

Response of Three Cucumber Varieties (*Cucumis sativus* L.) to Planting Season and NPK Fertilizer Rates in Lowland Humid Tropics: Sex Expression, Yield and Inter-Relationships between Yield and Associated Traits

Nwofia G. E.^{*}, Amajuoyi A. N., Mbah E. U.

Department of Agronomy, Michael Okpara University of Agriculture, Umudike, Nigeria

Abstract The response of three cucumber varieties (*Ashley*, *Betalpha*, and *marketmore*) to different rates of fertilizer (NPK 15:15:15) application were evaluated in two seasons (early and late) under rain-fed conditions in 2011 cropping season. The experiment was laid out in a split-split-plot in randomized complete block design with three replications. Seasons, (early and late rains) constituted the main plots, while cucumber varieties were fitted into the sub-plots with NPK fertilizer rates into sub-sub-plots. The results revealed significant increase in fruit yield of cucumber during the early planting season under rain-fed conditions in the humid tropics. During both cropping seasons, the application of N:P:K 15:15:15 fertilizer increased fruit yield of cucumber significantly up to 120 kg/ha. However, further increase did not affect fruit yield, which implies that 120 kg/ha fertilizer rate is the optimum quantity required for increased cucumber fruit yield. The interaction between cucumber variety and planting season significantly induced higher fruit yield in *market-more* compared to the other varieties tested. Principal component analysis showed that PC1, PC2 and PC3 with eigen-vector value loads greater than unity accounted for the cumulative variance of 70%, which exhibited the degree of influence the plant characters had on fruit yield. Pearson correlation indicated a highly significant ($P < 0.01$) and positive correlation between fruit yield and weight of fruit (0.574**) as well as number of fruits per plant (0.574**). Cause and effect analysis revealed that maximum direct effect on fruit yield of cucumber was achieved through fruit weight (0.565) and number of fruits per plant (0.457). This implies that in selection for high yields, premium should be placed on these characters.

Keywords *Cucumis sativus*, Yield attributes, Correlation, Principal component analysis, Path coefficient analysis

1. Introduction

Cucumber (*Cucumis sativus* L.), which is one of the monoecious annual crops of the cool climates belongs to the cucurbitaceae family comprising of 70 genera and 750 species (Thoa, 1998; Best, 2000). According to Shetty and Wehner (2002a) as well as Arunkumar *et al.* (2011a) the fruit of cucumber, which is soft and succulent is consumed raw (salad) or cooked with other vegetables. The nutritional composition of cucumber fruit per 100 g edible portion is carbohydrate (3%), protein (1 %), total fat (0.5% and dietary fibre (1%) (USDA, National Nutrient Data Base, 2014). The fruit is a veritable source of vitamins such as vitamin A, C, K, E, among others; minerals such as magnesium, potassium,

manganese, phosphorus, calcium and zinc as well as a number of phyto-nutrients (carotene-B, Xanthin-B and lutein) which add and enrich the diet of people living in the tropical regions (Vimale *et al.*, 1999). The crop is grown worldwide and according to Tatlioglu (1993) and ranks fourth in the list of economic vegetables in Asia after tomato, cabbage and onion.

Cucumber rarely grows luxuriantly in infertile soils, hence, its level of susceptibility to poor soil fertility manifests in the form of low fruit yield, bitter and misshapen fruits that have little marketability value. Belay *et al.* (2001), Eifediya and Remison (2010) in their various studies on nutrient requirements of cucumber reported that cucumber responds positively to organic, inorganic or combined nutrient applications for optimum growth and productivity. However, the nutrient requirements of the crop vary depending on soil type, native fertility, previous cropping and cultural practices.

Crop varieties in different seasons or environments react

^{*} Corresponding author:

enwofia@yahoo.co.uk (Nwofia G. E.)

Published online at <http://journal.sapub.org/ijaf>

Copyright © 2015 Scientific & Academic Publishing. All Rights Reserved

differently to a range of climate conditions, soil characteristics and technical practices (Makinde *et al.*, 2009; Singh and Ram, 2012). In the humid tropics characterized by bimodal weather condition, cucumber production is gaining increased attention and its cultivation cuts across the seasons. However, details on the crop's responses to the different seasons vary, hence demands attention aimed at improving its productivity.

Generally, cucumber produces male and female flowers separately on the same individual plant (monoecious), though some may produce bisexual flowers (Perl-Treves, 1999). This implies that sex expression in the plant is subject to regulation by a number of environmental factors such as photoperiod, temperature and plant hormones (Yamasaki *et al.*, 2005). According to Staub *et al.* (2005) as well as Wehner and Guner (2004) increase in cucumber yields can be achieved through breeding for disease resistance, use of improved cultural practices and improvements in gynecious sex expression which tend to promote the production of pistillate flowers. Critical studies on character responses of some cucumber varieties to planting season, rates of NPK fertilizer application and planting season are highly limited, especially in the lowland humid tropics. Therefore, the objectives of this study were to: determine the effects of NPK (15:15:15) fertilizer rates on sex expression of three cucumber varieties, determine the effect of early- and late-season planting and NPK fertilizer rates on the growth and yield of the cucumber varieties and to determine the inter-relationship between yield and yield components of cucumber as to identify areas that require breeding concentration and advancements.

