAP, and single dose N application at 8 WAP. Weeding frequency was the sub – plot factor, which comprised: no weeding (control), weeding once at 3 weeks after planting (WAP), and weeding twice at 6 and 9 WAP. The results obtained indicated that there were significant differences ($P \leq 0.05$) between the treatments in growth and yield parameters of okra. The two – year average values indicated that time of nitrogen application significantly increased okra leaf area from 2.15m²/plant for no nitrogen (control) to 2.71, 2.49 and 2.15m²/plant for single dose N application at 4 WAP, split N application at 4 and 6 WAP, and single dose N application at 8 WAP, respectively. The main effects of weeding on okra leaf area were 2.12, 2.63 and 2.19 m²/plant for no weeding (control), weeding once (3 WAP), and weeding twice (6 and 9 WAP), respectively. Time of nitrogen application significantly increased okra fruit yield from 7.1 t ha⁻¹ for no nitrogen (control) to 10.7, 9.1 and 7.9 t ha⁻¹ for single dose N application at 4 WAP, split N application at 4 and 6 WAP and single dose N application at 8 WAP, respectively. Similarly, weeding significantly increased okra fruit yield from 5.9 t ha⁻¹ for no weeding (control) to 10.5 and 7.7 t ha⁻¹ for weeding once (3 WAP) and weeding twice (6 and 9 WAP), respectively. The interactions between time of N application and weeding frequency had significant effects on growth and yield components of okra. The treatment combination of single dose N application at 4 WAP and weeding once (3 WAP) resulted in the highest values of growth and yield parameters of okra in both years.

KEYWORDS: Nitrogen application, weeding, okra yield

INTRODUCTION

Okra (*Abelmoschus esculentus*) is an important vegetable in Nigeria, but the yields of okra, over the years have been low because many of the okra farmers do not use fertilizers and improved methods of production (Bein, 2005). Okra, like any other tropical crop, requires relatively high soil fertility, particularly, nitrogen, phosphorus and potassium for high yields (Abe, 2002; Aito, 2004; Bale, 2007). Significant responses of okra to nitrogen application have been demonstrated by many studies (Abe, 2002; Aito, 2004; Demo, 2005; Bako, 2005; Bale, 2007). In all these studies, significant increases in growth and yield of okra on application of nitrogen fertilizers were reported. However, too liberal application of N to okra, results in excessive vegetative growth and increased lodging (Aito, 2004; Demo, 2005; Bako, 2005; Bale, 2007).

Weeds constitute one of the most complex pests which Nigerian farmers have to contend with. Yield reductions of crops in Nigeria due to weed interference may be as high as 40 – 90%, while weeding as a percentage of total farm labour ranges from 22 – 54% (Akobundu and Agyakwa, 1987). Previous research studies have indicated that the degree of weed – crop competition depends on a variety of factors, among which are crop types and seeding rate, spatial arrangement of crop, plant architecture, cropping patterns and soil fertility (Atilola, 2007).

Okra is so sensitive to weed infestation that its

fruit yield can be reduced by as much as 50 – 60% (Ayegebe, 2004; Atilola, 2007). Thus, to minimize the high fruit yield reduction associated with weed interference, weeding schedule should be planned in such a way that it will coincide with the stage in the life – cycle when okra is most sensitive to weed interference (Kurtz, 2004; Lynrol, 2006). Okra has been reported to benefit immensely from properly timed weeding, as delayed weeding will result in fruit yield reduction (Kurtz, 2004; Lynrol, 2006). Adeitan (2004); Bamipe (2006) recommended weeding at 2 – 3 weeks after planting, while Atilola (2007) recommended 4 weeks after planting as the time for the first weed removal in okra.

Although, in the Southwestern Nigeria, many aspects of the agronomy of okra have been researched, with a view to raising the present level of okra yield on farmer's fields, however, the influence of time of nitrogen application, weeding frequency, and the interactions between these two treatments on the performance of okra have not been accorded enough research attention. Thus, this paper reports a two – year trial, aimed at evaluating the growth and yield of okra as influenced by time of nitrogen application, weeding frequency, and the interactions between these two factors.

