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Nitrogen and Intra-row Spacing Effects on Growth and Yield of Onion (*Allium cepa* L.)

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Abstract: Experiments were undertaken at the Usmanu Danfodiyo University Fadama Teaching and Research Farm, Sokoto in 2004 and 2005 dry seasons to determine the effect of different nitrogen levels (0, 50, 100 and 150 kg N ha^{-1}) and intra-row spacing (10, 15, 20 and 25 cm) on the growth and yield of onion. Results revealed that nitrogen and intra-row spacing as well as their interaction, significantly affected plant height, number of leaves, crop growth rate, individual bulb weight, bulb diameter and total bulb yield per hectare. Nitrogen at the rate of 100 or 150 kg N ha^{-1} gave the best results and was statistically at par in all the parameters measured. Tweenty and 25 cm intra-row spacing were found to have recorded the highest and statistically similar values. The optimum yield of onion bulbs (30.83 t ha^{-1}) was obtained from 15 cm intra-row spacing combined with 100 kg N ha^{-1}. However, for large bulb size, application of 150 kg N ha^{-1} in plants spaced at 25 cm intra-row spacing and 20 cm inter-row spacing may be recommended.

Key words: Nitrogen, Intra-row spacing, growth and yield, onion

INTRODUCTION

Onion (*Allium cepa* L.) is a member of *Alliaceae* family and is of immense benefit due to its dietic and medicinal values. Onion is one of the most important vegetable crops in Nigeria, where it is exported and is an important condiment in the preparation of curry and spicy dishes. Yet the yield obtained by the farmers is low 15 t ha^{-1} compared to Niger Republic 36 t ha^{-1}, South Africa 26 t ha^{-1} Morocco 24.9 t ha^{-1} and Egypt 30.5 t ha^{-1} (FAOSTAT Data, 2005). Onion cultivation in Nigeria is confined to the semi-arid northern guinea and Sudan Savannah zones and the soils in this area are mostly low in nutrients, due to its low organic matter content which lowers the yield (Amans *et al*., 1996).

Inadequate N has been reported as major constraints to increased onion production. N is essential to growth and yield of onion but excessively high doses cause delay in bulb maturity and encourages bolting, which is an undesirable characteristic. Application of 80-90 kg ha^{-1} of N has been reported to be adequate for onion production (Umar *et al*., 2003; Halvorson *et al*., 2002). Nitrogen nutrition can influence onion bulb development, flavour and bulb quality (Randle, 2000). Samaila (2000) at Zaria, northern Nigeria and Al-Moshileh (2001) in Saudi Arabia reported a significant increase in the number of leaves per plant, plant height and yield as a result of N application on onion. However, responses up to 100-120 kg N ha^{-1} have been reported by Islam *et al*. (1999) and Singh *et al*. (2000).

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Various research findings revealed that population density greatly influenced growth and yield of onion. Kumar *et al*. (1998) obtained the highest yield with spacing of 20×10 cm. Khan *et al*. (2002) reported a significant effect of all the growth and yield components of onion. They maintained that larger percentage of small and medium bulbs were obtained in the narrowest spacing.

Keeping in view these aspects, the present research work was initiated to determine the optimum dose of nitrogen fertilizer and appropriate intra-row spacing on the growth and bulb yield of onion under Sokoto semi-arid condition.

MATERIALS AND METHODS

Field experiments were conducted at the Usmanu Danfodiyo University Sokoto Fadama Teaching and Research farm in the 2004 and 2005 dry seasons. The treatments consisted of factorial combination of four nitrogen levels (0, 50, 100 and 150 kg N ha^{-1}) and four intra-row spacing (10, 15, 20 and 25 cm) laid out in a split-plot design replicated thee times. Nitrogen was allocated to the main plots while intra-row spacing to the sub-plots keeping the net plot size at 4.8 m^2 and a row-to-row (inter-row) distance was maintained at 20 cm.

The soils at the experimental site were sandy loam in texture with low organic matter, total nitrogen and phosphorus content. The soil reaction was moderately acidic in nature (Table 1).

