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YIELD AND MARGINAL BENEFIT OF ONION (*Allium cepa* L.) PRODUCTION UNDER DIFFERENT RATES OF NITROGEN AND FARM YARD MANURE IN MAIDUGURI SUDAN SAVANNA, NIGERIA

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Abstract

Experiment was conducted during the dry season of 2015 and 2016 at the Teaching and Research Farm of the University of Maiduguri Sudan Savanna Nigeria, to determine the response of onion (*Allium cepa* L.) to different rates of farmyard manure and nitrogen. Treatments consisted of three levels of farmyard manure (0 t/ha, 15 t/ha and 30 t/ha) and four levels of nitrogen (0 kgN/ha, 50 kgN/ha, 100 kgN/ha and 150 kgN/ha) which were laid out in a Randomised Complete Block Design (RCBD) and replicated three times. The parameters studied include; establishment count, yield t/ha, fresh bulb weight (g), cured bulb weight (g) and bulb diameter (cm). Data were analysed using Analysis of Variance and means were separated using DMRT at 5% level of probability. The findings of results in 2015, 2016 and the combined analysis indicates that, there was significant ($P<0.05$) effect of farmyard manure and nitrogen fertilizer in all the parameters studied throughout the stages of the investigations. Application of farmyard manure at 30 t/ha and nitrogen at 150 kg/ha recorded the highest values, which were followed by 15 t/ha farmyard manure and 100 kg/ha nitrogen in all the parameters investigated. The results further showed that application of different rates of farmyard manure and nitrogen fertilizer had significantly affected marginal benefit of the onion production. The

KEYWORDS: Dry season, Onion, Irrigation, Nitrogen, Farm yard manure

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application of farmyard manure and nitrogen at 30 t/ha and 150 kgN/ha respectively gave the highest marginal benefit. Based on the results of the study conducted, a recommendation of 30 t/ha farmyard manure and 150 kg N/ha is optimum for Onion production in Maiduguri, Borno State.

Introduction

Onion (*Allium cepa* L.) belongs to family of *Alliaceae* and is believed to have originated in South West Asia or the Mediterranean (Best, 2000). Onion is ranked second to tomatoes as the most important horticultural crop (Brice *et al.,* 1997). It is grown on a wide range of climatic conditions, but thrives best in a mild climate without excessive rainfall or extremes of temperature (Boukary *et al.,* 2012). Onion requires soils with mild acid to neutral reaction (pH 6-7) and high soil moisture content for good yield (Gambo *et al.,* 2008). Globally, it is estimated that, over 3.6 hectares are devoted to onion production with an annual production yield of about 82,851,732 metric tons, Food and Agriculture Organization Statistics (2012). China ranked first in onion production with production output of 22,600,000 metric tons followed by India (16,308, 990) and United States (3,277,460) respectively. In Africa, Niger is the largest onion producer with an annual output of 1,350,000 metric tons followed by Nigeria with 1,183,268 (FAOSTAT, 2012).

Onion is widely used for cooking in nearly all regions of the world and has been used in diverse cultures and rituals throughout history (Wikipedia, 2011). Onions are very versatile and can be baked, boiled, braised, grilled, fried, roasted, sautéed or eaten raw in salads (Conant, 2006). Onions have been used as medicine for purposes ranging from treating wounds and stomach ailments to treating infertility. It also contains a phytochemical called quercetin, which is effective in reducing the risk of cardiovascular disease, an anticancer, and has a promising effect of antioxidant (Smith, 2003).

Average yield of onion obtained by farmers in Nigeria is 14.79 t/ha, which is considered low compared to what is obtained in other countries for example 45 tons/ha in Niger, 39 tons/ha in Egypt and 30 tons /ha in Senegal (Gambo, 2007). This low yield could be attributed to steady depletion of natural soil fertility and also occurrence of multiple nutrient deficiencies in onion field has led to the identification of nutrient management as a key factor limiting sustainable onion production (Sharma *et al*., 2003). Similarly, Harris (2006) and Been *et al.* (2011) reported that constraints to production of onion have been mainly attributed to poor soil fertility as well as use of in-appropriate dose of organic manure which is the main factor affecting crop production in the tropical region, hence, results in low yield.