MATERIALS AND METHODS

Study site

The two – year field experiment was carried out

at the Teaching and Research Farm of the University of Ado – Ekiti, Nigeria, during 2005 and 2006 cropping seasons. The soil of the study site belongs to the broad group alfisols (SSS, 2002). The soil is well drained, with an appreciable amount of quartz stones and iron stone concretions. The study site had earlier been planted with a variety of other arable crops, among which are maize, cassava, melon and sweet potato. It was left fallow for three years before the commencement of this study. The fallow vegetation was manually slashed, residues were burnt, and the land was ploughed and harrowed.

Collection and analysis of soil samples

Prior to planting, ten core soil samples, randomly collected from 0 – 15 cm top – soil were mixed to form a composite sample, which was analysed for physical and chemical properties. The composite soil sample was air – dried, ground, and passed through a 2 mm sieve. The sieved sample was then analysed. The pH was determined by glass electrode pH meter. Bray P – 1 extractant was used to extract available P, while organic C and total N were determined by Walkey – Black oxidation and Kjeldahl digestion techniques, respectively. Exchangeable K, Ca, Mg and Na were extracted by neutral normal ammonium acetate. K, Ca, and Na were determined by flame photometry, while Mg was by the Atomic absorption Spectrophotometry. Effective Cation Exchange Capacity was obtained by summation method (i.e. sum of K, Ca, Mg, Na and exchangeable acidity). The determination of exchangeable acidity was by extraction – titration method described by Mclean (1965). Particle size distribution was done by the hydrometer method of soil mechanical analysis as outlined by Bouyoucos (1951).

Experimental design and treatments

The design was a split – plot arrangement, laid out in a randomized complete block, with three replications. Time of N application constituted the main – plot treatment, which included: no nitrogen (control), single dose N application at four weeks after planting (WAP), split N application with half applied at 4 WAP, and the rest at 6 WAP, and single dose N application at 8 WAP. The source of N was urea, applied at the rate of 150 kg N ha⁻¹ (Fondufe, 1995). Weeding frequency was the sub – plot treatment and it comprised: no weeding (control), weeding once at 3 weeks after planting (WAP), and weeding twice at 6 and 9 WAP. The main – plot size was 4 m x 3 m, while the sub – plot size was 2 m x 2 m.

Planting

In 2005 and 2006, the plantings were done on March 25 and March 18, respectively. Three okra seeds were sown per hole at a spacing of 90 cm x 50 cm (22,222 plants ha⁻¹). Weeding was done manually using a hoe.

Collection and analysis of data

Leaf area was determined at 3, 6 and 9 WAP, by finding the product of the length and breadth of the leaf, and then multiplying by a factor of 0.6235 (Kaulen, 2000). Data were also collected on yield, number of fruits per plant, length and diameter of green mature okra fruits at harvest (at intervals of 3 days) until as many as 10 harvests had been taken. Analysis of variance was carried out, and treatment means were compared, using Duncan Multiple Range Test (DMRT) at 0.05 level of probability.

RESULTS

The physical and chemical properties of the soil of the study site before cropping are presented in Table 1. The soil was sandy loam, with a pH of 5.8. The organic C and total N were 2.96 and 1.90 gkg⁻¹, respectively. The available P was 1.81 mgkg⁻¹. The exchangeable bases – K, Ca, Mg and Na were 0.24, 1.84, 1.58 and 0.19 cmolkg⁻¹, respectively. Exchangeable acidity and effective cation exchange capacity were 0.25 and 4.10 cmolkg⁻¹, respectively.

Table 1: The physical and chemical composition of soil of the study site before cropping.

