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**Research Paper**

# Agronomic Performance and Association between Yield and Yield Related Traits of Some Watermelon [*Citrullus Lanatus* (Thumb) Mastum and Nakai] Genotypes Humid Tropical Agro-Ecology

AGAH*, L. J., ITTAH, M. A. and UKATU, P. O.
*Department of Crop Science, Faculty of Agriculture, Forestry and Wildlife Resources Management, University of Calabar, PMB 1115, Calabar, Cross River State, Nigeria*
*Corresponding author's E-mail: ukpat6237@gmail.*

***ABSTRACT***
*Six watermelon (Citrullus lanatus (Thumb) Mastum and Nakai) varieties were evaluated in the field to measure variations in yield traits and established the association between the traits and the yield. The experiment was laid out in randomized complete block design (RCBD) in three replications. The variety $F_1$ Koloss had the highest fruit yield (3.00 t/ha) while Baby Doll had the lowest fruit yield (1.67 t/ha). Among the reproductive characters, weight of fruits per plot and number of fruits per plant had high positive correlation ($r = 0.60$, $p < 0.05$).The number of fruits per plant had negative correlation with other characters except vine length per plant that had low correlation ($r = 0.23$, $p < 0.05$) with number of fruits per plant. Moderate positive correlation existed between number of leaves per plant with number of branches per plant ($r = 0.58$, $p < 0.05$), vine length ($r = 0.57$, $p < 0.05$), number of male flowers per plant ($r = 0.51$, $P < 0.05$) and number of branches per plant ($r = 0.61$, $p < 0.05$). Number of leaves, branches and longer vine could be simultaneously improved in watermelon. Hence, these characters could be used as criteria for improvement of the watermelon cultivated in the humid. The genotypes $F_1$ Koloss and Kaolack had the highest number of fruits per plant, number of branches per plant than the other varieties (Sugar baby, Sugar dragon, Crimson sweet and Baby Doll) planted in the humid environment. Therefore, $F_1$ Koloss and Kaolack are recommended for cultivation in the humid tropical ecology.*

***KEYWORDS: Citrullus lanatus , phenotypic variation, Correlation, genotypic variation, watermelon***

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## I. INTRODUCTION

Watermelon (*Citrullus lanatus* (Thumb.) Mastum and Nakai) is a member of the plant family Cucurbitaceae; it is grown in both temperate and tropical regions of the world. World production is about 77.5 MT of fruit from 3.1 million hectares of cultivated land (FAO 2018). According to FAO (2018) and Horticultural Statistics (2017), the major watermelon producing countries are China (70.3%), Turkey (4.7%), Iran (2.3%), United States of America (2.2%) and Egypt (1.7%). It is one of the most widely grown vegetable crops in the world after tomato, onions and cabbage (Pushpam *et al.*, 2017 and Wehner, 2016). Watermelon is an economically important fruit crop which provides important source of minerals and water for human consumption (Khan *et al.*, 2016). In Europe, heavy syrup is made from watermelon (Pete, 2008). Iraqis and Africans consume the flesh of watermelon as food, compound it to produce animal feed and use it as source of water in the desert (Johnson *et al.*, 2013).

Despite the high nutritional value of watermelon and its importance, production level in humid tropical environment hardly meets the demand requirement due to lack of improved varieties that can adapt to the widely different conditions in the agro-ecological zones and farmers rely on landraces with low productivity. Major morphological traits in watermelon have strong association with the yield, these traits includes vine length, number of primary and secondary vines, leaf area, the number of fruits, size of fruits, vigour, earliness, rind pattern and number of seeds. The traits contribute significantly to yield improvement and each of these components adds its own value to the genetic system and is useful in the improvement of yield trait (Om and

Vijay, 2016). Genetic improvement in watermelon is possible through selection as the breeding method for morphological trait with high associations with yield, especially traits that has high values of genetic components (Khan *et al*., 2016).

Cramer and Wehner (2000) confirmed that total yield can be determined by measuring various yield component traits. That is, total yield is measured as total number of fruits per plot; economic yield is measured as number of sizeable fruits per plot with marketable yield potential. Cramer and Wehner (2000) noted correlation between the yield component traits and observed that correlation between total and economic yield was positive and high (0.87), selection to increase the number of marketable fruits per plot would result in increase in total and economic or fruit yield.