2. Materials and Methods

The field experiments with three varieties of cucumber (*Ashley*, *Betalpha* and *Market-more*) were conducted in two seasons [wet (early season) and dry (late season)] in 2011 at Umuafia, Ohokobe, Ndume, Abia State, Nigeria (05° 35' N, 07° 51' E, 122 masl); a community located about 5 km from Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria in the humid tropics. The location is characterized by a distinct wet and dry season with a bimodal pattern of rainfall distribution. According to Allaby (2002), the agro-ecological zone has a distinctive short dry spell in August which separates the two peaks of the rainy season in July and September. During the cropping seasons, (2011), the mean rainfall between March and May and between September and November was 223.8 mm and 219.40 mm, respectively while the mean minimum and maximum temperatures of the area were 23°C and 32°C (early season) and 22°C and 30°C (late season), respectively (Table 1).

Prior to planting in early- and late-season cropping, soil samples were collected randomly from different locations in the site at a depth of 0-20 cm, bulked together and a composite sample collected, air-dried and sieved through a 2 mm sieve for laboratory soil analysis following standard

procedures and the results are as shown in Table 2. Particle size distribution of the sampled soils was determined by Bouyoucos hydrometer method as outlined by Gee and Bander (1986) while the pH was determined using a suspension of soil and distilled water in the ratio of 2:5 soil water, which was stirred for 30 minutes and the pH value read with the aid of a glass electrode pH meter (McLean, 1982). Available phosphorus was colorimetrically determined by Bray II method (Olsen and Sommers, 1982) while total nitrogen was determined following Kjeldahl digestion procedure (Bremner and Mulvaney, 1982). Soil exchangeable calcium (Ca), magnesium (Mg), sodium (Na), and potassium (K) were extracted with neutral ammonium acetate. The Ca and Mg in the extracted leachate were determined by ethylenediaminetetraacetic acid (EDTA) titration method (Lanyon and Heald, 1984) while Na and K were determined by flame photometric method (Kundsen *et al.*, 1982). The experiments were conducted on a sandy loam soil that belongs to the order ultisol and classified as paleustult (FDALR, 1985).

Table 1. Agro-meteorological data of the early and late planting season of the study area

| Month / Season | Rainfall (mm) | | Temperature (°C) | | Relative humidity (%) |
|----------------|---------------|------|------------------|-------|-----------------------|
| | Amount | Days | Min | Max | |
| Early season | | | | | |
| March | 111.4 | 10 | 22 | 32 | 86 |
| April | 166.3 | 9 | 23 | 30 | 83 |
| May | 393.7 | 20 | 23 | 33 | 82 |
| Total | 671.4 | 39 | 68 | 95 | 251 |
| Mean | 223.8 | | 22.67 | 31.67 | 83.67 |
| Late season | | | | | |
| September | 393.61 | 21 | 21 | 32 | 87 |
| October | 251.8 | 14 | 22 | 30 | 86 |
| November | 12.7 | 4 | 22 | 29 | 83 |
| Total | 658.10 | 39 | 65 | 91 | 256 |
| Mean | 219.40 | | 21.67 | 30.33 | 85.33 |

Table 2. Physico-chemical properties of the soils Of the experimental sites for the early and late cropping seasons

| Attributes | Early season | Late season |
|-----------------------|--------------|-------------|
| Sandy (%) | 92.33 | 92.42 |
| Silt (%) | 1.09 | 1.07 |
| Clay (%) | 6.58 | 5.51 |
| Textural class | Sandy loam | |
| pH (H ₂ O) | 6.08 | 6.06 |
| Available P (mg/kg) | 9.67 | 9.05 |
| Total N (%) | 0.011 | 0.095 |
| Organic matter (%) | 4.971 | 7.895 |
| Mg (Cmol/kg) | 1.04 | 0.92 |
| K (Cmol/kg) | 280.0 | 280 |
| Na (Cmol/kg) | 0.86 | 0.94 |

Cucumber seeds obtained from the sub-station of National Institute of Horticultural Research, Mbato, Oki-gwe, Imo State, Nigeria were sown in flat beds at a spacing of 25 x 75 cm, which gave a plant population of 53,333 plants/ha. The experiment was laid out in split-split-plot in randomized complete block design with season (early and late) as the main plot, cucumber varieties (*Ashley*, *Betalpha* and *Market-more*) as the sub-plot and NPK fertilizer rates (0, 60, 120, 180, 240, 300 kg/ha) as the sub-sub-plot. There were three replications.