Parameters	Values
pH (H ₂ O)	5.8
Organic C (gkg ⁻¹)	2.96
Total N (gkg ⁻¹)	1.90
Available P (mgkg ⁻¹)	1.81
Exchangeable K (cmolkg ⁻¹)	0.24
Exchangeable Ca (cmolkg ⁻¹)	1.84
Exchangeable Mg (cmolkg ⁻¹)	1.58
Exchangeable Na (cmolkg ⁻¹)	0.19
Exchangeable acidity (cmolkg ⁻¹)	0.25
ECEC (cmolkg ⁻¹)	4.10
Texture (gkg⁻¹)	
San	650
Silt	225
Clay	125

Okra leaf area

The effects of time of N application and weeding frequency on okra leaf area are presented in Table 2. The two – year mean values indicated that nitrogen application significantly increased okra leaf area from 2.15m²/plant for no nitrogen (control) to 2.17, 2.49 and 2.15 m²/plant for single dose N application at 4 WAP, split N application at 4 and 6 WAP and single dose N application at 8 WAP, respectively. The mean effects of weeding on okra leaf area were 2.12, 2.63 and 2.19 m²/plant for no weeding (control), weeding once (3 WAP), and weeding twice (6 and 9 WAP), respectively. The interactions between time of N application and weeding frequency had significant effects on okra leaf area.

Table 2: Effects of time of nitrogen application and frequency of weeding on okra leaf area.

Treatments	Okra leaf area (m ² / plant)						Mean
	3 WAP		6 WAP		9 WAP		
	2005	2006	2005	2006	2005	2006	
Time of N application							
No nitrogen (control)	1.29a	1.3 la	2.24c	2.30c	2.84c	2.91c	2.15
Single dose application (4 WAP)	1.32a	1.30a	3.10a	3.18a	3.68a	3.72a	2.71
Split application (4 and 6 WAP)	1.30a	1.28a	2.70b	2.80b	3.40b	3.44b	2.49
Single dose application (8 WAP)	1.29a	1.33a	2.30c	2.39c	2.79c	2.82c	2.15
Weeding frequency							
No - weeding (control)	1.24a	1.30a	2.33b	2.37b	2.71c	2.77c	2.12
Weeding once (3 WAP)	1.27a	1.3 la	2.96a	2.99a	3.60a	3.64a	2.63
Weeding twice (6 and 9 WAP)	1.25a	1.29a	2.34b	2.34b	2.94b	2.97b	2.19
N x W Interactions LSD (0.05)	S	S	S	S	S	S	

Values followed by the same letter in the same column under each treatment are not significantly different at P 0.05. WAP = Weeks after planting, N = nitrogen, W= weeding frequency, S= significant.

Fruit yield and number of fruits per okra plant

Table 3 shows fruit yield and number of fruits per okra plant as affected by nitrogen application and weeding. Nitrogen application significantly increased okra fruit yield from 7.1 t ha⁻¹ for no nitrogen (control) to 10.7, 9.1 and 7.9 t ha⁻¹ for single dose N application at 4 WAP, split N application at 4 and 6 WAP and single dose N application at 8 WAP, respectively. Similarly, weeding significantly increased okra fruit yield from 5.9 t ha⁻¹ for control i.e. no weeding to 10.5 and 7.7 t ha⁻¹ for weeding once (3 WAP), and weeding twice (6 and 9

WAP), respectively. Relative to the control treatment, the percentage increases in number of okra fruits per plant were 89, 65 and 16% for single dose N application, split N application and single dose N application, respectively. The mean effects of weeding on number of okra fruits per plant were 10.3, 21.9 and 18.8 for control i.e. no weeding, weeding once (3 WAP), and weeding twice (6 and 9 WAP), respectively. The interactions between time of N application and weeding frequency had significant effects on fruit yield and number of fruits per okra plant.

Table 3: Effects of time of nitrogen application and frequency of weeding on fruit yield and number of fruits per okra plant at harvest.

	Okra fruit yield (t ha ⁻¹)			Number of fruits per okra plant		
	2005	2006	Mean	2005	2006	Mean
Time of N application						
No nitrogen (control)	6.8d	7.3d	7.1	10.4d	10.8d	10.6
Single dose application (4 WAP)	10.4a	11.0a	10.7	19.6a	20.3a	20.0
Split application (4 and 6 WAP)	8.8b	9.3b	9.1	17.0b	17.9b	17.5
Single dose application (8 WAP)	7.6c	8.2c	7.9	12.0c	12.6c	12.3
Weeding frequency						
No - weeding (control)	5.6c	6.2c	5.9	10.2c	10.4c	10.3
Weeding once (3 WAP)	10.0a	10.9a	10.5	21.7a	22.0a	21.9
Weeding twice (6 and 9 WAP)	7.4b	8.0b	7.7	18.4b	19.1b	18.8
N x W Interactions LSD (0.05)	S	S		S	S	

Values followed by the same letter in the same column under each treatment are not significantly different at P = 0.05. WAP = Weeks after planting, N = nitrogen, W = weeding frequency, S= significant.

