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Effect of plant population density and varietal differences on yield and yield components of onion (*Allium cepa* L.) in North Eastern Nigeria

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Abstract

Onion is grown extensively during dry season in the North eastern Nigeria for bulb as well as leaves production. The local producers were known to use random density planting in the field. This study is aimed to determine the optimum plant density for different local cultivars (Ex-Borno, Kano Red, Local Red and White). Trials were carried out at Bululu irrigation site of Bade District in Yobe State, Nigeria during 2010/2011 and 2011/2012 season. The results indicated that the cultivars respond well with the 30 plants/m^2 while the Ex-Borno cultivar proved to be prominent among the cultivars studied with an average of 6.406t/ha.

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Introduction

Onion (*Allium cepa* L.) belongs to the family *Amaryllidaceae* (*Alliaceae*). It is an herbaceous biennial vegetable crop, (often grown as annual for bulb production) with cross-pollinated and monocotyledonous behaviour having diploid chromosomes number 2n=16 (Bassett, 1986). The bulb varies in size (small, medium and large), colour (yellow, white and red), and shape (flattened, round and globular) (Dawar, Wazir, Dawar and Dawar, 2007).

In Nigeria, Onion is grown extensively as dry season vegetable under irrigation. The average yield of onion in Nigeria is estimated to be over 1.2 Million metric tons and ranked 14th in the world. Although Onion is mainly used as seasoning vegetable, the bulbs make an important contribution to human diet, having vitamins, flavonoids, macro and micro elements (Jurgiel-Malecka and Suchorska-Orlowska, 2008).

Variations in plant density resulting from spacing produce diverse results from different experiments over time, for example, Vishnu and Parabhaka, (1989), obtained higher yield with close spacing (10 x 15 cm) while Bhaitia and Pandy (1991) harvested better yield with wider 45 x 15 cm plant spacing. Increase number of rows/bed i.e. decreasing row spacing, linearly increase Onion yield (Stoffela, 1996). Dawar, *et al*. (2007), reported that, interaction between planting densities and varietal difference was significant only for bulb yield, and that planting density greatly influenced the quality, texture, taste and yield of onion even within a particular variety. Same cultivars grown with different densities in the same environment often respond differently.

Onion production is still low in north-eastern Nigeria compared to the Northwest despite the suitable soil and environmental condition. This could be attributed to the lack of proper adaptable planting density and cultivation of unsuitable cultivar. Therefore, it can be observed that the use of random plant spacing by the local farmers may be one of the main contributing factors to low yield in the area, consequence of which will be low income and either under-utilization or exploitation of the already competitive farming land. Although the area was known for vegetable crop production, no literature on onion related work in the area was found during the search for this work. However, the study is necessitated by the zeal to improve onion production and better the lots of the farmers in the locality.

This study is aimed to obtain the optimum plant population required to produce maximum yield under the agro-ecological conditions of Bade District of Yobe, in North eastern Nigeria.

Materials and methods

Study area and experimental design

Field trials was carried out during the 2010/2011 and 2011/2012 season at the Bululu irrigation site in Bade district of Yobe state, Nigeria. The experiment was conducted in a split plot design and replicated three times to minimise error. The cultivars were allocated the main plot and plant density as sub-plots. Four onion cultivars (Kano red, Ex-Borno, Local Red, and white) were tried with planting densities of 20, 30, 40 and 50 plants/m^2. Plot size was kept at 2m x 2m for each treatment while plant density varies as stated earlier on a flat bed. Agronomic practices were carried out uniformly for all treatments. The crops were finally harvested when 80% of the top had fallen over and dried, indicating full maturity.

Data recording

Ten plants were randomly selected from each plot in such a way that the border effect was avoided for the highest precision and data were recorded on number of leaves plants^{-1}, length of leaves (cm), bulb weight (g), and bulb yield (t ha^{-1}).

Statistical analysis

Data were subjected to statistical analysis according to Snedecor and Cochran (1980) while means were separated using least significant difference (LSD) and Steel and Torrie, (1984) for comparison of mean values and declared significant level at $p<0.05$.

Results and discussion

Number of leaves per plant

The number of leaves per plant did not exhibit any significant differences within the cultivars studied but rather, it is significant in the different cultivars for both the 2010/2011 and 2011/2012 season as presented in table 1. The highest number of leaves per plant during the 2010/2011 season was obtained in the Ex-Borno cultivar (14.94). The second is Kano Red (12.69) then Local Red (11.77) and White cultivar having the least number of leaves per plant (9.64). The same trend was observed in the 2011/2012 season in which the cultivars Ex-Borno, Kano Red, Local Red and White had 14.94, 11.97, 10.64 and 9.64 number of leaves per plant respectively.

Table 1. Effect of plant population densities and cultivar variation on number of leaves per plant.

