academicJournals

Vol. 8(37), pp. 4686-4692, 26 September, 2013
DOI:10.5897/AJAR12013.6794
ISSN 1991-637X ©2013 Academic Journals
http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Analysis of pumpkin (*Cucurbita pepo* Linn.) biomass yield and its components as affected by nitrogen, phosphorus and potassium (NPK) fertilizer rates

Oloyede F. M.*, Agbaje G. O. and Obisesan I. O.

Department of Crop Production and Protection, Obafemi Awolowo University, Ile-Ife, Nigeria.

Accepted 24 May, 2013

Pumpkin (*Cucurbita pepo* L.) young leaves and vines are consumed as vegetables among the rural dwellers in Southwest Nigeria. It is a cheap source of protein, vitamins, fibres and antioxidants in their diet. Due to the intensive cultivation of available lands which affects the nutrient status of most soils and their productivity, the need to apply fertilizer on pumpkin became pertinent. Therefore, nitrogen, phosphorus and potassium (NPK) fertilizer influence on biomass accumulation in pumpkin was investigated for two consecutive seasons in 2010 at the Research Farm of Obafemi Awolowo University, Ile-Ife, Nigeria. NPK (15:15:15) compound fertilizer was applied at the rates of (0, 50, 100, 150, 200 and 250 kg ha^{-1}) to *C. pepo* at 2 weeks after planting (WAP). At 8 WAP, the following morpho-physiological traits: vine length, vine diameter, number of internodes, internodes length, vine weight, number of leaves, total fresh and dry biomass assessed were significantly influenced by season and fertilizer effects. The combined analysis of variance (ANOVA) results showed that the effects of season (S) and fertilizer (F) are significant effect on all the traits. Season effect showed that the early season was better (p = 0.05) while the application of fertilizer beyond 100 kg of NPK per hectare was not statistically beneficial for biomass yield and its components. However, the significant S X F interaction on the total dry matter fitted well into a quadratic equation with significant R^2 values. The response curves showed higher response to fertilizer in the early than late planting season and a maximum biomass yield was attained at the application of 205 kg and 244 kg ha^{-1} of NPK (15-15-15) for early and late season cultivations, respectively.

Key words: Biomass, nitrogen, phosphorus and potassium (NPK) fertilizer, pumpkin, dry matter, morpho-physiological trait, quadratic equation.

INTRODUCTION

Cucurbita pepo Linn. commonly known as pumpkin and locally called “Elegede” in Southwest Nigeria belongs to the Cucurbitaceae family. The family is among the most important plant families supplying humans with edible products and useful fibres (Smith, 1997). The palatable leafy vegetable deserts from this crop are relished in Southwestern Nigeria.

C. pepo L. produces a lot of biomass and its nutrient requirements are generally considered to be high (Graifenberg et al., 1996; Colla and Saccardo, 2003). Nevertheless, excessive fertilization is common among farmers due to their poor knowledge of fertilizer types and nutrient requirement of crops (Martinetti and Paganini, 2006). Generally, tropical soils require additional fertilizer application for crops to yield optimally. The tropical soils are degraded and are of low soil fertility status due to excessive rainfall and intensive cultivation. Hence, most tropical soils are deficient in essential nutrients

*Corresponding author. E-mail: funmilayooloyede@yahoo.co.uk

particularly nitrogen and phosphorus (Obalum et al., 2012). Optimal mineral nutrition is fundamental to the growth and productivity of plants (Liu et al., 2010). The optimum doses of nitrogen, phosphorus and potassium vary greatly with the length of growing season, fertility status of soil, soil type, cultivar, geographical location and the environmental factors. These factors will have marked effect on the growth and yield parameters of pumpkin (Manjunath Prasad et al., 2008). The macronutrient nitrogen (N), which is essential for amino acid, protein and enzyme biosynthesis, is quantitatively the most important element (Sinclair and Vadez, 2002). This study was designed to evaluate the influence of nitrogen, phosphorus and potassium (NPK) fertilizer application on the biomass and its components in pumpkin and determine the fertilizer rate required for maximum biomass yield.