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Nitrogen is undoubtedly the most limiting nutrient in Tropical soil, particularly in the Savannah where soils are predominantly coarse textured and characteristically low in organic manure, Federal Ministry of Agriculture and Natural Resources (FMANR, 1989). A deficiency of nitrogen normally leads to retardation of plant growth, yellowing of the leaves, and consequent reduction in yield (Onwueme and Sinha, 1991). Thus, sustainable production of onions on the same piece of land would require the application of fertilizers from both organic and inorganic sources. **C**omplimentary use of organic and inorganic fertilizers is widely known to be a reliable and sustainable soil fertility management strategy (Alasiri, 2002).

In view of the foregoing, the present research is therefore aimed at evaluating response of onion under complementary use of different rates of farm yard manure and nitrogen. The objective of the study was to determine the marginal benefit of onion production under different rates of nitrogen and farm yard manure in Maiduguri Sudan Savanna.

MATERIALS AND METHODS

Experimental Site

The experiments were conducted during the 2015 and 2016 dry seasons under irrigation at the University of Maiduguri Teaching and Research Farm. Maiduguri is located in Maiduguri Borno State, Nigeria at Latitude 11. 85' N and Longitude 13. 16' E and at about 325 meters above sea level. The climate of Maiduguri is favourable for vegetable production, with a mean annual rainfall and temperature of about 650 mm and 32°C respectively. April is the hottest month of the year with temperatures ranging between 35°C and 42°C. Relative humidity ranges from 20-35% in the dry season and 43-78% in the raining season. The area has cool dry period during harmattan, from November to February and hot dry spell from March to May, followed by short rainy season May/June-September/October. Nigerian Meteorological Agency NiMET (2015).

Soil Analysis

Soils of the experimental sites were sampled randomly by auger borings in four places at a depth of 0-15 cm. The samples were mixed to form composite soil sample, air dried and sieved through 2mm mesh for physico-chemical analysis. The particles size were analysed using Hydrometer Method as described by (Gree and Bauder, 1986). The textural class of the soil was obtained using Marshall's textural triangle (Palmer and Troeh, 1977). The soil pH was determined using glass electrode pH meter as described by Mclean, (1982). The regular Macro-Kjeldahl Method was used to determine the total Nitrogen (N) in the soil sample. The organic carbon content of the

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soil was determined using Dichromate Wet Oxidation Method of Walkey-Black. Available phosphorus in the soil sample was determined using Bicarbonate Method as described by Landon (1991). The soil exchangeable cations were extracted with 1N ammonium acetate solution. The concentration of Na^{+} and K^{+} was determined using flame photometer. Concentration of C^{++} and Mg^{++} was determined by Titration with 0.02 N EDTA solutions as described by Page *et al.* (1982). The exchange acidity: hydrogen (H) and aluminium (Al) was determined using the Titration Method as described by Blake (1986). (See table 1).

Cow Dung Analysis

The samples were oven dried at 60°C for 24 h and milled. Nitrogen was determined using Macro-Kjeldahl method as described by Bremner (1982). Samples were dry ashed using nitric-perchloric-sulphuric acid mixture for determination of P, K, Ca and Mg. Phosphorus was determined using vanado molybdate colorimetry, K by flame photometer and Ca and Mg by EDTA titration. (See table 2).

Experimental Materials

Source of seed

Bama red variety of onion was obtained from Borno State Agricultural Development Programme (BOSADP). The variety has a large bulb, red in colour and highly pungent; it is known to be the best variety of onion in Borno State. It is highly preferred in the market because of its pungency and yields about 25tons/ha when grown in cool season (BOSADP, 1993).

Sources of fertilizer

Farmyard manure

Cow dung was obtained from the University of Maiduguri Livestock Farm. The organic manure collected was analysed to ascertain it nutrient compositions (See table 2).