Fruit yield in watermelon is quantitatively inherited, thus improvement in yield trait requires an indirect approach of selecting yield characteristics that have high heritability and is correlated with yield. Morphological traits with strong association with yield are number of branches per plant, number of flowers per plant, fruit size and vine length (Ene *et al*., 2016, Ahamed *et al.*, 2012 and Wehner, 2014). Om and Vijay (2016) further showed that the number of leaves and number of branches per plant had the greatest direct effects on the total number of fruits per plant while correlation between other yield components and total fruit number were weak. These characteristics can also be utilized in a watermelon breeding programme when the available germplasm is fully characterized but this potential has not been sufficiently achieved in watermelon in the humid tropical ecology.

Many people in Nigeria consume watermelon as vegetable of choice and a large number of local lines and exotic varieties are cultivated in Nigeria yet there is no recommended cultivar for the humid tropical agro-ecology, this poses a challenge for watermelon breeding in the humid ecology. The plant breeders rely heavily on variability among genotypes as a mean of identifying and obtaining germplasm for improvement of high yielding cultivars. The humid tropic has about two-thirds the population of Nigeria and it is an important market for watermelon. This study is therefore designed to bridge the gap of insufficiency in supply of watermelon by evaluating the yield potentials of existing genotypes in the country and developing materials for farmers in the region. The objectives of the study were to measure the morphological variation in six varieties of watermelon and establish the association between the morphological and yield traits in the watermelon varieties.

## II. MATERIALS AND METHODS

**Experimental site**

The experiment was conducted in Akpabuyo Local Government Area, Cross River State, Nigeria. Akpabuyo is a humid environment with rainforest vegetation; it is characterized by high rainfall with distinct wet and dry seasons. The wet season start from March to early November and the dry season commenced in early November to late February (Meteorological data report 2018). The rainfall requirement for the growing season range from 400 mm to 600 mm, the temperature is about $27^0$C and relative humidity is 82% (FAO, 2018 and Meteorological data report 2018).The soil type in the experimental area is coastal plain soil with severe leaching and low organic matter and exchangeable bases (Udo *et al.*, 2009).

**Planting materials and Experimentation**

Six varieties of watermelon seeds were obtained from Agritropic Nigerian Limited, Calabar. The varieties were Sugar baby, Kaolack, Sugar dragon, Crimson sweet, $F_1$ Koloss and Baby doll. Two seeds were sown per hole at a spacing of 120cm X 120 cm and seedlings were thinned to one seedling per stand at two weeks after sowing. The experiment was laid in a randomized complete block design (RCBD) with three replications; the six watermelon varieties formed the six treatments. A plot of land, 42.8m x 18.8m (804.64 $m^2$) was manually cleared, prepared and planted in September 2015. Cured poultry manure was incorporated into the soil two weeks before sowing at the rate of 5 t/ha. The spacing of 120cm X 120 cm and a plant population of 558.77 plant/ha, seedling rate of 69,168.38kg/ha and a net plot size of 2.40m x 1.20m (2.88 $m^2$) were maintained and set aside for data collection.

Data, based on six tagged plants, were collected on number of leaves per plant at two, four and six weeks after planting (WAP), number of branches per plant at four, six WAP and at harvest, vine length per plant at four, six WAP and at harvest, number of days to 50% flowering, number of male and female flowers per plant, fruit weight per pod , number of fruit per plant , weight of 100 seeds per fruit and number of days to fruit maturity.

Data collected were analyzed using GENSTAT statistical package (Genstat, 1995) for randomized complete block design while means that were significantly different were compared with Duncan's Multiple Range Test (DMRT).

## III. RESULTS AND DISCUSSIONS

The data on morphological traits in the six watermelon cultivars grown in the humid environment showed no significant difference ($p \geq 0,05$) in number of leaves, number of branches and vine length (Table 1). This result is similar to report by Bernard *et al*., (2014) that noted no differences on qualitative characters of commercial varieties (Sugar baby and Crimson sweet) of watermelon grown in Kenya.