The experimental area was thoroughly prepared by ploughing and harrowing. Onion variety Violet de Galmi, was raised in the nursery using the recommended management practices. Seedlings were transplanted to the field at about four weeks after sowing. N fertilizer was split-applied using urea (46% N) as prescribed by the treatments. All recommended cultural practices were adopted uniformly according to onion requirements. Data was recorded on plant height, number of leaves per plant, crop growth rate, bulb diameter, individual bulb diameter, individual bulb weight and total bulb yield.

The data collected was subjected to Analysis of Variance technique (ANOVA) using SAS (2003) computer package. Duncan's Multiple Range Tests was adopted for the means comparison among treatments showing significant difference.

Table 1: Physico-chemical properties of soils at the experimental site during 2004 and 2005 dry seasons at Sokoto

	2004		2005	
	0-15	15-30	0-15	15-30
Properties	cm			
Chemical properties pH (water (1:1))	5.76	5.85	5.72	5.80
pH ($CaCl_2$)	5.27	5.46	5.22	5.43
Organic carbon (%)	7.66	8.50	7.63	8.51
Total nitrogen (%)	0.73	0.46	0.75	0.66
Available phosphorus (mg kg^{-1})	0.50	0.52	0.51	0.53
Exchangeable Cations (Meq 100 g^{-1})				
Ca (cmol kg^{-1})	1.25	0.96	1.23	0.98
Mg (cmol kg^{-1})	1.29	1.26	1.27	1.26
K (cmol kg^{-1})	2.54	1.06	2.53	1.03
Na (cmol kg^{-1})	1.73	1.62	1.71	1.52
CEC (cmol kg^{-1})	33.30	20.57	33.45	21.20
Physical properties (%)				
Sand	53.30	63.10	53.00	63.50
Silt	31.20	21.40	31.50	21.00
Clay	15.50	15.50	15.50	15.50
Textural class	Sandy loam	Sandy loam	Sandy loam	Sandy loam

RESULTS AND DISCUSSION

Plant Height

Nitrogen had significant effect on plant height of onion with the highest value 55.85 cm obtained from application of 150 kg N ha^{-1} which was at par with 55.67 cm obtained from the application of 100 kg N ha^{-1} (Table 2). This clearly showed that nitrogen is mainly concerned with the vegetative growth of the plants. Similar findings were reported by Kumar *et al*. (1998), Amans *et al*. (1996), Arboleya and Garcia (1993), Samaila (2000) and Khan *et al*. (2002).

Significantly highest plant height 52.51 cm was obtained from intra-row spacing of 20 cm followed by 51.78 cm obtained when the spacing of 25 cm was used. The shortest plants 47.37 cm were observed from 15 cm intra-row spacing (Table 3). Closer spacing resulted in competition for nutrient and light thus resulting in plants that were short while the wider spaced plants had adequate space for their growth and development.

There was a significant effect of interaction between nitrogen and intra-row spacing on height of onion. At 0 kg N ha^{-1} 20 and 25 cm intra-row spacing were at par. Similarly at 50 and 100 kg N ha^{-1} 20 and 25 cm spacing were at par. While at 150 kg N ha^{-1}, 10 and 15 cm intra-row spacing recorded similar height but significantly higher than 20 and 25 cm. This could be due to luxury consumption where enough nutrients were available thus preventing competition between plants. Highest plant height was obtained from 100 kg N ha^{-1} combined with 20 and 25 cm intra-row spacing (Table 4).

Number of Leaves per Plant

Nitrogen levels significantly affected the number of leaves per plant of onion with the highest value (12.63) obtained from 150 kg N ha^{-1} but not statistically different from 12.52 obtained from 100 kg N ha^{-1} (Table 1). This also shows that, nitrogen played important role in leaf production via its role in vegetative growth. Effect of nitrogen in increasing number of leaves of onion was reported by Kumar *et al*. (1998) and Khan *et al*. (2002) who reported that number of leaves per plant increased with increasing nitrogen levels up to 150 kg ha^{-1}.

