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*Research Article*

# Response of Onion (*Allium cepa* L.) to spacing and inorganic fertilizer in Edo rainforest of Nigeria

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**ABSTRACT: Two field experiments were carried out during the 2010/2011 and 2011/2012 dry cropping seasons of October–March to investigate the effects of 0, 40, 80 and 120 kg/ha NPK 15:15:15 and crop spacings on the growth and yield of onion plant (*Allium cepa* L.). The experiment was a factorial combination of three spacings 15 x 20 cm, 20 cm x 20 cm and 25 cm x 25 cm; and four levels of NPK 15:15:15 inorganic fertilizer at 0, 40, 80 and 120 kg/ha NPK laid out as a randomized complete block design (RCBD) with three replications. Each replicate had 12 plots for a total of 36 plots. Data was collected on growth and yield characters and analysed. Results of this study indicated that the spacings of 25 cm x 25 cm and 20 cm x 20 cm were statistically similar and enhanced the growth and yield of onion in terms of leaf length, individual bulb and shoot weight of onion better than 15 cm x 20 cm. However, bulb and shoot yield were significantly higher with closer spacing of 15 cm x 20 cm and 20 cm x 20 cm. Application of 80 kg/ha of NPK 15:15:15 fertilizer significantly increased the leaf length, bulb, and shoot yield above the other treatments. Therefore, for optimum yield of onion production in Edo ecology and convenience in planting application of 80 kg/ha of NPK 15:15:15 with 20 cm x 20 cm spacing is recommended.**

**KEYWORDS: onion, fertilizers, chlorophyll content, crop growth rate, yield.**



## INTRODUCTION

The onion (*Allium cepa* L.) belongs to the family of Alliaceae (Kochhar, 1986). George *et al.,* (2007) stated that it is a biennial crop which forms bulbs from seeds in the first season of growth and flowers in the second season to form seeds. According to Hussaini *et al.* (2000) the crop ranks second in importance after tomatoes among the vegetables in Nigeria. Aliyu *et al.,* (2008) documented that it is grown mainly for its bulbs, which is used almost daily in every home. The demand for onion is worldwide. In Nigeria it forms part of an ingredient of main meals, being used mainly in flavouring and seasoning of a wide variety of dishes. It is also harvested in the green state and used as salads. Bulbs could be boiled, used in soups and stew, fried or eaten raw. As documented by United States Dietary Allowance (2008) and Paul (2006), onion like other vegetables provides vitamins such as vitamin A and C, and a good amount of mineral elements to the human body.

Griffiths *et al.* (2002) evaluated the health benefits from onions and reported them to include antithrombotic activity, antiasthmatic and antibiotic effects. In addition, Micheal (2006) revealed that onion is among the food plants to which moderate level of anticancer activities is associated. Onion cultivation in Nigeria is confined to the Sudan Savanna zones especially Kano, Gombe, Sokoto, Kaduna, Plateau and Bornu States. Soils of these areas are mostly low in nutrient, due to low organic matter content (Amans *et al.,* 1996). The rain forest zone of South-West Nigeria (Oyo, Ogun, Osun, Ondo, Ekiti) and South-South (Edo and Delta ) of Nigeria depend solely on the ever-ready onion supply from the northern part of the country. This is attributed to the ignorance of resource-poor farmers on the possibility of onion cultivation in the rain forest agroecological zone of Nigeria. Although onion has been grown in Nigeria for a long time, the

yield is still low compared to other region of the world. The reason for this is because improved production practices based on research findings have not been made available to the generality of farmers. Fertilizer application and spacing are important factors that influence onion productivity. There is dearth of information in the rainforest zone of Edo State on the effects of fertilizer application and spacing on onion performance and if known will help to increase onion production as well as the bulb size for worthwhile economic returns. The objective of this study therefore was to investigate the optimum level of fertilizer application and spacing for the growth and yield of onion in Edo ecology.