MATERIALS AND METHODS

Location, soil characteristics and meteorological data

Field studies were conducted at the Teaching and Research Farm, Obafemi Awolowo University, Ile-Ife, Nigeria, for two seasons, the early season (May to August) and late season (August to November) of 2010 to determine the effect of NPK fertilizer on biomass yield and the fertilizer rate required for maximum biomass yield. Soil samples were taken randomly across the plots prior to ploughing of land. The soil samples were mixed to form a composite sample for physical and chemical composition analyses in the laboratory. Soil was ploughed twice and harrowed once before sowing. Two seeds per hole were sown and the seedlings were thinned to one plant per stand at 2 weeks after planting (WAP). The NPK fertilizer was added in two equal halves at 2 and 6 WAP. Insecticide (lambda-cyhalothrin) was applied fortnightly from 6 WAP. Post-emergence herbicide, glyphosate was applied at the rate of 200 ml in 15 L of H_2O at 4 and 7 WAP for weed control.

Climatological data regime

Rainfall pattern at Ile-Ife, Osun State, during the early season of the experiment from May to August, 2010 ranged from 7 to 16 mm. Maximum temperature ranged from 28 to 32°C while minimum temperature ranged from 21.0 to 23.0°C. The average rainfall, average maximum temperature and average minimum temperature during the period were 13.2 mm, 29.9°C and 22.5°C, respectively. During the late season of the experiment, August to November 2010, rainfall pattern ranged from 9 to 16 mm. Maximum temperature ranged from 28 to 31°C while minimum temperature ranged from 22.0 to 22.4°C. The average rainfall, average maximum temperature and average minimum temperature during the period were 15.4 mm, 30.1°C and 22.2°C, respectively (Table 2).

Experimental design, treatments and agronomic practices

The experimental treatments were laid in a randomized complete block design and replicated six times. Each plot size was 10 X 12 m and consisted of 7 rows. Alley was 3 m, while the plants were spaced 2 X 2 m. The treatments consisted of a local cultivar of *C. pepo* and 6 rates of NPK 15:15:15 fertilizer. Fertilizer was applied at the rate of 0, 50, 100, 150, 200, 250 kg ha^{-1} at 2 WAP of seeds. Plantings were done on the 15th of May and 1st of August, 2010, respectively.

Agronomic data collection

Data were collected on biomass yield at 8 WAP. Samples of the plants were obtained within the two last rows by destructive sampling. Five plants per plot were harvested above the ground level to collect data on fresh weight, vine length, vine diameter, number of internodes, internodes length, vine weight and number of leaves. Dry matter was obtained by drying the samples to constant weight in the oven at 70°C.

Statistical analysis

All data were subjected to combined analysis of variance (SAS, 2003). Means squares were significantly different and separated using Duncan multiple range test (DMRT) at 5% level of probability. Regression analysis was performed on the total dry matter using the quadratic equation to determine the fertilizer rate required for maximum biomass yield. The fertilizer rate for maximum biomass yield (N_y) was calculated using the formula: $N_y = -b/2c$ where b and c are the estimates of the regression coefficients in $Y = a + bN + cN^2$ (Gomez and Gomez, 1983).

RESULTS

Soil properties of the experimental site

The results of general chemical and physical properties of the soil in the experimental area before and after cropping for both early and late cropping seasons, respectively are presented in Table 1. The surface soil was slightly acidic with a pH of 6.4 and 6.0. The soil of the site was low in organic carbon (9.5 and 9.8 g kg^{-1}) and also moderate in total nitrogen (1.6 and 1.7 g kg^{-1}). Available P (Bray-P) was 5.4 and 5.80 mg kg^{-1}. Exchangeable Mg^{2+} was 0.38 and 0.43 cmol/kg. The values of exchangeable Ca^{2+} was 2.81 and 1.0 while for K^+ it was 0.40 and 0.28 cmol/kg. The soil of the site was classified as sandy loam. There was a reduction in the amount of N and organic carbon left in the soil after cropping in both seasons.