Nitrogen fertilizer

Nitrogen fertilizer in the form of Urea (46%) was purchased from the Borno State Fertilizer Company.

Source of irrigation water

The source of water for the experiment was from the university farm Bore-Hole located within the University of Maiduguri Teaching and Research Farm. Gasoline power operated water pump was used.

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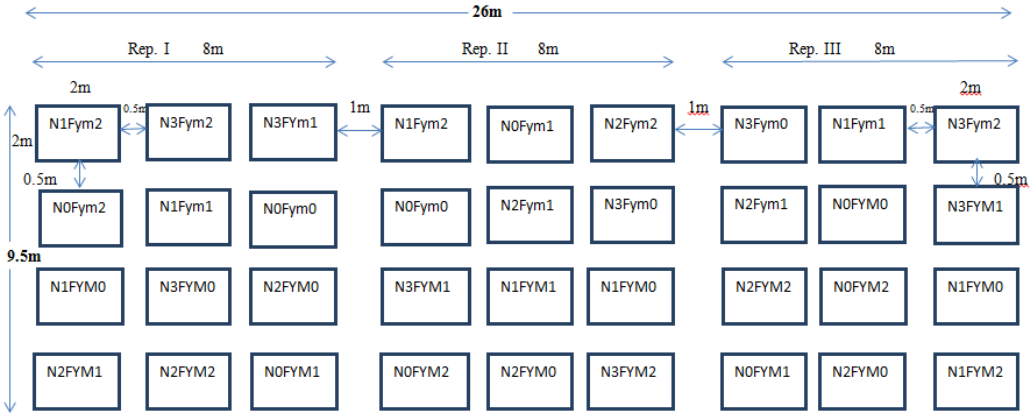
Treatments and Experimental Design

Treatments consisted of three different rates of farm yard manure (0, 15, and 30 t/ha) and four different rates of nitrogen fertilizer (0, 50, 100, and 150 kg/ha) which was laid out in a Randomized Complete Block Design (RCBD), with three replicates.



KEY:

Nitrogen fertilizer		Farmyard manure	
No	0 kg/ha	FYM0	0 kg/ha
No	50 kg/ha	FYM1	15 kg/ha
No	100 kg/ha	FYM2	30 kg/ha
No	150 kg/ha		

Fig. 1 Experimental Lay Out

Cultural Practices

Nursery preparation

The nursery site was cleared and measured to a convenient length. The site was then harrowed to a depth of about 0.3m so that stones and roots lying underneath are dug out and removed. A well-tilled seedbed of 1 x 2m was constructed. Seeds were broadcast uniformly on the bed and covered lightly with soil and were mulched with dry grasses and watered daily for the first one week and later three times in a week. After germination the seedlings were allowed to remain in the nursery beds for about 8 weeks. The seedlings were transplanted to the field after they attained about 10 - 15cm height and possess 3-4 leaves.

Land preparation and field layout

The experimental site was harrowed, leveled and worked to fine tilth. The site was then prepared into three replicates. Each replication consist of 12 plots measuring 2 x 2m ($4m^2$) with spacing of 1m alley and 0.5m paths separating individual plots. Materials used include; measuring tape, rake, hoe, digger, shovel and rope.

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Application of farmyard manure and nitrogen fertilizer

Farmyard manure was applied at the rate of (0, 15 and 30t/ha) and incorporated at land preparation. Nitrogen in the form of Urea (46%) was applied in a split form at the rate of 50, 100 and 150 kg/ha at 3 and 6 weeks after transplanting respectively.

Pre-transplanting irrigation and transplanting

The field was watered fully a day to transplanting to enhance good establishment. Irrigation was applied daily for the period of one week; thereafter the schedule was altered to 3 days per week. The seedlings were transplanted at a spacing of 15 cm x 25 cm on each bed.

Weeding

Weeding was carried out manually as at when due, in order to reduce crop weed competition and to maintain weed free environment, using special hand hoe.

Harvesting

Harvesting was done manually by hand pulling with hoes to lift the bulbs. It was done when onion leaves reached physiological maturity "Fall-Over" as shown by change of colour of the leaves from green to yellow and 50% of the leaves defoliated.