All data measurements were taken on a sample of four plants randomly selected in each plot. Sex expression attributes such as male and female flowers were determined at two days intervals by counting and the ratio obtained at the end of the experiment by dividing the male flowers against the female flowers. Cucumber fruits were harvested at six days intervals as they mature. Number of fruits per plant was obtained by counting and each fruit from all sampled plants was weighed with a sensitive electronic scale. Fruit length was obtained by measuring the fruit with a graduated rule from the fruit stalk to the tip of the fruit while fruit girth was obtained by measuring the fruit diameter with mathematical dividers and then the reading taken on a meter rule. Fruit yield was obtained as the cumulative weight of the fruits per plot and the total yield converted to tons per hectare.

All collected data were subjected to analysis of variance using Genstat Discovery Edition 3 Software (Genstat, 2003). Mean separation was done according to Obi and Obi (2002) using least significant difference (LSD) at 5% probability level. Principal component analysis (PCA), which is a multivariate technique used in the analyses of series of data which observations are explained by several inter-correlated quantitative dependent variables was used to measure the genetic diversity in the selected cucumber varieties (Abdi and Williams, 2010). Principal components of plant characters are known to be orthogonal and normally independent of each other. According to Mohammadi and Prasanna (2003), the total variation obtained in the original data may be broken down into components that are cumulative in nature. PCA also, helps us to identify the genetic distance between crop genotypes. Our data was therefore analyzed according to PRINCOMP procedure using SAS software (SAS Institute Inc., 2002). Multiple correlation coefficients were obtained between all possible combinations of traits using Pearson correlation coefficients analysis with the help of SPSS for windows version 17.0 software (2010) following the procedure outlined by Miller *et al.* (1958) and the significance tested by referring to the biometrical standard table (Steel *et al.*, 1997). Path coefficients analysis was done based on Dewey and Lu (1959) and Wright (1960; 1934) to partition the correlation coefficients of the traits into direct and indirect effects. It was achieved by generating standardized partial regression coefficients (path coefficients) that were independent of the original units of measurement. A large path coefficients is an indication that the resultant change will show a proportional (or inversely proportional) change in another correlated trait,

whereas weak path coefficients is an indication that the resultant change will have insignificant effect on the second trait.

3. Results and Discussion

The yield and yield attributes of three cucumber varieties as influenced by planting season and NPK fertilizer rates are shown in Table 3. The results revealed that planting season significantly ($P<0.01$) affected fresh fruit yield of cucumber while variety, NPK rate and the interaction effects were not significant ($P>0.05$). Early planting had better yield (2.00 kg/ha) than late planting (0.94 t/ha), which indicated 112.8% increase in yield compared to the late planting season. This implied that in this agro-ecological zone (humid tropics), cucumber is best cultivated during the early planting season when the rains are relatively stable with less cloudiness. Contrarily, Makinde *et al.* (2009) in their studies on maize/cucumber intercrop in the guinea savanna reported higher cucumber fruit yields under late planting season relative to early planting season. Furthermore, Singh and Ram (2012) indicated that cucumber genotypes grown in multi-environmental structures react differently to a range of climatic conditions, soil characteristics and even technical practices. Among the varieties evaluated (*Ashley*, *Betalpha* and *Market-more*), *Ashley* had higher yields relative to *Betalpha* and *market-more*. However, there was no significant ($P>0.05$) difference between them. Furthermore, irrespective of the season and cucumber varieties, there was an increase in the yield of cucumber from 0 kg/ha NPK up to 120 kg/ha NPK, and thereafter, there was a progressive yield reduction with further increase in fertilizer application up to 300 NPK kg/ha, suggesting that 120 kg/ha NPK is the optimum NPK (15:15:15) fertilizer rate for the cucumber varieties evaluated in this agro-ecological zone. However, the effect of different rates of fertilizer on yield of the cucumber varieties did not show any significant ($P>0.05$) difference. The systematic increase in NPK fertilizer rate enhanced the release of essential nutrients, which invariably increased cucumber growth and productivity. The findings are in consonance with studies by Adekiya and Ojeniyi (2002) as well as John *et al.* (2004).

The interaction of planting season and cucumber variety on fruit weight of the evaluated varieties (Table 4) showed that early season planting significantly ($P<0.05$) gave higher fresh fruit weight (180.13 g/plant) than late season planting (152.0 g/plant), irrespective of the cucumber variety. Among the cucumber varieties, *Market-more* produced fruit weight that was higher by 14.8% and 24.3% compared to *Ashley* and *Betalpha*, respectively, regardless of the planting season. As shown in Table 5, the influence of planting season, variety and N:P:K fertilizer rates on fruit number per plot revealed that there was significant ($P<0.05$) interaction between planting season, variety and N:P:K fertilizer rate as well as between planting season and N:P:K fertilizer rates. Irrespective of cucumber variety, the application of 240 t/ha N:P:K fertilizer during early season planting gave the highest

number of fruits per plot (15.13) compared with the other N:P:K fertilizer rates studied while 0 t/ha NPK fertilizer gave the lowest (9.22). Similarly, Mahmond *et al.* (2009), Eifediye and Remison (2010) as well as Shehatal *et al.* (2012) in their various investigations indicated increased fresh fruit yield of cucumber with the application of inorganic fertilizers, however, they remarked that a combination of inorganic and organic fertilizers induced higher and better quality fruits. Early season planting gave significantly ($P < 0.05$) higher fruit weight per plot compared to late season planting regardless of cucumber variety and N:P:K fertilizer rates used in the study.