The number of leaves per plant produced at 2 weeks after planting (WAP) ranged from 2.0 in Kaolack to 3.33 in Sugar Dragon, the number of leaves per plant produced by the watermelon varieties was not significantly different ($p \geq 0.05$) at two WAP. At six WAP, Crimson sweet had the highest number of leaves (19.70), but there was no significant difference in the leaf number among the varieties.

The mean number of branches per plant at four WAP, ranged from 1.0 in Baby Doll and Sugar Dragon to 1.33 Sugar baby, Kaolack, Crimson sweet, and $F_1$ Koloss . Kaolack and Baby Doll had the same and highest number of branches (6.67) at six WAP. There is no significant difference ($p \geq 0.05$) in the number of branches per plant produced by the cultivars studied at four and six WAP , at harvest, the number of branches per plant ranged from 11.33 in Sugar baby, producing the fewest branches to 23.67 in Kaolack producing the highest number of branches. There was no significant difference in the number of branches among the following varieties, Crimson sweet, $F_1$ Koloss and Baby Doll at first harvest.

The length of vines per plant at four WAP ranged from10 cm in Baby Doll to 18.3 cm in $F_1$ Koloss. Kaolack, produced the longest vines (70.0cm) at six WAP, there was no significant difference ($p \geq 0.05$) in length of vine among the varieties at four and six WAP, at harvest, Kaolack had the longest length of vine (430cm) and Baby Doll with the shortest vine length of (177 cm) at first harvest.

The higher number of branches and longer vines at first harvest observed among the different varieties could increase photosynthetic activities in vegetative and yield stages in the crop. This study has result similar to report by Bernard *et al.,* (2014) that noted significant difference in Sugar baby and Crimson sweet varieties of watermelon for vine length and number of branches. The result also agrees with the reports by Afangideh *et al.,* (2005) that observed high number of branches at harvest and longer vines in exotic cucumber cultivars.

The number of primary branches per plant is shown in Table 1. There was no significant difference in the number of branches between Kaolack and Sugar dragon, but the number of branches at harvest was significantly more in Kaolack and Sugar dragon than in Sugar baby, Crimson sweet, $F_1$ Koloss and Baby Doll.

**TABLE 1.** Some growth traits in six exotic watermelon varieties planted in humid tropical agro-ecology

| Accessions | Number of Leaves | | | N Br | | Vine length | | VLH | NPBH |
|---|---|---|---|---|---|---|---|---|---|
| | 2WAP | 4WAP | 6WAP | 4WAP | 6WAP | 4WAP | 6WAP | | |
| Sugar baby | 3.00$^{a}$ | 5.67$^{a}$ | 11.30$^{a}$ | 1.33$^{a}$ | 5.33$^{a}$ | 11.70$^{a}$ | 40.00$^{a}$ | 314$^{ab}$ | 11.33$^{e}$ |
| Kaolack | 2.00$^{a}$ | 6.00$^{a}$ | 19.30$^{a}$ | 1.33$^{a}$ | 6.67$^{a}$ | 16.70$^{a}$ | 70.00$^{a}$ | 430$^{a}$ | 23.67$^{a}$ |
| Sugar dragon | 3.33$^{a}$ | 5.33$^{a}$ | 9.70$^{a}$ | 1.00$^{a}$ | 5.33$^{a}$ | 10.70$^{a}$ | 30.00$^{a}$ | 283$^{ab}$ | 18.67$^{ab}$ |
| Crimson sweet | 3.00$^{a}$ | 5.33$^{a}$ | 19.70$^{a}$ | 1.33$^{a}$ | 5.67$^{a}$ | 13.30$^{a}$ | 42.70$^{a}$ | 270$^{ab}$ | 17.00$^{cd}$ |
| $F_1$ Koloss | 3.00$^{a}$ | 6.00$^{a}$ | 17.30$^{a}$ | 1.33$^{a}$ | 5.67$^{a}$ | 18.30$^{a}$ | 49.30$^{a}$ | 360$^{ab}$ | 13.67$^{cd}$ |
| Baby Doll | 2.67$^{a}$ | 5.67$^{a}$ | 18.70$^{a}$ | 1.00$^{a}$ | 6.67$^{a}$ | 10.00$^{a}$ | 33.30$^{a}$ | 177$^{c}$ | 13.00$^{cd}$ |

Key: Means followed by the same letter are not significantly different by DMRT at ($P<0.05$); WAP = Week after planting, NBr = number of branches per plant, VLH = Vine length at first harvest, NPBH = Numbers of primary branches at first harvest.