Data Collection

The data collected for the study include the following;

Establishment count

This was obtained by counting the stands from each plot when fully established and the mean was recorded.

Bulb diameter (cm)

Bulb diameter was obtained at harvest from the 5 tagged plants, using Venier caliper and the mean was recorded.

Fresh bulb weight per plant (g)

This was determined by weighing bulbs of 5 tagged plants within the net plots by the use of sensitive weighing balance and the mean was recorded thereof.

Cured bulb weight per plant (g)

This was determined by weighing cured bulbs of 5 tagged plants within the net plots by the use of sensitive weighing balance and the mean was recorded.

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Bulb yield (t/ha)

Bulb yield was obtained at harvest from the net plot by using weighing scale (kg) and later converted to tonnes per hectare and the mean was recorded.

Marginal Benefit

Marginal benefit was estimated by using the following formula:

Marginal benefit (MB) = TR – TVC
Where;
TR = Total Revenue (benefit)
TVC = Total Variable Cost
Marginal benefit = Benefit /Cost

Data Analysis

Data were subjected to Analysis of Variance (ANOVA) using Statistical Analysis System package (SAS 2003). Treatment means were compared using Least Significant Difference (LSD) and Duncan's Multiple Range Test (DMRT) at 5 % level of significance.

RESULTS

Table 1: Physico-chemical Properties of the Soil at the Experimental site during 2015 and 2016 dry seasons

Parameter	2015	2016
Physical Properties		
Sand (%)	56.90	84.80
Silt (%)	25.00	9.10
Clay (%)	18.10	6.10
Textural sand	Sandy loam	Loamy
Chemical Properties		
pH 1:2.5(Water)	3.25	7.35
Organic Carbon (%)	1.42	0.23
Total N (%)	0.35	0.10
Available P (mg/kg soil)	9.45	10.30
Cation exchange capacity (CEC) (Cmol/kg soil)		
Exchange bases (Cmol/kg soil)	0.30	11.13
Ca^{2+}	4.80	13.20
Mg^{2+}	6.60	8.40

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K^+	0.50	0.18
Na^+	2.48	0.05

Table 2: Nutrient composition of Cow dung used at the Experimental site during 2015 and 2016 dry seasons

Nutrient composition	
N	2.45 (%)
P	0.19 (%)
K	1.70 (%)
Ca^{2+}	2.61 (%)
Mg^{2+}	2.20 (%)
Critical level	
% N<2.0 – Deficient	
2.0 – 2.3 – Low	
2.3 – 2.8 – Normal	
2.8 – 3.2 – High	
>3.2 – Toxic	
% P<0.07 – Deficient	
0.07 – 0.13 – Low	
0.13 – 0.18 – Normal	
0.18 – 0.30 – High	
>0.30 – Toxic	
% K<0.3 – Deficient	
0.3 – 0.6 – Low	
0.6 – 1.5 – Normal	
1.5 – 2.0 – High	
>2.0 – Toxic	

Establishment Count

Table 3 shows the effect of nitrogen and farmyard manure on establishment count of onion during 2015 and 2016 dry season and the combined years. The result of the experiment revealed that establishment count statistically was not significantly ($P<0.05$) different in both season and the combined years. The application of nitrogen at varying levels did not significantly ($P<0.05$) affects the establishment count in both years and in the combined analysis.

Farmyard manure was found to influence the establishment count of onion significantly ($P<0.05$) in the year 2016, though was not significant in the combined analysis. The application of farmyard manure at 30t/ha was found to produce the

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highest establishment count, which was significantly higher than the establishment count when nitrogen was applied in both season and in the combined analysis.
The interaction between nitrogen and farmyard manure on establishment count was not significantly different in both years and in the combined analysis.