Principal component analysis (PCA), which is an important multivariate technique employed to examine associations between characters, and measure the genetic diversity in the selected cucumber varieties according to Solanki and Shah, (1989) as well as Abdi and Williams (2010) revealed that only the first three principal component axes (PC₁, PC₂ and PC₃) in the PCA analysis had eigen-vector values whose loads were more than unity (Table 6) while the four principal components altogether accounted for the cumulative variance of 82.60%. The results further showed that PC₁, PC₂, PC₃ and PC₄ with

eigen-values of 2.3699, 1.4741, 1.0544 and 0.8842, respectively, accounted for 33.9%, 21.1%, 15.1% and 12.6%, respectively of the total variability observed among the three cucumber varieties. In PC₁ and PC₂, the characters that accounted for most of the variability include number of female flowers, male-female flower ratio, fruit girth and fruit length. PC₃ was particularly high in male flowers (0.6592), fruit number (0.5029) and male-female flower ratio (0.4423). Furthermore, PC₃ and PC₄ with percentage variation ranging from 12.60 to 15.10 showed high loading for fruit weight. The cumulative variance of 70.0% by the first three axes with eigen-vector values > 1.0 indicated that the identified characters within them exhibited great influence on the cucumber varieties, hence, could effectively be employed for selection in cucumber studies. The findings corroborate results reported by Cui *et al.* (1995) in their investigation on traits selection in cucumber breeding expressing the efficacy of principal component analysis in enhancing cucumber improvement strategies and Staub *et al.* (1997) on their studies on problems associated with the selection of determinant cucumber plant types in a multiple lateral background as well as Shetty and Wehner (2002b) in their studies on fruit yield of cucumber.

Table 3. Effect of seasons and NPK rates on the yield and yield components of three cucumber varieties

| Treatment | Attributes | | | | | | | |
|---------------------|--------------|------------------|--------------|-------------------|------------------|-------------|--------------------------|---------------|
| | Yield (t/ha) | Fruit weight (g) | No. of Fruit | Fruit Length (cm) | Fruit girth (cm) | Male flower | Male-female flower ratio | Female flower |
| Season | | | | | | | | |
| Early | 2.00 | 180.1 | 11.98 | 16.77 | 14.71 | 123.1 | 0.145 | 17.1 |
| Late | 0.94 | 152.0 | 10.50 | 13.57 | 10.40 | 225.3 | 0.104 | 35.0 |
| LSD _{0.05} | 0.08 | 48.77 | - | - | 3.13 | 39.71 | - | - |
| Sig. | ** | ** | ns | ns | * | * | ns | ns |
| Varieties | | | | | | | | |
| Ashley | 1.70 | 162.7 | 11.33 | 14.69 | 12.83 | 176.8 | 0.162 | 27.8 |
| Betalpha | 1.11 | 144.5 | 11.11 | 15.48 | 12.25 | 177.5 | 0.147 | 23.2 |
| Marketmore | 1.60 | 191.0 | 11.28 | 15.33 | 12.58 | 168.3 | 0.154 | 26.0 |
| LSD _{0.05} | - | - | - | - | - | - | 0.035 | - |
| Sig. | ns | ns | ns | ns | ns | ns | * | ns |
| NPK rates | | | | | | | | |
| 0 | 0.92 | 129.0 | 9.89 | 14.45 | 12.24 | 161.6 | 0.157 | 16.3 |
| 60 | 1.23 | 153.6 | 10.44 | 13.15 | 10.89 | 190.1 | 0.159 | 28.5 |
| 120 | 1.96 | 196.2 | 10.11 | 15.12 | 11.89 | 181.7 | 0.175 | 34.0 |
| 180 | 1.61 | 169.1 | 10.78 | 15.37 | 14.26 | 162.1 | 0.146 | 22.1 |
| 240 | 1.70 | 191.9 | 11.83 | 16.44 | 12.49 | 185.1 | 0.141 | 23.3 |
| 300 | 1.40 | 157.5 | 14.39 | 16.46 | 10.89 | 164.6 | 0.149 | 23.7 |
| LSD _{0.05} | - | - | 2.808 | - | - | - | - | - |
| Sig. | ns | ns | * | ns | ns | ns | ns | ns |