The yield and yield related characters are presented in Table 2. The number of days to 50% flowering per plant ranged from 30.33 days in Kaolack to 38 days in Baby doll.

The number of male flowers per plant ranged from 4.00 in Baby Doll to 10.67 in Kaolack (Table 2). Kaolack producing the highest number of pollen and Baby Doll producing least. Kaolack significantly ($p \leq 0.05$) produced more male flowers than $F_1$ Koloss and Baby doll.

. The number of female flowers per plant ranged from 11.00 in Sugar baby to 13.33 in Baby Doll, there was no significant difference ($p \geq 0.05$) in the number of female flowers per plant. This result in exotic watermelon varieties disagrees with Ahamed *et al.,* (2012) that noted wide variation in flowering pattern of pumpkin genotypes in Bangladesh. The number of fruits per plant ranged from 1.67 in Baby Doll to 3.00 in $F_1$ Koloss. $F_1$ Koloss significantly ($p \leq 0.05$) produced more fruits per plant than Sugar baby and Baby doll, and Baby Doll variety producing the fewest fruits. Similar result was reported by Ene *et al.,* (2016), they observed significant differences in number of fruits per plant in cucumber, Ahamed *et al.,* (2012) observed significant differences in number of fruits per plant in pumpkin genotypes and Kumar and Wehner (2013a) also reported wide variation in Kaolack in tropical environment. Kaolack produced the lowest weight of 100 seeds per fruit

(457g) and Sugar baby produced the highest seeds weight per fruit (556g), there is no significant difference in weight of 100 seeds among the varieties. Weight of fruits per plant ranged from 3.80 kg in Kaolack to 7.30kg in Sugar dragon variety. Sugar dragon significantly produced heavier fruits per plant than Sugar baby, Kaolack, Crison sweet, $F_1$ Koloss and Baby doll in the humid tropical ecology.

The mean number of days from planting to fruit maturity ranged from 76 days in Baby Doll to 82.67days in Kaolack variety. The variation in the number of days to fruit maturity is an indication of varietal differences along with the influence of the environment on the cultivars analysed. Kumar and Wehner (2013) reported similar observation; they noted a longer duration in the number of days to fruit maturity in Kaolack in tropical environment than Baby Doll.

**TABLE 2.** Variation in yield and yield related characters in six exotic watermelon varieties planted in humid tropical agro-ecology.

| Variety | D50% F | NMF | NFF | MFN | W100S | MFP | DFM |
|---|---|---|---|---|---|---|---|
| Sugar baby | 33.00$^{b}$ | 8.33$^{ab}$ | 11.00$^{a}$ | 2.00$^{ef}$ | 556$^{a}$ | 5.33$^{b}$ | 78.33$^{ab}$ |
| Kaolack | 30.33$^{a}$ | 10.67$^{a}$ | 13.00a | 2.67$^{ab}$ | 457$^{a}$ | 3.80$^{f}$ | 82.67$^{c}$ |
| Sugar dragon | 35.00$^{a}$ | 7.67$^{ab}$ | 11.33$^{a}$ | 2.67$^{abc}$ | 460$^{a}$ | 7.30$^{a}$ | 77.67$^{ab}$ |
| Crimson sweet | 32.00$^{a}$ | 9.00$^{ab}$ | 11.33$^{a}$ | 2.33$^{abcd}$ | 487$^{a}$ | 4.33$^{de}$ | 77.00$^{ab}$ |
| $F_1$ Koloss | 33.67$^{b}$ | 6.33$^{cd}$ | 13.00$^{a}$ | 3.00$^{a}$ | 534$^{a}$ | 5.53$^{b}$ | 80.00$^{ab}$ |
| Baby doll | 38.00$^{a}$ | 4.00$^{e}$ | 13.33$^{a}$ | 1.67$^{g}$ | 459$^{a}$ | 4.90$^{bc}$ | 76.00$^{a}$ |

Key: Mean followed by the same letter are not significantly different by DMRT at (P<0.05); NMF= Number of male flowers, NFF = Number of female flowers, MFN= fruit number per plant, W100 S= Weight of 100 Seed per plot, MFP=Mean fruit pod weight per plant,D50% F = Number of days to 50% flowering, DFM = days to fruit maturity.