Biomass traits of pumpkin as influenced by NPK fertilizer at 8 WAP

The effects of season and fertilizer were significant on the biomass yield and its component traits. However, when the percentage contribution of the mean square to the variation in biomass traits were compared, only in the number of internodes and the number of leaves per plant were fertilizer effects more than that of season. Although, the season x fertilizer effect was significant on six of the assessed traits except in vine length, number of internodes and internodes length, its mean square contribution to traits variation was the least (Table 3).

The performance of the traits was better in early season than in late season. Table 4 showed that the vine growth traits from early season were significantly higher than in the late season. Fresh weight and dry matter was

Table 1. Pre-planting and post-planting soil chemical and physical properties at 0 to 15 cm depth in the experimental site for Season 1 (S1) and 2 (S2).

Chemical property	Pre-planting S1	Post-planting S1	Pre-planting S2	Post-planting S2
pH (H_2O) (1:2)	6.4	6.8	6.0	6.2
Organic carbon (g kg^{-1})	9.8	7.8	9.5	8.1
Total N (g kg^{-1})	1.7	0.85	1.6	0.66
Available P (mg kg^{-1})	5.80	6.50	5.4	6.1
Exchangeable cations (cmol/kg)				
K^+	0.4	0.32	0.28	0.26
Ca^{2+}	0.38	0.45	1.0	0.9
Mg^{2+}	2.81	2.85	1.03	0.54
Physical property				
Sand (g kg^{-1})	802	790	760	760
Silt (g kg^{-1})	97	99	140	120
Clay (g kg^{-1})	101	111	100	120

Table 2. Summary of weather data at Ile-Ife, Osun-State during the cropping year (2010).

Months	Total rainfall (mm)	Average temperature (Min) °C	Average temperature (Max) °C	Solar radiation ($MJ/m^2/day$)
January	0	22.1	33.9	11.12
February	3.7	23.8	35.6	13.38
March	3.9	24.1	34.7	13.61
April	6.7	23.9	33.9	14.71
May	14.4	23.0	31.7	12.74
June	6.9	23.0	30.6	12.45
July	16	21.9	28.6	11.16
August	15.5	22.2	28.4	10.13
September	15.2	22.1	29.7	13.40
October	22	22.0	30.6	13.66
November	8.7	22.4	31.4	9.30
December	0	21.5	32.8	7.83

31 and 39% higher, respectively in the early season compared to the late season while vine length and vine diameter were 17 and 22% higher in the early season plants. Number of internodes and internodes length in early season plants was 15% each higher compared to the late season plants. Number of leaves and leaves weight reduced by 57 and 40%, respectively in late season plants while number of branch in early

Table 3. Combined analysis of variance showing means squares for biomass growth traits of pumpkin as influenced by season and NPK fertilizer at 8 WAP.

Source	DF	Biomass fresh weight (g/plant)	Vine length (cm)	Vine diameter (cm)	No of internodes (n)	Internodes length (cm)	No of leaves (n/plant)	Leaf weight (g/plant)	No of branch (n)	Total biomass dry weight (g/plant)
Season	1	9046131**	240471**	0.80**	480.5**	124.3*	188293**	6293561**	840.5**	3792601**
Rep within season	10	446844	7334	0.01	25.6	12.5	5667	40587	16.26	1413
Fertilizer	5	5838958**	205319**	0.28**	697.9**	72.2**	19805**	1949939**	276.72**	128182**
Season*Fertilizer	5	311701**	6592	0.02**	5.3	1.6	5824*	150651*	53.73**	5771**
Pooled error	50	80100	3067	0.01	14.0	3.5	2357	44689	3.85	859
CV (%)		14.9	13.2	7.3	11.8	11.4	38.2	17.9	17.0	9.7

* = significant at 0.05 level of probability, ** = significant at 0.01 level of probability.

Table 4. Biomass traits of pumpkin as influenced by season at 8 WAP.