Table 4. Influence of planting season and variety on fruit weight of three cucumbers (g/plant)

| Season | Attributes | | | |
|--------|---------------|-----------------|-------------------|--------|
| | <i>Ashley</i> | <i>Betalpha</i> | <i>Marketmore</i> | Mean |
| Early | 201.3 | 176.1 | 163.0 | 180.13 |
| Late | 124.1 | 112.9 | 219.0 | 152.0 |
| Mean | 162.2 | 144.5 | 191.0 | |

LSD0.05 = season x variety = 48.77

Table 5. Influence of planting season, variety and NPK rates on fruit number per plot

| Season | Variety | 0 | 60 | 120 | 180 | 240 | 300 | Mean |
|-------------|-------------------|-------|-------|-------|-------|-------|-------|-------|
| Early 11.98 | <i>Ashley</i> | 7.67 | 13.33 | 12.60 | 11.33 | 18.00 | 13.33 | 12.61 |
| | <i>Betalpha</i> | 8.00 | 10.00 | 13.33 | 13.67 | 11.69 | 12.00 | 11.45 |
| | <i>Marketmore</i> | 12.00 | 9.67 | 11.67 | 10.67 | 15.69 | 11.67 | 11.89 |
| | | 9.22 | 11.00 | 12.53 | 11.89 | 15.13 | 12.33 | |
| Late 10.50 | <i>Ashley</i> | 11.33 | 8.33 | 10.00 | 13.00 | 4.67 | 13.00 | 10.60 |
| | <i>Betalpha</i> | 9.33 | 10.33 | 5.00 | 4.67 | 12.67 | 22.67 | 10.74 |
| | <i>Marketmore</i> | 11.33 | 11.33 | 8.67 | 11.33 | 8.33 | 13.67 | 10.67 |

LSD0.05: season x variety x NPK rates = 9.667

Season x NPK rates = 4.784

Table 6. Eigen vector values of the principal components of the yield and associated traits

| Attributes | PC ₁ | PC ₂ | PC ₃ | PC ₄ |
|-----------------------------------|-----------------|-----------------|-----------------|-----------------|
| Female flowers | 0.5267 | 0.4042 | 0.0380 | -0.0541 |
| Male-female flower rates | 0.3620 | 0.5405 | 0.4423 | -0.1995 |
| Male flowers | 0.3707 | -0.1061 | 0.6592 | 0.1774 |
| Fruit girth | -0.4349 | 0.4293 | 0.0660 | 0.2622 |
| Fruit length | -0.4398 | 0.4368 | 0.0911 | 0.1953 |
| Fruit number | 0.0902 | 0.3849 | 0.5029 | 0.1040 |
| Fruit weight | 0.2519 | 0.0997 | 0.3208 | 0.8885 |
| Eigen vector value | 2.36985 | 1.47410 | 1.05439 | 0.88422 |
| Percentage variation contribution | 33.90 | 21.10 | 15.10 | 12.60 |
| Cumulative variance contribution | 33.90 | 54.90 | 70.00 | 82.60 |

Table 7. Pearson correlation coefficients of yield and yield components of three cucumber varieties grown under different planting seasons and NPK fertilizer rates

| | Male flower | Female flower | No. of Fruits / plant | Fruit weight (g) | Fruit length (cm) | Fruit girth (cm) | Male-female flower ratio | Yield (kg/ha) |
|--------------------------|----------------------|----------------------|-----------------------|----------------------|----------------------|----------------------|--------------------------|---------------|
| Male flower | 1.00 | | | | | | | |
| Female flower | 0.573** | 1.00 | | | | | | |
| Fruit ns | 0.102 ^{ns} | 0.167 ^{ns} | 1.00 | | | | | |
| Fruit weight (g) | 10.113 ^{ns} | -0.173 ^{ns} | 0.021 ^{ns} | 1.00 | | | | |
| Fruit length (cm) | -0.270** | -0.235* | 0.061 ^{ns} | 0.213* | 1.00 | | | |
| Fruit girth (cm) | -0.269** | -0.233* | 0.050 ^{ns} | 0.171 ^{ns} | 0.670** | 1.00 | | |
| Male-female flower ratio | -0.096 ^{ns} | 0.742** | 0.139 ^{ns} | -0.131 ^{ns} | -0.109 ^{ns} | -0.110 ^{ns} | 1.00 | |
| Yield (kg/ha) | -0.137 ^{ns} | -0.036 ^{ns} | 0.471** | 0.574** | 0.178 ^{ns} | 0.181 ^{ns} | 0.052 ^{ns} | 1.00 |