Table 3: Effect of nitrogen and farmyard manure on the establishment count of onion (EC) during 2015 and 2016 dry season and the combined years in Maiduguri

	Establishment count		
Treatments	2015	2016	Combined
Nitrogen (kg/ha) (N)			
0	90.21	90.91	90.56
50	93.10	94.84	93.97
100	91.77	93.75	92.76
150	93.87	93.66	93.77
SE±	1.651	1.140	1.033
LSD	4.844	3.345	2.941
Farmyard manure (t/ha) (F)			
0	89.96	91.31	90.64
15	92.93	93.61	93.27
30	93.82	94.95	94.38
SE±	1.430	0.987	0.894
LSD	4.195	2.897	2.079
Interaction			
N X F	NS	NS	NS

NS = Not-Significant at 5% level

Fresh Bulb Weight (g)

Table 4 shows the effect of nitrogen and farmyard manure on fresh bulb weight of Onion during the dry season of 2015, 2016 and the combined years.
The results revealed that, application of nitrogen at varying levels had significant ($P<0.05$) influence on fresh bulb weight in both years and the combined. The highest fresh bulb weight were obtained from the application of 150 kg/ha nitrogen. The values produced at varying levels are statistically different in both seasons and the combined years.
Application of varying levels of farmyard manure had significant ($P<0.05$) effect on fresh bulb weight of onion in both years 2015, 2016 and the combined. Highest fresh bulb weight were obtained with the application of 30 t/ha of farmyard manure. Control recorded the least bulb weight in the both seasons and the combined years.

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Table 4: Effect of nitrogen and farmyard manure on fresh bulb weight (g) of onion during 2015 and 2016 dry season and the combined years in Maiduguri

	Fresh bulb weight (g)		
Treatments	2015	2016	Combined
Nitrogen (kg/ha) (N)			
0	45.86	39.71	42.78
50	68.52	61.08	64.80
100	94.21	91.44	92.83
150	113.00	108.76	110.88
SE±	0.433	0.807	0.458
LSD	0.270	2.368	1.306
Farmyard manure (t/ha) (F)			
0	72.72	67.60	70.16
15	80.25	75.22	87.74
30	88.22	82.92	85.57
SE±	0.375	0.699	0.397
LSD	1.100	2.050	1.131
Interaction			
N X F	*	*	*

*= Significant at 5% level

Cured Bulb Weight (g)

The result in table 5 shows the effect of nitrogen and farmyard manure on cured bulb weight of onion during 2015, 2016 seasons and the combined years.

Application of nitrogen significantly (P<0.05) affect cured bulb weight. Increase in nitrogen fertilizer resulted into a significant difference in cured bulb in both seasons and the combined years.

Application of farmyard manure had also significant (P<0.05) effect on cured bulb weight during 2015, 2016 dry seasons and the combine years. Generally, increase in farmyard manure resulted into significant increase in cured bulb in both seasons 2015, 2016 and the combined years. Application of 30 t/ha recorded the highest cured bulb weight while the least was observed on control (0 t/ha).

3.8 Table 5: Effect of nitrogen and farmyard manure on cured bulb weight (g) of onion during 2015 and 2016 dry season and the combined years in Maiduguri

	Cured bulb weight (g)		
Treatments	2015	2016	Combined
Nitrogen (kg/ha) (N)			
0	40.60	34.26	37.43
50	62.81	54.99	58.90
100	90.60	85.18	87.89
150	106.88	102.06	104.47

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SE±	1.185	0.883	0.644
LSD	3.475	2.591	1.834
Farmyard manure (t/ha) (F)			
0	67.34	61.84	64.59
15	73.84	69.17	71.52
30	84.46	76.34	80.40
SE±	1.026	0.765	0.558
LSD	3.010	2.244	1.589
Interaction			
N X F	*	*	*

*= Significant at 5% level

Bulb Yield (t/ha)

Table 6 shows the effects of nitrogen and farmyard manure on bulb yield of onion during the dry season of 2015, 2016 and the combined. The results revealed that application of nitrogen at varying levels was found to affect the bulb yield (t/ha) significantly (P<0.05) in both season and the combined years.

The application of nitrogen at 150 kg/ha produced the highest bulb yield and the least bulb yield was recorded on control (0 kg/ha) for both years and the combined years.