Season	Fresh weight (g)	Dry matter (g)	Vine length (cm)	Vine diameter (cm)	No of internodes (n)	Internodes length (cm)	No of leaves (n)	Leaves weight (g)	No of branch (n)	Biomass growth rate (4-8 WAP) (g/day)
Early season	2255.3	375.52	477.36	1.10	34.39	17.62	178	1476.39	14.97	13.0
Late season	1546.4	230.36	361.78	0.89	29.22	14.99	76	885.08	8.14	8.0
LSD (0.05)	163.7	14.54	28.11	0.04	1.82	0.97	23.99	97.66	1.05	0.73

NS = not significant at 5% level of probability.

season plants was 47% higher than the late season plants.

The fresh and dry matter weights and values from other traits increased with the addition of fertilizer. The control traits had the lowest yields or values and these increased significantly when fertilizer rate applied was 100 kg ha^{-1}. However, there was no significant difference in fresh or dry matter weight or in the other traits when the applied fertilizer rate (NPK 15-15-15) increased above 100 kg ha^{-1} (Table 5). The mean fresh and dry biomass yields at maximum fertilizer rates were depressed by about 50 and 37% when fertilizer rates of zero and 50 kg ha^{-1} were applied, respectively. The addition of 50 kg ha^{-1} increased vine length by 58% when compared to the control treatment and this could be as high as 150% when fertilizer rates increased to 100 and 250 kg ha^{-1}. Vine diameter also increased by 21 and 50% with the addition of fertilizers at 50 kg ha^{-1} and above, respectively.

The application of fertilizers above 100 kg ha^{-1} increased the number of internodes by 100% while the internode length increased by 5 to 6 cm more when compared with the control treatment. The number of branches increased by over 200% and number of leaves by 170% and leaves weight by as much as 180% when fertilizer rates increased to 100 kg ha^{-1} and above when compared to the control treatment.

The response of dry matter of biomass to fertilizer rates at 8 WAP fitted into quadratic equation and the R^2 was significant at 0.95 and 0.91 for early and late seasons, respectively (Figure 1). The rate for dry matter production was higher in early season (b, 3.29 g dy^{-1}) than in late season (b, 1.94 g dy^{-1}) in response to fertilizer increase. Also, higher yield was obtained across fertilizer rates during the early than in the late season. The control had a biomass yield of 180 g plant^{-1} while at the optimal fertilizer rate, 480 g plant^{-1} was obtained. For late season, dry matter yield was 100 g plant^{-1} in zero fertilizer but 300 g/plant at optimal fertilizer application of 200 kg ha^{-1} NPK. From the equation on the fertilizer rates for required maximum yield were estimated to be 205 and 244 kg of NPK (15-15-15) ha^{-1} for early and late season's production, respectively.

Table 5. Pumpkin biomass at 8 WAP as affected by NPK fertilizer.

NPK level (kg ha^{-1})	Fresh weight (g)	Dry matter (g)	Vine length (cm)	Vine diameter (cm)	No of internodes (n)	Internodes length (cm)	No of leaves (n)	Leaves weight (g)	No of branch (n)
Control	854.6^{c}	134.9^{c}	200.1^{c}	0.73^{c}	19.1^{c}	12.2^{c}	59^{c}	532.7^{c}	4.5^{d}
50	1168.3^{b}	211.6^{b}	316.0^{b}	0.88^{b}	25.6^{b}	14.5^{b}	96^{b}	820.0^{b}	6.4^{c}
100	2391.7^{a}	370.2^{a}	512.1^{a}	1.11^{a}	37.1^{a}	18.2^{a}	155^{a}	1500.6^{a}	14.3^{ab}
150	2327.5^{a}	364.1^{a}	481.6^{a}	1.06^{a}	36.3^{a}	17.4^{a}	148^{a}	1419.2^{a}	13.8^{b}
200	2268.4^{a}	371.4^{a}	499.2^{a}	1.09^{a}	36.6^{a}	17.7^{a}	145^{a}	1376.8^{a}	14.7^{ab}
250	2394.4^{a}	365.3^{a}	508.5^{a}	1.09^{a}	36.2^{a}	18.0^{a}	160^{a}	1435.3^{a}	15.7^{a}

Means with the same letter in each column are not significantly different at 5% level of probability using Duncan's multiple range test.