## MATERIALS AND METHODS

The Experiments were carried out in the 2010/2011 and 2011/2012 dry season at the Teaching and Research Farm of the University of Benin, Ugbowo Campus, Benin-City, in Edo State and Lies within the geographical coordinates of longitude $5^{0,}$ 04" and $06^{0}$ 43"E and latitude $05^{0}$ 44"N and $07^{0}$ 34"N of Greenwich (FOS,1994). The climate is tropical and the vegetation is lowland rainforest in the south (with mean annual rainfall of 2300mm) to guinea savanna in Edo North with 1400 mm mean rainfall. Meteorological data during the experimental period was obtained from Nigerian Institute for Oil Palm Research (NIFOR) and is presented in Table 1.

Prior to analysis, the soil samples were air dried and crushed to pass through a 2mm sieve. Soil pH was determined using a pH meter. Organic carbon was determined by (Walkley and Black, 1962) wet oxidation method as modified by Jackson (1969). Total nitrogen was obtained by macro Kjeldahl methods as modified by Jackson (1969). Available P was extracted by Bray I method (Bray and Kurtz, 1945) and the P was estimated by the blue colour method of Murphy and Riley (1962).

Exchangeable K and Na were determined using flame photometer, and Ca and Mg using the Atomic Absorption Spectrophotometer. The result of the analysis is as presented in Table 2.

The experiment was laid out as a randomized complete block design (RCBD) with three replications. The treatments were composed of a factorial combinations of four rates (0, 40, 80 and 120 kg/ha NPK 15:15:15) fertilizer and three spacings 15 x 20, 20 x 20 and 25 x 25 cm, which corresponded to 333,333, 250,000 and 160,000 plants per ha respectively. Each replicate had 12 plots giving a total of 36 plots in this experiment. The land was cleared with the debris worked into the soil with a hoe. Beds for planting were prepared and onion seeds (Kano red) were sown in the nursery and transplanted to the field when seedlings were seven weeks after sowing and at about 14cm tall. Plots were mulched to conserve soil moisture and suppress weeds.

The inorganic fertilizer application at (0, 40, 80 and 120kg/ha of NPK 15:15:15 compound fertilizer were applied in two split applications. The first dose was applied two weeks after transplanting and the remaining half at six weeks after transplanting by side placement along the rows to the respective plots depending on the treatment. The field was weeded manually using hoe. A total of three hand weedings were done at 3, 6 and 8 weeks after transplanting. Insects were handpicked when necessary. Data collection started four weeks after transplanting. Four plants were randomly selected from each plot and tagged for the purpose of collecting data for leaf length, individual bulb and shoot weight, leaf thickness, harvest index, bulb yield and total fresh yield per hectare. The data obtained were subjected to statistical analysis of variance (ANOVA) using SAS following the model for factorial experiment in a randomized complete block design and means separated by Duncan Multiple Range Test (DMRT).

**Table 1: Weather conditions at NIFOR station, Benin from October 2010 to March 2012.**

| Year | Weather condition | October | November | December | January | February | March |
|---|---|---|---|---|---|---|---|
| 2010/11 | Rainfall (mm) | 373.80 | 109.40 | 0.00 | 0.00 | 57.50 | 38.70 |
| | Temperature (°C) | 26.60 | 27.40 | 26.60 | 26.05 | 25.75 | 24.70 |
| | Relative humidity (%) | 80.10 | 76.60 | 66.35 | 66.45 | 69.04 | 71.70 |
| 2011/12 | Rainfall (mm) | 240.80 | 68.80 | 0.00 | 00.00 | 116.20 | 84.90 |
| | Temperature(°C) | 26.36 | 27.40 | 26.60 | 27.35 | 25.75 | 27.70 |
| | Relative humidity (%) | 78.90 | 74.10 | 63.65 | 53.35 | 69.90 | 72.30 |

## RESULTS

Mean leaf length per plant of onion at 4, 6, 8, and 10 WAT as affected by spacing and inorganic fertilizer is presented in Table 3. Data on leaf length showed that at 4 WAT there was no significant difference on leaf length of onion. However, at 6, 8, and 10 WAT the results were statistically similar. Plants spaced at either (20 x 20cm) or (25 x 25cm) produced similar leaf length that were significantly longer than those produced with the closest (15 x 20cm) spacing.