There was significant effect of intra-row spacing on number of leaves per plant. Significantly higher number of leaves 11.18 was recorded with 20 and 25 cm intra-row spacing then 10, 15 cm

Table 2: Effect of nitrogen on the growth and yield of onion

	Nitrogen (kg N ha^{-1})			
Parameters	0	50	100	150
Plant height (cm)	41.85c	47.66b	55.67a	55.85a
Number of leaves (plant^{-1})	8.25d	10.19c	12.52a	12.63a
Crop growth rate (g m^{-2} day^{-1})	0.57d	0.71c	0.92b	1.03a
Cured bulb yield (t ha^{-1})	10.29c	25.17b	40.59a	40.81a
Individual bulb weight (g)	89.61c	151.38b	228.30a	230.32a
Bulb diameter (cm)	3.75c	7.10b	8.76a	8.74a

Within a parameter, means in a row followed by the same letter (s) are not significantly different at 5% level using DMRT

Table 3: Effect of intra-raw spacing on growth and yield of onion

	Intra-row spacing (cm)			
Parameters	10	15	20	25
Plant height (cm)	50.12b	47.37bc	52.51a	51.78a
Number of leaves (plant^{-1})	10.29c	10.78b	11.15a	11.18a
Crop growth rate (g m^{-2} day^{-1})	0.75c	0.78b	0.87a	0.84a
Cured bulb yield (t ha^{-1})	30.81b	31.71a	30.22b	26.93c
Individual bulb weight(g)	105.38c	170.44b	199.17a	202.53a
Bulb diameter(cm)	4.68c	7.14b	8.11a	8.12a

Within a parameter, means in a row followed by the same letter(s) are not significantly different at 5% level using DMRT

Table 4: Effect of interaction between nitrogen and intra-row spacing on the growth and yield of onion

N (kg ha^{-1})	Intra-row spacing (cm)	Plant height (cm)	No. of leaves (plant^{-1})	Crop growth rate (g m^{-2} day^{-1})	Cured bulb yield (t ha^{-1})	Bulb weight (g)	Bulb diameter (cm)
0	10	45.20f	7.62h	0.51e	10.56j	54.89i	2.25i
"	15	49.19d	7.76h	0.49e	14.09h	84.58h	4.69f
"	20	56.89b	8.89g	0.56de	13.34i	119.04g	6.17f
"	25	56.68ab	8.74g	0.56de	8.38k	119.94g	5.57g
50	10	41.44g	9.40g	0.56de	24.36h	135.73f	5.72g
"	15	49.46ef	10.20e	0.63cd	26.24g	145.89ef	6.96e
"	20	56.89ab	10.54d	0.72bc	26.14g	156.04de	7.77d
"	25	57.72ab	10.61d	0.72bc	25.04g	154.46de	7.97d
100	10	56.89b	11.83c	0.72bc	38.12de	163.00cd	7.89d
"	15	56.07a	12.36ab	0.78b	40.83a	168.50cd	8.53c
"	20	58.07a	12.53ab	1.01a	38.53de	215.58bc	9.56a
"	25	58.61a	12.00ab	1.04a	37.15ef	215.40bc	9.37ab
150	10	56.68ab	12.36b	1.02a	40.71b	166.74e	7.77d
"	15	57.72ab	12.00a	0.99a	40.89a	202.80b	8.37c
"	20	54.87bc	12.63ab	0.97a	39.66c	226.00a	9.20b
"	25	54.12bc	12.80a	0.01a	36.26	224.30a	9.57a
SE±	0.77	0.11	0.025	0.104	3.979	0.104	

Means in a column followed by the same letter(s) are not significantly different at 5% level using DMRT

significant effect of interaction between N and intra-row spacing with higher values obtained at 20 and 25 cm intra-row spacing at all levels of N. However, both 100 and 150 kg N ha^{-1} recorded similar leaf number with 20 and 25 cm intra-row spacing (Table 4).

Crop Growth Rate (CGR)

Crop growth rate was significantly influenced by the nitrogen application up to 150 kg ha^{-1}. It was observed that the nitrogen triggers the growth rate of onion with the highest value 1.03 g m^{-2} day^{-1} obtained from 150 kg N ha^{-1}. This was followed by 0.92 g m^{-2} day^{-1} obtained from 100 kg N ha^{-1}. Control plot recorded the lowest crop growth rate of 0.5 g m^{-2} day^{-1} (Table 2). Similarly, intra-row spacing had significant effect on CGR with highest value at 20-25 cm spacing (Table 3). Interaction between N and spacing was significant with 100 kg N ha^{-1} and 20-25 cm spacing recording higher CGR than other N levels and spacing (Table 4).