Farmyard manure was also found to influence the bulb yield of onion significantly (P<0.05) in both season and the combined. The applications of farmyard manure at 30 t/ha found to produce the highest bulb yield. However, the application of farmyard manure at 0 t/ha (control) produced the least bulb yield which was significantly higher than yield produced when nitrogen fertilizer was applied at 0 kg/ha and 50 kg/ha in both season and in the combined analysis.

Table 6: Effect of farmyard nitrogen and farmyard manure on bulb yield (t/ha) of onion during 2015 and 2016 dry season and the combined years in Maiduguri

	Bulb yield (t/ha)		
Treatments	2015	2016	Combined
Nitrogen (kg/ha) (N)			
0	5.84	5.13	5.48
50	10.54	9.42	9.98
100	19.92	16.89	15.91
150	19.32	18.29	18.81
SE±	0.225	0.234	0.160
LSD	0.659	0.685	0.456
Farmyard manure (t/ha) (F)			

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0	11.87	10.32	11.09
15	13.20	12.12	12.66
30	14.40	13.37	13.88
SE±	1.195	0.202	0.139
LSD	0.571	0.593	1.395
Interaction			
N X F	NS	NS	*

NS = Not-Significant at 5% level, *= Significant at 5% level

Marginal Benefit

The result of the marginal benefit of using different rates of nitrogen and farmyard manure during the 2015, 2016 growing period and combined mean is presented in table 7 and 8. The marginal benefit realized from the application of different rates of nitrogen during the both growing season and combined had increased with increase in nitrogen rates. The highest values were recorded with the application of 150 kg/ha N in both season and combined. Similarly, highest marginal benefit was recorded from the application of farmyard manure at 30 t/ha followed by application of 15 t/ha of farmyard manure and the lowest were observed with the control.

3.12 Table 7: Marginal benefit of growing onion under different rates of nitrogen (at farm gate price) during 2015 and 2016 dry season in Maiduguri

Nitrogen (kg/ha)	2015 (₦)	2016 (₦)	Mean (₦)
0	321,400.00	302,503.00	311,951.50
50	606,920.00	518,210.00	562,565.00
100	930,710.00	818,895.00	874,802.50
150	1,062,720.00	1,005,895.00	1,034,307.50

Table 7 above shows the marginal benefit of growing onion under different rates of nitrogen in both seasons and combined mean. The result revealed that application of farmyard manure at 30 t/ha gave the highest marginal benefit values in both season and combined mean. While the lowest was recorded with control.

Table 8: Marginal benefit of growing onion under different rates of farmyard manure (at farm gate price) during 2015 and 2016 dry season in Maiduguri

Farmyard manure (t/ha)	2015 (₦)	2016 (₦)	Mean (₦)
0	353,125.00	367,435.00	360,280.00
15	726,000.00	666,435.00	696,217.50

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30	792,000.00	735,185.00	763,592.50

The above table shows the marginal benefit of growing onion under different rates of farmyard manure during the dry season 2015, 2016 and combined mean. The result revealed that application of farmyard manure at 30 t/ha gave the highest marginal benefit values in both season and combined mean and the lowest was recorded with control.

Conclusion

From the findings, it was concluded that nitrogen and farmyard manure had significantly affected yield of onion in Maiduguri Sudan Savanna during 2015, 2016 dry seasons and the combined years. Therefore, application of nitrogen at 150 kg/ha and farmyard manure at 30 t/ha produced the highest effects on all parameters studied. Similarly, the application of nitrogen at 150 kg/ha and farmyard manure at 30 t/ha produced the highest marginal benefit indicating the profitability of growing onion under the different rates of nitrogen and farmyard manure in the Sudan Savanna.

Recommendations

From the findings of the study, the following recommendations could be made.

- **i.** Based on the results obtained from this study, it is recommended that for optimum onion production in Maiduguri Sudan Savannah, a combination of 150 kg/ha nitrogen and farmyard manure at 30 t/ha be used.
- **ii.** Further study should be carried out to determine the response of onion to different rates of nitrogen and farmyard manure in study area.

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