Trt(Plt/m²)	K.R	L.R	Ex-B	W	(X)
			2010/2011		
20	12.40	11.70	15.12	9.87	12.35^{ns}
30	12.31	10.40	15.11	9.66	11.97^{ns}
40	11.66	10.36	14.63	9.51	11.64^{ns}
50	11.51	10.11	14.81	9.53	11.59^{ns}
(Y)	11.97^{b}	10.64^{c}	14.94^{a}	9.64^{d}	
			2011/2012		
20	13.01	12.07	16.11	10.11	12.83^{ns}
30	12.77	11.63	16.01	9.63	12.51^{ns}
40	12.50	11.91	15.81	9.52	12.94^{ns}
50	12.47	11.47	15.91	9.50	12.84^{ns}
(Y)	12.69^{b}	11.77^{c}	15.96^{a}	9.69^{d}	

Key: Trt.=Treatment, K.R.=Kano Red, L.R. = Local Red, Ex-B = Ex-Borno, W=White, (x) = Mean for treatments, (Y) = Mean for cultivar, plt/m2=plants per meter square, ns= not significant at $p<0.05$, mean with the same letter are not significantly Different at $p<0.05$.

Table 2. Effect of plant population densities and cultivar variation on leaf length.

Trt(Plt/m²)	K.R	L.R	Ex-B	W	(X)
			2010/2011		
20	45.00	38.11	55.60	30.63	42.34^{a}
30	43.10	37.50	53.60	28.11	40.34^{b}
40	40.71	36.11	50.10	28.10	38.36^{c}
50	40.00	33.32	45.40	26.66	36.35^{d}
(Y)	42.20^{b}	36.26^{c}	51.18^{a}	28.38^{d}	
			2011/2012		
20	45.61	39.60	56.10	30.13	42.86^{a}
30	44.41	38.11	53.70	29.01	41.31^{b}
40	41.11	36.31	51.11	29.19	39.43^{c}
50	40.00	33.41	47.61	25.00	36.51^{d}
(Y)	42.88^{b}	36.86^{c}	52.13^{a}	28.33^{d}	

Key: Trt.=Treatment, K.R.= Kano Red, L.R.= Local Red, Ex-B = Ex-Borno, W=White, (X) = mean for treatments, (Y) = mean For cultivar, ns= not significant at $p<0.05$, plt/m2= plants per meter square. (g)=grams, mean with the same letter are not significantly different at $p<0.05$.

The effect of plant population density on number of leaves did not show any significant difference within the same cultivar in both seasons of trails. The plant density of 20 plants gave the utmost mean number of leaves (12.35) in 2010/2011 and (12.83) in the 2011/2012 season. This can be attributed to less competition for water and nutrients compared to the other higher plant densities, while the differences in number of leaves per individual plant may be due to genetic variability that exist both within and between the cultivar studied. This is similar to the findings of Rizk (1997) that reported highest number of leaves per plant with increase in plant spacing (lower density).

Table 3. Effect of plant population densities and cultivar variation on bulb weight (g).

Trt(Plt/m²)	K.R	L.R	Ex-B	W	(X)
			2010/2011		
20	180.10	100.71	310.10	85.71	169.16[a]
30	160.00	97.30	285.80	71.09	151.05[b]
40	150.00	95.41	250.10	70.11	143.91[c]
50	144.10	93.31	222.10	63.20	130.68[d]
(Y)	158.51[b]	96.68[c]	267.03[a]	72.53[d]	
			2011/2012		
20	189.20	108.10	323.10	88.71	177.28[a]
30	170.10	98.60	280.10	76.21	156.25[b]
40	158.30	97.10	261.00	73.33	147.43[c]
50	147.40	94.30	220.10	64.20	130.68[d]
(Y)	166.25[b]	99.53[c]	271.08[a]	75.61[d]	

Key: Trt.=Treatment, K.R. = Kano Red, L.R.= Local Red, Ex-B = Ex-Borno, W= White, (X)= mean for treatments, (Y) = mean for cultivar, ns= not significant at $p<0.05$, plt/m2= plants per meter square. (g)= grams, means with the same letter are not significantly different at $p<0.05$.

Length of Leaf

The result presented in table 2 showed that leaf length pied significantly both in terms of cultivar variation and population densities for the two seasons (2010/2011 and 2011/2012). The Ex-Borno cultivar showed advantage in terms of leaf length by having the longest leaf length (51.18) followed by Kano Red (42.20), Local Red (36.26) and White (26.66) in the 2010/2011 season while the values of for 2011/2012 season (52.13, 42.88, 36.86 and 28.33 were obtained for Ex-Borno, Kano Red, Local Red and White cultivars respectively.