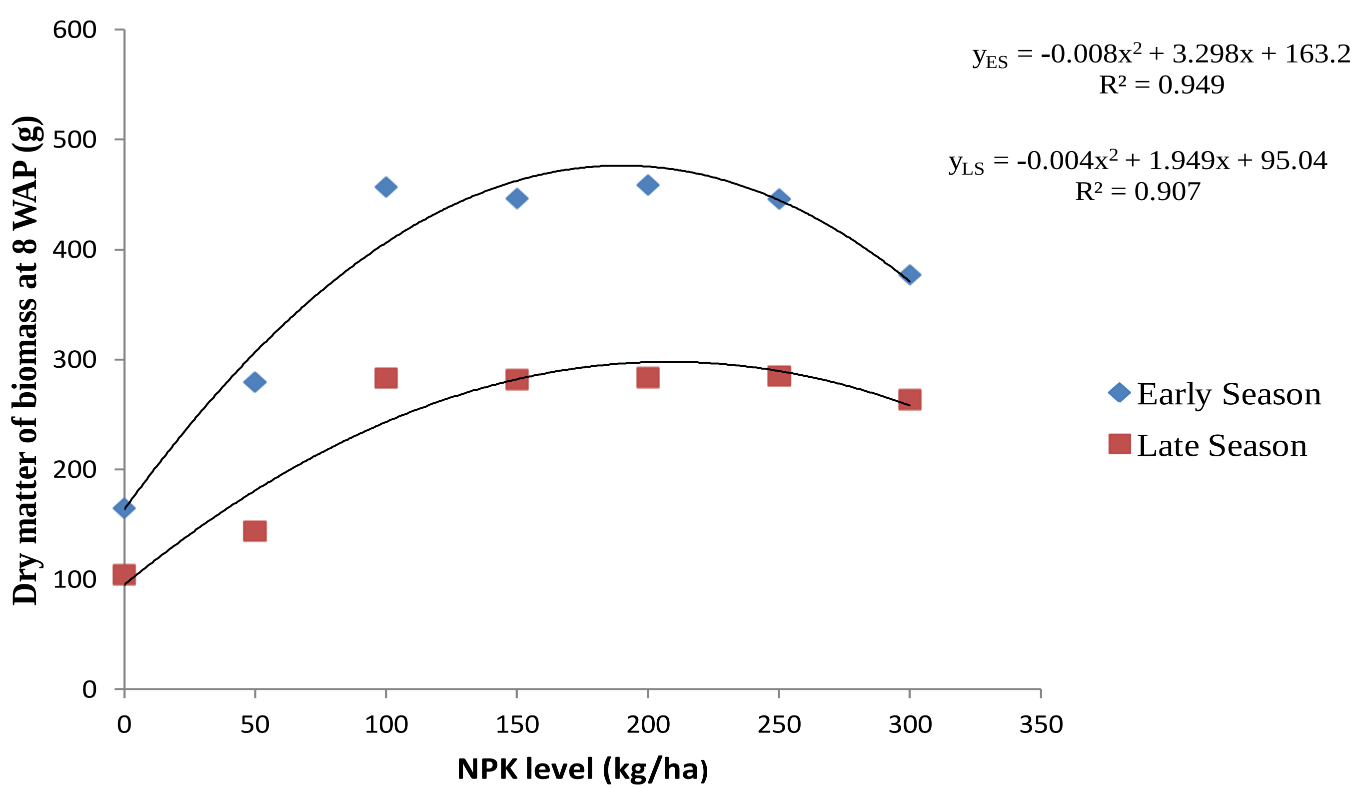

Figure 1. Biomass dry matter at 8 WAP as affected by season x fertilizer.

DISCUSSION

Available P (Bray-P) was considered inadequate when compared with the critical value of 10 to 16 mg kg^{-1} for Southwest Nigeria (Sobulo et al., 1975; Agbede and Aduayi, 1978). Exchangeable Mg^{2+} was considered adequate in Southwest Nigeria where the critical value is 0.2 to 0.4 cmol/kg. The values of exchangeable Ca^{2+} and K^+ were considered adequate considering the critical values of 2.5 and 0.16 to 0.25 cmol/kg, respectively for Ca^{2+} and K^+.