*, ** = significant at 5%, and 1% level, respectively, ns = non significant

Table 8. Cause and effect analysis showing direct and indirect effects of yield components on fresh fruit yield of three varieties of cucumber

| Attributes | Direct effect | Indirect effect | | | | |
|----------------------|---------------|-------------------------|------------------|----------------------|---------------------|---|
| | | No. of fruits/ plant | Fruit weight (g) | Fruit length (cm) | Fruit girth (cm) | Pearson correlation with fruit yield |
| No. of fruits/ plant | 0.457 | - | 0.0121 | -0.001 | 0.004 | 0.471** |
| Fruit weight (g) | 0.565 | 0.010 | - | -0.004 | 0.013 | 0.013** |
| Fruit length (cm) | -0.019 | 0.028 | 0.118 | - | 0.051 | 0.178 ^{ns} |
| Fruit girth (cm) | 0.076 | 0.023 | 0.095 | -0.013 | - | 0.818 ^{ns} |
| Residual effect | | | | | | 0.456 |

** , ns = significant at 1% level and non significant, respectively.

Pearson correlation analysis among cucumber fruit yield and its contributing attributes (Table 5) showed that correlation of fresh fruit yield per hectare was found to be highly significant ($P \leq 0.01$) and positive for number of fruits per plant and weight of fruits per plant with correlation coefficients (r) of 0.471 and 0.574, respectively. The findings are in line with that of Ogbodo *et al.* (2010) in their multi-locational trial on cucumber in the derived savanna agro-ecological zone as well as Afangideh *et al.* (2005) in the forest agro-ecological zone of Southeastern Nigeria. Highly significant ($P \leq 0.01$) and positive correlation was obtained between male-female flower ratio and number of female flowers per plant (0.742) and between fruit girth and fruit length (0.670). However, number of male flowers per plant showed negative and significant correlation with number of female flowers per plant (-0.233). Fruit length was significantly and positively correlated with fruit weight with ($r = 0.213$) but showed significant and negative correlation with number of male flowers per plant and number of female flowers per plant with ($r = -0.270$ and -0.235), respectively. The relationship between number of female flowers and number of male flowers was highly significant ($P \leq 0.01$) and positive ($r = 0.513$). Number of fruits per plant and fruit weight showed significant and positive correlation with total fruit yield. The findings are in consonance with results of Golabadi *et al.* (2013) in their studies on determining relationships between different horticultural traits in *Cucumis sativus* genotypes.

Cause and effect analysis means partitioning of Pearson correlation coefficients into direct and indirect effects (Table 7) and the maximum direct effect on fruit yield of cucumber was shown by fruit weight (0.565) followed by number of fruits per plant (0.457) and fruit girth (0.076). Fruit weight also exerted positive indirect effect via number of fruits per plant and fruit girth while number of fruits per plant exerted positive indirect effect only through fruit weight. The results from the study corroborates similar reports by Roa *et al.* (2004) and Arunkumar *et al.* (2011b) in India as well as Golabadi *et al.* (2013) in Iran in their separate investigations in which they indicated that number of cucumber fruits per plant projected the greatest positive effect on total fruit yield of cucumber, an indication that the trait is one of the most reliable component for selecting high fruit yielding cucumber genotypes. However, Cramer and Wehner (2000)

in their studies on eight distinctive cucumber populations reported strong positive interaction between number of branches per cucumber plant and total number of fruits per plant and stressed the importance of number of branches per plant in selection for improved total fruit yield. Indirect and positive effect of fruit girth was achieved via number of fruits per plant and fruit weight. Fruit weight and number of fruits per plant had high direct effect along with genotypic correlation. The contribution of other characters, viz.; fruit girth and fruit length was negligible. A low residual effect (0.456) was obtained from the analysis.

4. Conclusions

Our findings indicated significant increase in fruit yield of cucumber planted during the early rainfall season in the humid tropics. *Market-more* cucumber variety gave better fruit yield at 120 kg/ha N:P:K fertilizer rate compared to the rates used in the trial. Principal component analysis, correlations and path coefficients analysis revealed that plant characters such as number of female flowers per plant, male-female flower ratio, fruit weight per plant and number of fruits per plant significantly influenced fruit yield of cucumber in both seasons, hence, in breeding and selection for high yield, these characters demand prime attention.

REFERENCES

- [1] Abdi, H. and Williams, L.J. (2010). Principle Component Analysis. Wiley Interdisciplinary, Reviews Computational Statistics. 2: 433-459.
- [2] Adekiya, A.O. and Ojeniyi, S.O. 2002. Evaluation of tomato growth and soil properties under methods of seedling bed preparation in an Alfisol in the rainforest zone of southwest Nigeria. Bio-resource Technol., 96: 509-516.
- [3] Afangideh, U., Uyoh, E.A., Ittah, M. and Uko, A.E. 2005. Morphological characterization of some cultivars of cucumber (*Cucumis sativus* L.). J. Sustain. Trop. Agric. Res., 14: 13 - 18.
- [4] Allaby, M. (2002). Encyclopedia of weather and climate. New York.