Length and diameter of okra fruit

Table 4 shows the effects of nitrogen application and weeding on length and diameter of okra fruits. Nitrogen application significantly increased length of okra fruit from 6.07 cm for control i.e. no nitrogen to 7.70, 7.53 and 6.36 cm for single dose N application (4 WAP), split N application and single dose N application (8 WAP), respectively. Similarly, weeding significantly increased length of okra fruit from 5.36 cm for control i.e. no weeding to 7.47 and 6.25 cm for weeding once (3 WAP), and weeding twice (6 and 9 WAP), respectively.

The percentage increases in diameter of okra fruit were 35, 15 and 8% for single dose N application (4 WAP), split N application and single dose N application (8 WAP), respectively. Weeding significantly increased diameter of okra fruit from 6.61 cm for control i.e. no weeding to 8.88 and 7.15 cm for weeding once (3 WAP) and weeding twice (6 and 9 WAP), respectively. The interactions between time of N application and weeding frequency had significant effects on length and diameter of okra fruits.

Table 4: Effects of time of nitrogen application and frequency of weeding on length and diameter of okra fruit.

Treatments	Length (cm) of okra fruit			Diameter (cm) of okra fruit		
	2005	2006	Mean	2005	2006	Mean
Time of N application						
No nitrogen (control)	6.05d	6.08d	6.07	6.71d	6.74d	6.73
Single dose application (4 WAP)	7.69a	7.71a	7.70	9.06a	9.09a	9.08
Split application (4 and 6 WAP)	7.51b	7.55b	7.53	7.71b	7.77b	7.74
Single dose application (8 WAP)	6.34c	6.38c	6.36	7.21c	7.26c	7.24
Weeding frequency						
No - weeding (control)	5.34c	5.38c	5.36	6.58c	6.63c	6.61
Weeding once (3 WAP)	7.44a	7.50a	7.47	8.84a	8.91a	8.88
Weeding twice (6 and 9 WAP)	6.21b	6.29b	6.25	7.11b	7.18b	7.15
N x W Interactions LSD (0.05)	S	S		S	S	

Values followed by the same letter in the same column under each treatment are not significantly different at P= 0.05. WAP = Weeks after planting, N= nitrogen, W = weeding frequency, S= significant.

Table 5: Time of nitrogen application x weeding frequency interactions on okra leaf area, okra fruit yield, number of fruits per okra plant, length and diameter of okra fruit.

Weeding Frequency	Nitrogen application	Okra leaf area (m ² / plant)	Okra fruit yield (t ha ⁻¹)	No of fruits per okra plant	Length (cm) of okra fruit	Diameter (cm) of okra fruit
W ₀	No	1.21c	1.67d	1.91d	1.08d	0.88d
	N ₁	1.89a	2.68a	2.41a	2.16a	1.91a
	N ₂	1.40b	2.31b	2.18b	2.00b	1.54b
	N ₃	1.30c	1.90c	2.04c	1.81c	1.30c
W ₁	No	1.33c	1.90d	2.20d	1.24d	1.20d
	N ₁	1.99a	2.94a	2.88a	2.53a	2.49a
	N ₂	1.58b	2.54b	2.54b	2.28b	2.00b
	N ₃	1.38c	2.30c	2.32c	1.99c	1.70c
W ₂	No	1.26c	1.79d	2.05d	1.14d	1.03d
	N ₁	1.91a	2.81a	2.64a	2.31a	2.21a
	N ₂	1.46b	2.40b	2.33b	2.17b	1.76b
	N ₃	1.34c	2.05c	2.20c	1.88c	1.51c

W₀ = No weeding (control), W₁ = weeding once (3 WAP), W₂ - weeding twice (6 and 9 WAP), No = No nitrogen (control), N₁ = single dose N application (4 WAP), N₂ = split N application (4 and 6 WAP), N₃ = single dose N application (8 WAP).