**Table 2: Pooled chemical and physical properties of experimental soils two weeks before and after planting for both years under study.**

| Soil Properties | Pre | After |
|---|---|---|
| pH ($H_2O$) | 5.30 | 6.01 |
| Organic Matter g(100g)$^{-1}$ | 0.83 | 2.18 |
| Total N g(100g)$^{-1}$ | 0.06 | 0.07 |
| Total P mg(kg)$^{-1}$ | 2.10 | 18.36 |
| K (cmolkg$^{-1}$) | 0.26 | 0.29 |
| Ca (cmolkg$^{-1}$) | 1.20 | 1.80 |
| Mg(cmolkg$^{-1}$) | 0.60 | 0.80 |
| Sand (%) | 64.80 | 68.62 |
| Clay (%) | 27.20 | 26.66 |
| Silt (%) | 8.00 | 8.14 |
| Textural class | Sandy loam | |

The effect of fertilizer application on leaf length of onion in 2010/2011 (Table 3) was highly significant at most sampling intervals. At 6, 8 and 10 WAT, plants treated with either 80 or 120 kg/ha NPK produced similar heights and were significantly taller than plants which received 40 kg/ha NPK and no fertilizer (control). However, application of 40 kg/ha NPK increased leaf length significantly above the control treatment. The effect of spacing on harvest index and leaf thickness of onion was not significant. Plants grown at 15 x 20cm, 20 x 20cm and 25 x 25cm produced similar harvest indices and leaf thickness. However, the effect of fertilizer application on harvest index and leaf thickness was significant. Plants treated with 40, 80 or 120 kg ha$^{-1}$ were statistically similar and significantly different from the control. Bulb fresh weight increased with increase in spacing. Plants spaced at either 20 x 20cm or 25 x 25cm were at par and significantly increased bulb weight above the closer spacing of 15 x 20cm. The effect of fertilizer application on bulb weight of onion in 2010/2011 (Table 4) was highly significant. Plants treated with 80 or 120 kg/ha NPK produced similar bulb weight and were significantly heavier than that produced by plants which received 40 kg/ha and no fertilizer treatment however, plants treated with 40 kg/ha NPK produced heavier bulbs compared to the control plot.

In 2011/2012, bulb weight was significantly affected by spacing. Plants grown at either 20 x 20cm or 25 x 25cm produced similar bulb weight which were significantly above that produced at 15 x 20 cm (Table 4). Similarly, fertilizer application significantly affected bulb weight of onion. Plants treated with either 80 or 120 kg/ha NPK produced similar bulb weight and were significantly heavier than the control which received no fertilizer and 40 kg/ha NPK. However, plants treated with 40 kg/ha significantly increased bulb weight above the control plots. Shoot fresh weight in 2010/2011 was not significantly affected by spacing. Similar shoot fresh weight were recorded for 15 x 20 cm, 20 x 20 cm, or 25 x 25 cm spacings. Increase in fertilizer application from 0 to 80 kg/ha significantly increased shoot weight of onion. Plants treated with either 80 or 120 kg/ha produced similar shoot fresh weight which was significantly higher than plants which received 40 or 0 kg/ha. In 2011/2012, as shown in Table 4, shoot fresh weight of onion increased with increase in spacing, 20 x 20 cm and 25 x 25 cm recorded similar shoot fresh weight. However, 25 x 25 cm increased shoot fresh weight above the 15 x 20 cm spacing. Similarly, the effect of fertilizer application on shoot fresh weight of onion was significant.