The Ex-Borno gave the highest leaf length of 56.10 in 2011/2012 season with plant density of 20 plants, while the shortest leaf length was obtained in the white cultivar 25.00 at plant density of 50/m² during 2011/2012 season. It was generally observed that plant population density and cultivar differences significantly affect leaf length (Table 2). The lower density recorded maximum leaf length while higher density gave shorter leaf length. This effect cut across all densities and cultivars in this study.

Bulb weight

Plant population density and cultivar variation significantly affect mean bulb weight. A decrease in bulb weight was observed with increase plant density except for plant density of 40 and 50 plant/m² in which no significant difference was observed. Also, there is a great difference in bulb weight between the cultivars studied. This result is presented in Table 3.

Table 4. Effect of plant population densities and cultivar variation on bulb yield (t/ha).

Trt(Plt/m²)	K.R	L.R	Ex-B	W	(X)
			2010/2011		
20	5.250	3.259	6.369	2.217	4.274[b]
30	5.662	4.003	7.128	3.106	4.975[a]
40	5.271	3.162	6.123	2.279	4.208[c]
50	4.511	3.001	5.556	1.791	3.715[d]
(Y)	5.174[b]	3.356[c]	6.294[a]	2.348[d]	
			2011/2012		
20	5.241	3.305	6.411	2.236	4.298[b]
30	5.770	4.107	7.311	3.207	5.099[a]
40	5.263	3.184	6.236	2.318	4.250[c]
50	4.454	3.106	5.665	1.689	3.729[d]
(Y)	5.182[b]	3.426[c]	6.406[a]	2.363[d]	

Key: Trt.=Treatment, K.R.= Kano Red, L.R.= Local Red, Ex-B = Ex-Borno, W=White, (X) = mean for treatments, (Y) = mean for cultivar, ns= not significant at $p<0.05$, plt/m2 = plants per meter square. (t/ha)= ton per hectare, Means with the same letter are not significantly different at $p<0.05$.

The mean bulb weight in Ex-Borno cultivar was highest (276.03) while the white cultivar was least with 63.20. The Kano Red had 144.10 and Local Red 96.68 in the 2010/2011 season. Slight change with increase in weight was recorded in the 2011/2012 season in which the mean bulb weights were 267.08, 166.25, 99.53 and 75.61 for Ex-Borno, Kano Red, Local Red, and White cultivars respectively.

The plant population density of 20 plants/m² in the Ex-Borno cultivar gave the highest weight among all cultivars, the highest density of 50 plants /m² gave the least bulb weight. Moderate densities of 30 gave medium weight bulbs. A similar result was reported by (kanton, *et al.* 2003).

Bulb yield

The result for bulb yield is presented in table 4 below. The Mean bulb yield, range from 2.348 to 6.294 t/ha in 2010/2011 and 2.363 to 6.406 t/ha in the 2011/2012 season. The Ex-Borno cultivar gave the highest mean bulb yield of 6.294 followed by Kano Red (5.174), Local Red (3.356) and white (2.348) in the 2010/2011 season while the yield for 2011/2012was 6.406, 5.182, 3.426 and 2.33 for Ex-Borno, Kano Red, Local Red and White respectively.

The population of 30 plants/m² in Ex-Borno cultivar gave the highest yield of 7.128 in the 2010/2011 season and 7.311 in 2011/2012 season. Also the maximum yield for all the cultivars was observed at the 30 plants/m² densities while the 50 plants/m² densities gave the lowest bulb yield (1.689) in the white cultivar. This could be attributed to the fact that, although the bulbs are more in number, the sizes are very small. All the cultivars in the trial gave different yield which varies considerably. Result of the study indicates that mean bulb yield is affected by cultivar as well as density. Statistically, all plant densities gave diverse results from one other in all seasons studied with no significant combine effect. Similar result was reported by ijoyah *et al.* (2008) in which significant variation in bulb yield of onion from different local cultivars was observed in field trial in Anse Boileu, Seychelles.

Conclusion

The lower plant density of 20 plants/m² was found to increase bulb weight (larger bulbs). Increase plant density up to 50 plants/m² has negative effect on bulb weight and total bulb yield due to smaller bulbs produced but increases the total number of bulbs per unit area. The medium plant density of 30 plants/m² gives lower bulb weight compared to 20 plants/m²

but improve overall bulb yield, thereby making it better choice to the onion producer in the locality that are interested in increase yield in addition to choice of medium bulbs by consumers. High plant population density of 50 plants/m² gave poor performance in all the traits studied from all the cultivars in both growing season with smaller bulbs that are not suitable to consumers.

Based on the results of this study, further studies with these cultivars could look into possible ways of improving the cultivar of choice giving the 20 plants/m² for bulb weight or 30 plants/m² for bulb yield. This implies that mean bulb yield can be increased with decreasing population density from 50 to 30. The low yield of onion experienced in the study area can be improved by using the appropriate plant population density and the right cultivar for the locality thereby alleviating the teething problem of low productivity by farmers and helping in better income and standard of living.

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