- [5] Arankumar, K.H., Patil, M.G., Hunchinmamani, C.N., Goud, I.S., Thiremath, S.V. 2011a. Genetic relationship of growth and development traits with fruit yield in F2 population of BGDIX hot season of cucumber (*Cucumis sativus* L.). karnataka J. Agric. Sci., 24: 497-500.
- [6] Arunkumar, K.H., Ramanjinapa, V., Ravishankar, M. 2011b. Path coefficient analysis in F2 population of cucumber (*Cucumis sativus* L.). Plant Archives. 11: 471-474.
- [7] Belay, A.A., Classens, S., Wehner, F.C. and De Beer, J.M. 2001. Influence of residual manure on selected nutrient elements and microbial composition of soil under long term crop rotation. South African J. Plant and soil, 18:1-6.
- [8] Best, K. 2000. Adaptation of cabbage varieties. ARP Training Reports. AVRDC-AFRICA. Regional Programme, Arusha, Tanzania. 10 pp.
- [9] Bremner, J.M. and Mulvaney, C.S. 1982. Nitrogen total. In: Page, A.L., Miller, P.H., Keeney, D.R, editors. Methods of soil analysis. Part 2. Chemical and microbiological properties. (2nd ed.). Madison (WI): American Soc. Agron. pp.595-262.
- [10] Cramer, C. and Wehner, T. 2000. Path Analysis of the Correlation between Fruit Number and plant traits of cucumber populations. Hortsci., 35(4): 708–711.
- [11] Cui, H., Zang, M., Meng, H. and Deng, J. 1995. Principal component analysis for traits selection in cucumber breeding. Cucurbit Genetics Cooperative Report, 18 (5): 10-12.
- [12] Dewey, D.R. and Lu, K.H. 1959. A correlation and path coefficient analysis of components of crested wheatgrass seed production. Agron. J., 51:515–518.
- [13] Eifediyi, E.K. and Remison, S.U. 2010. Growth and yield of cucumber (*Cucumis sativus* L.) as influenced by farmyard manure and inorganic fertilizer. Researcher, 2(4): 1-6.
- [14] FDALR., 1985. Federal Department of Agriculture and Land Resources Reconnaissance Soil Survey of Anambra State, Nigeria, Soil Report, FDALR., Kaduna, Nigeria.
- [15] Gee, G.W. and Brauder, J.W. 1986. Particle size analysis. In: Klute, A. (eds.). Methods of soil Analysis. Part 1. Monograph No. 9. America Soc. Agron., Madison, WI. 91-100.
- [16] Genstat Committee (2003). Reference Manual (Genstat Release 7.0) VSN International Limited, Oxford, Uk. www.discovery.genstat.co.uk.
- [17] Golabadi, M., Eghtedary, A.R., Golkar, P.P. 2013. Determining relationships between different horticultural traits in (*Cucumis sativus* L.) Genotypes with multivariate analysis. Sabrao J. Breeding and Genet., 45 (3): 447-457.
- [18] John, L.W., James, D.B., Samuel, L.T. and Warner, L.W. 2004. Soil Fertility and Fertilizers: An Introduction to Nutrient Management. Pearson Education, India. pp.106–53.
- [19] Kundsén, D., Peterson, G.A. and Pratt, P.F. 1982. Lithium, Sodium and Potassium. In: page, A.L. (ed.). Methods of soil analysis. Part 2. Monograph, No. 9. American Soc. Agron., Madison, WI., pp. 241-262.
- [20] Lanyon, L.E. and Heald, W.R. 1984. Magnesium, Calcium, Strontium and Barium. In: Page, A.L. (ed.). Methods of soil Analysis. Part 2. Monograph, No. 9. American Soc. of Agron., Madison, WI. pp. 241-262.
- [21] Mahmoud, E., Abd EL- Kader, N., Robin, P., Akkal-Corfini, N. and Abd El-Rahman, L. 2009. Effects of Different Organic and Inorganic Fertilizers on Cucumber Yield and Some Soil Properties. World J. Agric. Sci., 5 (4): 408-414.
- [22] Makinde, A.A and Bello, N.J. 2009. Effects of soil temperature pattern on the performance of cucumber intercrop with maize in a tropical wet-and-dry climate of Nigeria. Researcher, 1(2): 24-36. www.sciencepub.net, sciencepub@gmail.com.
- [23] Mclean, E.O. 1982. Soil pH and lime requirements. In: Page A.L., Miller, P.H., Keeney, DR., editors. Methods of soil analysis. Part 2. Chemical and microbiological properties. (2nd ed.) Madison (WI): American Soc. Agron., pp. 199-124.
- [24] Miller, P.A., Williams, J.C., Robinson, H.F. and Comstock, R.E. 1958. Estimates of genotypic and environmental variances and covariances in upland cotton and their implications in selection. Agron. J., 50:126-131.
- [25] Mohammadi, S.A. and Prasanna B.M. 2003. Analysis of genetic diversity in crop plants salient statistical tools and considerations. Crop Sci., 43: 1235–1248.
- [26] Obi, I.U. and Obi, E. 2002. Statistical Methods of Detecting Differences Between Treatment Means and Methodology Issues in Laboratory and Field Experiments. (2nd ed.), AP Express Publishing Company, Limited, Nsukka, Nigeria. 116 pp.
- [27] Ogbodo, E.N., Okorie, P.O. and Utobo, E.B. 2010. Introducing cucumber for cultivation at New different zone in Ebonyi State, southeastern, Nigeria. Libyan Agric. Res. Cent. J. Internl., 1 (16): 336-343.
- [28] Olsen, S.R. and Sommers, L.E. 1982. Phosphorus. In: Page, A.L., Miller, R.H. and Keeney, D.R. (eds.). Methods of soil Analysis, Part 2. (2nd ed). America Soc. Agron., Inc. Madison, WI.
- [29] Perl-Treves, R.1999. Male to female conversion along the cucumber shoot: approaches to study sex genes and floral development in *Cucumis sativus*. In: Ainsworth, C.C. (ed.). Sex determination in plant. Oxford: BIOS Scientific Publishers, 189-286.
- [30] Rao, E.S., Munshi, A.D., Verma, V.K. 2004. Genetic association and interrelationship of yield and its components in cucumber (*Cucumis sativus* L.). Indian J. Hort., 61: 315-318.
- [31] Shehata, S.A., Yasser, M.A., Youssef, T.E. and Mahmoud A.A. 2012. Influence of some organic and inorganic fertilizers on vegetative growth, yield and yield components of cucumber plants. Res. J. Agric. and Biol. Sci., 8(2): 108-114.
- [32] Shetty, N.V and Wehner, T.C. 2002a. Estimation of fruit grade weights based on fruit number and total fruit weight in cucumber. Hort. Sci., 37: 1117-1121.
- [33] Shetty, N.V. and Wehner, T.C. 2002b. Screening the cucumber germplasm collection for fruit yield and quality. Crop sci., 42: 2174-2183.
- [34] Singh, A. and Ram, H.H. 2012. Estimates of stability parameters for yield and its components in cucumber (*Cucumis sativus* L.). Vegetable Sci., 39 (1): 31-34.
- [35] Solanki, S.S. and Shah, A. 1989. Path analysis of fruit yield components in cucumber. Progressive Hort., 21: 322–324.