Spacing significantly affected fresh bulb yield of onion. Bulb yield decreased with increase in spacing. Plants grown at either 15 x 20 cm or 20 x 20 cm spacing were at par in fresh bulb yield and significantly produced higher bulb yield above plants in the widely (25 x 25 cm) spaced. Similarly, the effect of fertilizer application on fresh bulb yield of onions in both years (Table 5) was highly significant. Plants treated with 80 or 120 kg/ha NPK produced similar fresh bulb yields and were significantly higher than that produced from plants which received 40 kg/ha and no fertilizer (control). Shoot yield decreased with increase in spacing. Plants grown at the narrower spacing of 15 x 20 cm or 20 x 20 cm produced similar shoot fresh yield which were significantly higher than that produced at the widely spaced 25 x 25 cm. Fertilizer application significantly affected shoot fresh yield of onion (Table 5). Plant treated with either 80 or 120 kg/ha produced similar fresh shoot yield. However application of 80 or 120 kg/ha increased fresh shoot yield significantly above 40 kg/ha and the control which received no fertilizer treatment. Total fresh yield decreased with increase in spacing. Plants grown at the narrower spacing of either 15 x 20 cm or 20 x 20 cm significantly produced statistically similar total fresh yield above the wider spacing of 25 x 25 cm.

Fertilizer application significant affected total fresh and dry yield of onion. Total fresh and dry yield increased with increase in fertilizer application. Increasing the fertilizer level from 0 to 80 kg/ha significantly increased total fresh and dry yield. A further increase in fertilizer level to 120 kg/ha did not increase the yield significantly. Plants treated with either 80 or 120 kg/ha significantly produced similar yield above 40 kg/ha and the control plots which produced the lowest total yield.

**Table 3: Effect of spacing and level of NPK 15:15:15 fertilizer on leaf length of onion 2010/2011 and 2011/2012 dry cropping season**

| | 2010/2011 Cropping season | | | | 2011/2012 Cropping season | | | |
|---|---|---|---|---|---|---|---|---|
| (WAT) | 4 | 6 | 8 | 10 | 4 | 6 | 8 | 10 |
| **Spacing (cm)** | | | | | | | | |
| 15 x 20 | 28.73$^{a}$ | 30.75$^{b}$ | 32.50$^{b}$ | 36.20$^{b}$ | 26.47$^{b}$ | 28.97$^{b}$ | 30.68$^{b}$ | 32.07$^{b}$ |
| 20 x 20 | 32.16$^{a}$ | 34.97$^{a}$ | 37.16$^{a}$ | 42.47$^{a}$ | 29.20$^{ab}$ | 33.56$^{a}$ | 36.79$^{a}$ | 39.93$^{a}$ |
| 25 x 25 | 32.47$^{a}$ | 35.87$^{a}$ | 38.56$^{a}$ | 43.21$^{a}$ | 30.19$^{a}$ | 35.94$^{a}$ | 38.29$^{a}$ | 41.70$^{a}$ |
| **SEM** | 1.37 | 1.38 | 1.40 | 1.41 | 1.29 | 1.30 | 1.36 | 1.38 |
| **NPK 15:15:15 fertilizer (Kgha$^{-1}$)** | | | | | | | | |
| 0 | 21.63$^{c}$ | 23.49$^{c}$ | 26.17$^{c}$ | 30.17$^{c}$ | 24.67$^{b}$ | 25.53$^{c}$ | 29.18$^{b}$ | 31.80$^{c}$ |
| 40 | 29.97$^{b}$ | 33.44$^{b}$ | 35.38$^{b}$ | 39.55$^{b}$ | 25.06$^{b}$ | 30.02$^{b}$ | 36.98$^{a}$ | 38.02$^{b}$ |
| 80 | 37.42$^{a}$ | 41.45$^{a}$ | 43.88$^{a}$ | 48.90$^{a}$ | 34.74$^{a}$ | 38.57$^{a}$ | 40.53$^{a}$ | 45.31$^{a}$ |
| 120 | 38.14$^{a}$ | 42.43$^{a}$ | 44.57$^{a}$ | 49.16$^{a}$ | 35.76$^{a}$ | 39.12$^{a}$ | 42.18$^{a}$ | 47.89$^{a}$ |
| **SEM** | 1.55 | 1.44 | 1.47 | 1.48 | 1.33 | 1.40 | 1.42 | 1.44 |

WAT = Weeks After Transplanting. Means followed by the same letter in a column are not significantly different at 5% level of probability using DMRT.