Biomass production in *C. pepo* was significantly influenced by the quantity of nutrient supplied in this experiment. Yield of pumpkin was found to have increased by 120% with the application of 200 to 280 kg of NPK fertilizer in temperate environment (Martinetti and Paganini, 2006). Although, the experimental site has moderate N status (0.17 to 0.18 g kg^{-1}), the plant biomass increased with fertilizer rates up to 200 kg NPK ha^{-1} but above this a reduction in biomass was observed. The result agreed with earlier reports that biomass yield increased with fertilizer application up to a certain optimal limit (Bradley et al., 1976; Shukla and Gupta, 1980; Almishaal et al., 1984; Alwan, 1986; Al-Mukhtar et al., 1987).

Vine length and its rate of extension have influence on plant biomass. Pumpkin vine length increased with NPK fertilizer rate in this study and could be as long as five meters from the point of sowing. This created a technical problem for maintenance and mechanization of pumpkin production. The extensive foliage covering though genetic was enhanced by fertilizer application due to the fundamental involvement of NPK in the large number of enzymatic reactions as well as other metabolic, energy transfer and biological processes which hasten cell division and growth in plants (Al-Mukhtar et al., 1987). Similar results were obtained in the application of NPK fertilizer to *Philodendron domesticum* L., *Cordyline terminalis* and *Codiaeum variegatum* (Zaghloul et al., 1996; Atta-Alla et al., 1996; Reem, 1997).

It is suggested that the development of plants with shorter vine length and more internodes or branches where more leaves can be harvested is preferred when pumpkin is to be cultivated for leafy vegetables. The use of growth regulators such as maleic hydrazide and ethephon has been found to be effective in reducing the length of the main stem and increasing the number of primary branches in cucumber (Mukesh et al., 2011). The inhibition of apical growth and the proliferation of ancillary branches by the growth regulators was responsible for profuse branching (Odejimi and Akpan, 2006). Similar findings were reported in long melon, gherkin, eggplant and pepper (Murthy et al., 2007; Arora et al., 1994; Miller et al., 1996). If this is applied on pumpkin, probably more shoots with shorter length will be produced per unit land area. Mukesh et al. (2011) reported that the application of growth hormone on cucumber is cost effective and profitable, considering the number of fruits produced per hectare and the additional income generated when compared with a control treatment.

In this study, biomass growth was higher in early season compared to the late season irrespective of the factors imposed. Also, early season require lower fertilizer for maximum yield than the late season. The excessive rainfall which is often accompanied by leaching could have contributed to the higher fertilizer requirement in the late season when compared to early season planting. Márton (2004) reported that excessive rainfall reduced the yield of Rye by 29%. Oloyede and Adebooye (2005) found out that early season’s biomass of snake tomato (*Trichosanthes cucumerina* L.) significantly out yielded the late seasons. Even though biomass yield and hence profit returns to prospective Cucurbit leaf vegetable, farmers are better during early planting season, the calculation of economic fertilizer rate in this study from the cut marketable leaves would have captured the economic profitability of this new practice.

REFERENCES

Almishaal AJ, Buhairi AG, Gallum, AAA (1984). Effect of soaking seeds with some micronutrients on the flowering and fruit yield of squash cv. Eskandarany grown under plastic houses. Iraqi J. Agric. Sci. Zanco. 2:59-64.

Al-Mukhtar FA, Hummadi FM, Al-Sahaf FH (1987). Effect of different levels of NPK fertilizer on growth and yield of two summer squash cultivars. Acta. Hortic. 200:253-258.

Alwan OK (1986). Effect of nitrogen fertilization and yield of summer squash *Cucurbita pepo* L. M.Sc. Thesis. Horticultural Department University of Mosul, Iraq.

Arora SK, Pandita ML, Pratap PS, Batra BR (1994). Response of long melon (*Cucumis melo* var. *utilissimus*) to foliar application of plant growth substances. Indian J. Agric. Sci. 69(12):841-844.