- [36] SPSS Statistical Package for Windows (2010). SPSS for windows. Release 17.0 Standard Version.
- [37] Statistical Analysis System. 2002. Guides for personal computers. Version 9.00 (ed.). SAS Institute Inc., Cary NC. USA.
- [38] Staub, J.E., Chung, S.M. and Fazio, G. 2005. Conformity and genetic relatedness estimation in crop species having a narrow genetic base: The case of cucumber (*Cucumis sativus* L.). Plant Breeding, 124: 44-53.
- [39] Staub, J.E., Serquen, F.C. and McCreight, J.D. 1997. Genetic diversity in cucumber (*Cucumis sativus* L.): III. An evaluation of Indian germplasm. Genetics. Res. Crop Evol., 46: 297-310.
- [40] Steel, R.G., Torie, J.H. and Dickey, D.A. 1997. Principles and Procedures of Statistics: A Biometrical Approach. (3rd ed.). McGraw Hill, Co. Inc. New York, 666 pp.
- [41] Tatliogu, T. 1993. Cucumber (*Cucumis sativus* L.) In: Kailor, G. and Bo Bergn, (eds.). Genetic improvement of vegetable crops. Oxford Pergamon Press, pp. 197-227.
- [42] Thoa, D.K. 1998. Cucumber seed multiplication and characterization. AVRDC/ARC Training, Thailand.
- [43] United States Department of Agriculture, Agricultural Research Service, Nutrient Data Laboratory. 2014. USDA National Nutrient Database for standard reference, Release 27. 128 pp.
- [44] Vimala, P., Ting, C.C., Salbiah, H., Ibrahim, B. and Ismail, L. 1999. Biomass production and nutrient yields of four green manures and their effects on the yield of cucumber. J. Trop. Agric. and Food Sci., 27: 47-55.
- [45] Wehner, T.C. and Guner, N. 2004. Growth stage, flowering pattern, yield and harvest date prediction of four types of cucumber tested at 10 planting dates. Proc. XXVI IHC-Advances in Vegetable Breeding. (eds.). McCreight, J.D. and Ryder, E.J., Acta Hort., 637: 223-229.
- [46] Wright S. 1960. Path coefficient and path regression: alternative or complementary concepts? Biomet., 16: 189-202.
- [47] Wright S. 1934. The method of path coefficients. Ann. Math. Stat. 5:161-215.
- [48] Yamasaki, S., Fuji, N. and Takahashi, H. 2005. Hormonal regulation of sex expression in plants. Vitamins and Hormones, 72: 79-110.