DISCUSSION

The better performance (in terms of growth and yield) of okra associated with single dose N application (4 WAP) and split N application (4 and 6 WAP) than single dose N application (8 WAP) agrees with the findings of Aito (2004); Demo (2005); Bako (2005); Bale (2007), who noted significantly higher values of growth and yield parameters of okra for single dose N application and split N application than those of the growth and yield indices of okra for single dose N application counterpart. This observation suggests the indispensability of early N application in the nutrition of okra. This is because early N application has been reported to boost up initial growth in plants by accelerating the development of good vegetative structures (Demo, 2005; Bako, 2005; Bale, 2007). Thus, the good initial growth rate, characterized by leaf area expansion (Bale, 2007) may have promoted photosynthetic activities of okra, with resultant high carbohydrate production during fruiting (Demo, 2005; Bako, 2005; Bale, 2007). The significantly lower values of growth and yield indices of okra for single dose N application at 8 WAP than those of the growth and yield of okra for single dose N application at 4 WAP and split N application at 4 and 6 WAP agree with the report of Bako (2005) and Bale (2007). This observation implies that okra crops did not benefit immensely from the N applied at eight weeks after planting. From the findings of this study, and as far as nitrogen nutrition of okra is concerned, it is apparent that not the number of N applications that actually matters, but planning N applications in such a way that they will coincide with the most critical stage in the life – cycle of okra crops when they are most responsive to N application. In view of the tremendous benefits that okra derived from early N application, especially at four weeks after planting, hence, the

recommendation of properly timed N application, especially at four weeks after planting for okra cultivation is imperative.

The highest values of growth and yield indices of okra consistently recorded for weeding once (3 WAP) are in agreement with the findings of Kurtz (2003); Adeitan (2004); Ayegbe (2004); Lynrol (2006); Atilola (2007) who noted that okra crops weeded three weeks after planting out – performed those weeded at later stages of growth. This observation points to the superiority of weeding once (3 WAP) treatment to other weeding treatments appraised in this study as far as growth and yield of okra are concerned. The superiority emanates from the fact that weeding once (3 WAP) reduced the incidence of weed – okra competition for growth resources, compared to weeding twice (6 and 9 WAP) treatment, characterized by weed – okra competition for growth resources, especially in the first five weeks of planting before weeding was done later at six weeks after planting. Thus, weeding once (3 WAP) may have provided an initial weed – free micro – environment for proper establishment of okra crops before the first flush of weeds got established. The proper establishment of okra crops, perhaps, gave them a higher competitive advantage for growth factors over weeds. This implies that early weeding, especially at three weeks after planting is indispensable in okra cultivation. From the findings of this study, it is obvious that not the number of weeding that actually counts, but programming weeding operations in such a way that they will coincide with the most critical stage in the life – cycle of okra crops when they are most sensitive to weed interference. In view of the immense benefits that okra derived from early weeding especially at three weeks after planting, thus, the recommendation of properly timed weeding operations, especially at three weeks after planting for okra cultivation is imperative. The production of big – sized okra fruits that attended single dose N application at 4 WAP and weeding once (3 WAP) treatments suggests that one major advantage of the administration of early N application and early weeding in okra cultivation is that of increase in fruit size, which may consequently result in an increase in the quantity of commercially acceptable okra fruits, especially if and when fruit size determines the degree of marketability or acceptability for presentation at Agricultural Shows. The significant interactions between nitrogen application and weeding, imply that the magnitude of the differences in growth and yield indices of okra among the various times of nitrogen application was affected by weeding treatments.

CONCLUSION

The results of this study have shown that single dose N application at 4 WAP and split N application at 4 and 6 WAP gave significantly higher values of growth and yield parameters of okra than single dose N application at 8 WAP. Weeding once (3 WAP) significantly increased the growth and yield indices of okra far more than weeding twice (6 and 9 WAP) counterpart.

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60

B. OSUNDARE

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