Cured Bulb Yield

Bulb yield of onion was significantly affected by the application of nitrogen (Table 2). Increase in N dose up to 100 kg ha^{-1} resulted in the increased yield of onion bulbs 40.59 t ha^{-1}. But further increase to 150 kg N ha^{-1} did not significantly increase the yield. The lowest bulb yield of 10.29 t ha^{-1} was recorded from the control plot, where no N was applied. Similar results were reported by Shaikh *et al*. (1987), Patel and Patel (1990) and Khan *et al*. (2002).

Intra-row spacing of (15 cm) produced the highest bulb yield (31.7 t ha^{-1}) followed by 30.81 t ha^{-1} recorded when 10 cm intra-row spacing was used. Widest spacing of 25 cm recorded the lowest yield 26.93 t ha^{-1} (Table 3).

Similarly, interaction of nitrogen and intra-row spacing had significant effect on the cured bulb yield of onion (Table 4). In contrast to growth parameters, significantly higher cured bulb yield was recorded with 15 cm intra-row spacing than other spacing at all levels of N including 0 (control). However, yield recorded with 100 and 150 kg N ha^{-1} and 15 cm spacing was similar and significantly higher than 0 (control) and 50 Kg N ha^{-1} (Table 4). 100 kg N ha^{-1} appeared to be the optimum for onion production with a combination of 15 cm intra-row spacing. Wider spacing reduced yield due to total reduction in the plants per hectare i.e. space is not fully utilized while close spacing of 10 cm resulted in competition for nutrients, water and light resulting in lower yield.

Bulb Diameter

Nitrogen significantly affected the bulb diameter of onion with highest 8.7 cm recorded from application of 100 kg N ha^{-1} (Table 2). The minimum value for bulb diameter 3.75 cm was recorded from the control plots where no nitrogen was applied. Kumar *et al*. (1998) and Khan *et al*. (2002) also reported that bulb diameter was significantly affected by the application of nitrogen.

The highest bulb diameter (8.12 cm) was recorded with 25 cm spacing, which was statistically at par with that recorded for 20 cm spacing (8.11 cm). The lowest bulb diameter (4.68 cm) was obtained with 10 cm spacing.

Bulb Weight

Increased nitrogen application up to 100 kg ha^{-1} resulted into an increase in the bulb weight of onion. But further increase to 150 kg ha^{-1} did not result in the weight increase (Table 2). 150 kg N ha^{-1} produced the heaviest bulbs 230.32 g which was not statistically different from the 228.30 g obtained from the application of 100 kg N ha^{-1}. Therefore 100 kg N ha^{-1} is the most optimum technical dose for onion bulb production. Control plots produced the lowest values for bulb weight 89.61 g due to the absence of the nitrogen, which is an important element needed for proper growth and development of every plant including onion. Kashi and Frodi (1998) Greenwood *et al*. (2001) and Khan *et al*. (2002) reported significant increase in the bulb weight of onion due to increased nitrogen application.

Intra-row spacing had significant effect on the bulb weight of onion with 20 and 25 cm spacing recording similar bulb weight but significantly higher than 10 and 15 cm spacing (Table 3).

There was significant effect of interaction between Intra-row spacing and N (Table 4). Significantly higher bulb weight was recorded with 20 and 25 cm intra-row spacing at 0, 50 and 150 kg N ha^{-1}. At 100 kg N ha^{-1}, all spacing recorded similar bulb weight. However, higher bulb weight was recorded with 150 kg N ha^{-1} with 20 and 25 cm intra-row spacing than any other treatment combinations.

CONCLUSIONS

From this study, it can therefore be concluded that higher total tuber yield (irrespective of the bulb size) could be obtained by applying 100 kg N ha^{-1} in plants spaced at 15 cm intra-row spacing and 20 cm inter-row spacing. However, for large bulb size, application of 150 kg N ha^{-1} in plants spaced at 25 cm (25 cm spacing may be preferred over 20 cm for convenience in planting and other cultural operations) intra-row spacing and 20 cm inter-row spacing may recommended.

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