**Table 4: Effect of spacing and levels of NPK 15:15:15 fertilizer on Harvest index (HI), Leaf thickness (cm), Bulb fresh weight (g), and shoot fresh weight (g) of onion in 2010/2011 and 2011/2012 dry**

| Treatment | 2010/2011 Cropping season | | | | 2011/2012 Cropping season | | | |
|---|---|---|---|---|---|---|---|---|
| | Harvest Index | Leaf thickness (cm) | Bulb fresh weight/bulb (g) | Shoot fresh weight/plant (g) | Harvest Index | Leaf thickness (cm) | Bulb fresh weight/bulb (g) | Shoot fresh weight/plant (g) |
| **Spacing (cm)** | | | | | | | | |
| 15 x 20 | 0.88$^{a}$ | 0.14$^{a}$ | 27.09$^{b}$ | 7.48$^{a}$ | 0.75$^{a}$ | 0.11$^{b}$ | 22.86$^{b}$ | 4.34$^{b}$ |
| 20 x 20 | 0.90$^{a}$ | 0.14$^{a}$ | 43.96$^{ab}$ | 7.82$^{a}$ | 0.76$^{a}$ | 0.12$^{b}$ | 38.79$^{a}$ | 4.82$^{ab}$ |
| 25 x 25 | 0.90$^{a}$ | 0.15$^{a}$ | 50.32$^{a}$ | 8.90$^{a}$ | 0.76$^{a}$ | 0.16$^{a}$ | 41.44$^{a}$ | 5.71$^{a}$ |
| **SEM** | 0.02 | 0.01 | 6.38 | 1.61 | 0.02 | 0.01 | 5.10 | 0.53 |
| **NPK 15:15:15 fertilizer (Kgha$^{-1}$)** | | | | | | | | |
| 0 | 0.78$^{b}$ | 0.06$^{b}$ | 12.40$^{c}$ | 4.33$^{b}$ | 0.61$^{b}$ | 0.10$^{b}$ | 13.44$^{c}$ | 4.55$^{b}$ |
| 40 | 0.88$^{a}$ | 0.14$^{a}$ | 33.23$^{b}$ | 5.47$^{b}$ | 0.80$^{a}$ | 0.11$^{b}$ | 30.19$^{b}$ | 4.63$^{b}$ |
| 80 | 0.90$^{a}$ | 0.15$^{a}$ | 52.57$^{a}$ | 10.50$^{a}$ | 0.82$^{a}$ | 0.16$^{a}$ | 48.64$^{a}$ | 6.28$^{a}$ |
| 120 | 0.91$^{a}$ | 0.15$^{a}$ | 56.96$^{a}$ | 11.90$^{a}$ | 0.83$^{a}$ | 0.18$^{a}$ | 50.75$^{a}$ | 6.42$^{a}$ |
| **SEM** | 0.03 | 0.02 | 6.40 | 1.65 | 0.03 | 0.02 | 5.42 | 0.59 |

WAT = Weeks After Transplanting. Means followed by the same letter in a column are not significantly different at 5% level of probability using DMRT.

**Table 5: Effect of levels of NPK 15:15:15 fertilizer and spacing on yield of onion 2010/2011 and 2011/2012 dry cropping seasons**