Atta-Alla HK, Zaghloul MA, Waly AK, Khattab SH (1996). *In vitro* culture, establishment and effect of NPK fertilizer on *ex vitro* of *Cordyline terminals* cv. Atoom. Ann. Agric. Sci. Moshtohor 34:691-709.

Bradley GA, Barker EC, Motes DR (1976). Cultural and fertilizer studies on summer squash. Arkansas Farm Res. 25(5):11-12.

Colla G, Saccardo F (2003). Application of systematic variation method for optimizing mineral nutrition of soilless-grown zucchini squash. J. Plant Nutr. 9:1859-1872.

Gomez KA, Gomez AA (1983). Statistical procedures for agricultural research (2nd Edition). Publisher: John Wiley and sons, New York. pp. 323-327.

Graifenberg A, Botrini L, Giustiniani L, Lipucci Di Paola M (1996). Yield, growth and element content of zucchini squash grown under saline-sodic conditions. J. Hortic. Sci. 2:305-311.

Liu W, Zhu D, Liu D, Geng M, Zhou W, Mi W, Yang T, Hamilton D (2010). Influence of nitrogen on the primary and secondary metabolism and synthesis of flavonoids in *Chrysanthemum morifolium*. J. Plant Nutr. 33(2):240-254.

Manjunath Prasad CT, Ashok SS, Vyakaranahal BS, Nadaf HL, Hosamani RM (2008). Influence of Nutrition and Growth Regulators on Fruit, Seed Yield and Quality of Pumpkin cv. Arka Chandan. Karnataka J. Agric. Sci. 21(1):115-117.

Martinetti L, Paganini F (2006). Effect of organic and mineral fertilization on yield and quality of zucchini. Acta. Hortic. 700:125-128.

Miller CH, Lower RL, Mc Murray AL (1996). Some effects of etherel (2 chloroethyl phosphonic acid) on vegetable crops. Hortic. Sci. 4:248-249.

Mukesh T, Satesh K, Romisa R (2011). Influence of plant growth

regulators on morphological, floral and yield traits of cucumber (*Cucumis sativus* L.). Kasetsart J. Nat. Sci. 45:177-188.
Murthy TC, Negegowda S, Basavaiah V (2007). Influence of growth regulators on growth, flowering and fruit yield of gherkin (*Cucumis anguria* L.). Asian J. Hortic. 2(1):44-46.
Obalum SE, Buri MM, Nwite JC, Hermansah L, Watanabe Y, Igwe CA, Wakatsuki T (2012). Soil Degradation-Induced Decline in Productivity of Sub-Saharan African Soils: The Prospects of Looking Downwards the Lowlands with the Sawah Ecotechnology, Applied and Environmental Soil Science,Volume 2012. Article ID 673926, 10pages doi:10.1155/2012/673926.
Odejimi RAO, Akpan GA (2006). Effect of mineral supplements (NPK) on sex expression in fluted pumpkin (*Telfairia occidentalis*) Hook F. Int. J. Nat. Appl. Sci. 1(1):56-58.
Oloyede FM, Adebooye OC (2005). Effect of season on growth, fruit yield and nutrient profile of two landraces of *Tricosanthes cucumerina* L. Afr. J. Biotechnol. 4(6):1040-1044.
Reem MSS (1997). Effect of some chemical fertilization on croton plant. M.Sc. Thesis, Faculty of Agriculture, Cairo University.
SAS (2003). Version 9.1. SAS Institute Inc., Cary, NC.
Shukla V, Gupta R (1980). Notes on the effect of levels of nitrogen, phosphorus fertilization on the growth and yield of squash. Indian J. Hortic. 37(2):160-161.
Sinclair TR, Vadez V (2002). Physiological traits for crop yield improvement in low N and P environments. Plant Soil 245:1-15.
Smith BD (1997). The initial domestication of *C. pepo* in the Americas 10,000 years ago. Science 276:932-934.
Zaghloul MA, Atta-Alla HK, Waly AK, Khattab SH (1996). *In vitro* culture, establishment and effect of potting mixture and NPK fertilizer on *ex vitro* of *Philodendron domesticum* L. Ann. Agric. Sci. Moshtohor. 34:711-725.