There was medium positive correlation between number of leaves per plant and the number of branches per plant ($r = 0.58$, $p < 0.05$) and vine length ($r = 0.57$, $p < 0.58$). The implication is that selection for number of leaves per plant and number of branches can be selected simultaneously in this watermelon population (Table 3).Number of fruit per plant had showed high positive correlation ($r = 0.60$ $p < 0.05$) with fruit weight per plot among all reproductive characters measured. The implication is that selection for number of fruit per plant could have direct association with fruit weight per plot. The result also agrees with the reports of Ene *et al.*, (2016), they observed high positive correlation in number of fruit per plant with yield related component in cucumber. Similar result was reports by Ahamed *et al.*, (2012), they observed high positive correlation between number of fruit per plant and fruit weigh in pumpkin and Wehner (2014) also observed high positive correlation between number of fruit per plant and fruit weight in watermelon grown in USA. Hence, selection of these traits could be used as an indicator for crop improvement in watermelon cultivars cultivated in humid tropic (Table 3).

Low correlation existed between number of female flower, number of days to 50% flowering, number of days to fruit maturity and weight of 100 seeds per plot. The implication is that, a decrease in reproductive characters could adversely affect yield and other related yields components in watermelon. Hence, characters could be used as an indicator for yield traits crop improvement in watermelon. This result confirmed reports by Om and Vijay (2016) that noted low correlation between yield and other related yields component in tomato

**TABLE 3. Correlations indices for yield traits in six exotic watermelon varieties grown in humid environment**

| Character FWP | FWP | DFF | DFM | MLN | MBN | NPBH | NFF | NMF | NFP | W100S MVL |
|---|---|---|---|---|---|---|---|---|---|---|
| **DFF** | **0.43*** | | | | | | | | | |
| **DFM** | **-0.20** | **-0.47** | | | | | | | | |
| **MLN** | **-0.03** | **-0.10** | **0.33*** | | | | | | | |
| **MBN** | **-0.68** | **-0.28** | **0.12*** | **0.58**** | | | | | | |
| **NPBH** | **-0.19** | **-0.50** | **0.38*** | **-0.06** | **-0.05** | | | | | |
| **NFF** | **0.40*** | **0.07** | **-0.12** | **0.12*** | **-0.03** | **0.21*** | | | | |
| **NMF** | **-0.22** | **-0.76** | **0.23*** | **0.30*** | **0.13*** | **0.51**** | **0.29*** | | | |
| **NFP** | **0.60**** | **-0.33** | **0.05*** | **-0.24** | **-0.23** | **0.28*** | **0.08*** | **0.18*** | | |
| **W100S** | **0.03*** | **-0.11** | **-0.22** | **-0.03** | **0.18*** | **-0.22** | **-0.12** | **0.06*** | **0.19*** | |
| **MVL** | **-0.20** | **-0.37** | **0.40*** | **0.57**** | **0.61**** | **0.28** | **0.25*** | **0.33*** | **0.23*** | **0.08*** |

**Key: FWP = Fruit weight per plot, DFF = Number of days to 50% flowering, DFM = Number of days to fruit maturity, MLN = Mean leaves number, MBN = Mean branch number, NFF = Number of female**

**flowers, NMF = Number of male flowers, NFP = Number of fruit yield per plant, W100 S = weight of 100 seeds per fruit, MVL = Mean vine length,**

## IV. CONCLUSION AND RECOMMENDATIONS

Positive correlation existed between number of leaves per plant with number of branches per plant, length of vine, number of male flowers, number of fruit per plant, fruit weight per plot and number of branches per plant. Number of leaves, branching and longer vine could lead to simultaneous improvement of watermelon. Hence, these characters should be used as basis for improvement of the watermelon cultivars cultivated in the humid tropical environment.

F1 Koloss and Kaolack had the best performance in the varieties should be cultivated the humid tropical agr-ecology.

**CONFLICT OF INTEREST DECLARATION**: The authors hereby declare that there is no conflict of interest on this work.

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