| Treatment | 2010/2011 Cropping season | | | | 2011/2012 Cropping season | | | |
|---|---|---|---|---|---|---|---|---|
| | Bulb yield (t ha$^{-1}$) | Shoot yield (t ha$^{-1}$) | Total yield (t ha$^{-1}$) | Total dry yield (t ha$^{-1}$) | Bulb yield (t ha$^{-1}$) | Shoot yield (t ha$^{-1}$) | Total yield (t ha$^{-1}$) | Total dry yield (t ha$^{-1}$) |
| **Spacing (cm)** | | | | | | | | |
| 15 x 20 | 13.92$^{a}$ | 1.97$^{a}$ | 15.89$^{a}$ | 2.14$^{a}$ | 13.84$^{a}$ | 1.30$^{a}$ | 15.14$^{a}$ | 2.54$^{a}$ |
| 20 x 20 | 14.08$^{a}$ | 2.23$^{a}$ | 16.31$^{a}$ | 2.26$^{a}$ | 14.68$^{a}$ | 1.86$^{a}$ | 16.54$^{a}$ | 2.70$^{a}$ |
| 25 x 25 | 9.03$^{b}$ | 1.02$^{b}$ | 10.05$^{b}$ | 1.02$^{b}$ | 8.19$^{b}$ | 0.86$^{b}$ | 9.05$^{b}$ | 0.98$^{b}$ |
| **SEM** | 1.34 | 0.30 | 1.47 | 0.32 | 1.27 | 0.24 | 1.49 | 0.28 |
| **NPK 15:15:15 fertilizer (Kgha$^{-1}$)** | | | | | | | | |
| 0 | 4.45$^{c}$ | 0.97$^{b}$ | 5.42$^{c}$ | 0.31$^{c}$ | 5.15$^{c}$ | 0.92$^{b}$ | 6.07$^{c}$ | 0.43$^{c}$ |
| 40 | 10.11$^{b}$ | 1.30$^{b}$ | 11.41$^{b}$ | 1.35$^{b}$ | 10.49$^{b}$ | 1.10$^{b}$ | 11.59$^{b}$ | 1.40$^{b}$ |
| 80 | 14.83$^{a}$ | 2.59$^{a}$ | 17.42$^{a}$ | 2.60$^{a}$ | 14.82$^{a}$ | 2.57$^{a}$ | 17.39$^{a}$ | 2.58$^{a}$ |
| 120 | 15.81$^{a}$ | 2.85$^{a}$ | 18.66$^{a}$ | 2.82$^{a}$ | 15.15$^{a}$ | 2.78$^{a}$ | 17.93$^{a}$ | 2.77$^{a}$ |
| **SEM** | 1.41 | 0.34 | 1.51 | 0.34 | 1.35 | 0.26 | 1.52 | 0.31 |

WAT = Weeks After Transplanting. Means followed by the same letter in a column are not significantly different at 5% level of probability using DMRT.

## DISCUSSION

The increase in vegetative characters of onion as a result of increase in plant spacing could be due to the fact that plants did not experience serious competition for nutrients compared with the closely spaced plants and this result conforms with the findings by Bodnar *et al.* (1998) that widely spaced garlic plants tend to grow more vegetatively and bears more and longer leaves per plant. Aliyu and Olarewaju (2000) also recorded a similar result in his work on onion. However the highest yield per hectare recorded from the closer spacing could be attributed to greater crop biomass found with the narrower spacing as supported by Tijani-Eniola *et al.* (2003). The results from this study have shown clearly that bulb yield can be increased at a spacing of 15 x 20 cm and 20 x 20 cm. Wider spacing reduced yield due to total reduction in plants per hectare and consequently spacing is not fully utilized. These results are in accordance with those of Samaila (2002), Khan *et al.* (2002), and Aliyu (2008) who in their different studies found correlations between bulb yield increase and decrease in plant spacing. The increase in the vegetative and yield characters produced by plants treated with higher rate of inorganic fertilizer over the control could be due to the quantity and rate of release of the major plant nutrients present in the inorganic fertilizer thereby providing better growth and development of the plants. Jeyathilake *et al.* (2006) stated that onion is a heavy feeder of nutrient and that the role of nutrient is of paramount importance in boosting productivity and quality of onion. The least values for yield recorded from the control could be due to the fact that no fertilizer was applied to the plots and so the plants had to depend on the inherent nutrient status for their growth and development. This trend was similar to the result reported for edible pea (Kulsum *et al.,* 2007). It was recommended that relatively high level of nutrients is required for optimum growth and development of the crop. These results are in agreement with those obtained by Abdelrazzag (2002) on onion (*A. cepa*) and Togun and Akanbi (2003) on tomato *Lycoperscum esculentum*) who found that the vegetative and yield characters of the crops increased with increase in application rate of inorganic fertilizer.

We conclude that onion vegetative growth and yield can be increased using a spacing of either 15 x 20 cm or 20 x20 cm at 80 kg /ha NPK 15:15:15 fertilizer application.

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