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**Research Article**

# Selection indices for fruit yield improvement in elite cucumber (*Cucumis sativus* L.) cultivars

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Cucumber (*Cucumis sativus* L.) is an important vegetable crop, rich in vitamins and minerals and eaten fresh as a dessert. Its fruit yield is relatively low, though could be improved through knowledge of character association with it and selection of desirable materials for improvement programmes. Fifteen cultivars of Cucumber were evaluated at two locations (Abeokuta and Ibadan), South West, Nigeria in a randomized complete block design with three replicates in order to determine heritability, correlation, direct and indirect effects of characters on fruit yield. Data collected on agro-morphological characters were subjected to analysis of variance, estimates of heritability, correlation, and path analysis. Significant variations ($p$ <0.05) were observed in the cultivars. High heritability estimates (>90%) was observed for fruit length at both locations. A significant phenotypic and genotypic correlation was observed between fruit yield and fruit weight. Number of days to 50% flowering and fruit width could also be selected directly for improvement of fruit yield in cucumber.

**Keywords:** cucumber, selection indices, heritability, correlation, path analysis

## 1 Introduction

Cucumber (*Cucumis sativus* L) is an important crop in Nigeria (Nweke et al.,2013) and it's a useful ingredient in pharmaceuticals (Kumar et al., 2010). Crop improvement through selection depends on fruit yield and inter-relationships of characters that contributes to yield (Pal et al., 2017). Yield is polygenic character, which is determined by the inter-relationship of other characters. The extent of variability is determined by coefficients of variances (Johnson et al., 1955). High genotypic coefficients of variation are indicative of the potential for selection (Burton & DeVane, 1953). Heritability is an indication of the ease of transmission of characters from parent to offspring, while genetic advance estimates actual gain expected under selection (Ogunniyan & Olakojo, 2015). High heritability and genetic gain are indicative of additive gene action and response to selection (Singh & Rai, 1981). Correlation coefficients were used to determine pair-wise comparison between characters and yield while path analysis was used to partition correlation coefficients into direct and indirect effects, showing individual contribution of a character and how it contributes to yield. The objectives of this study were to determine the heritability and inter relationship of characters in cucumber will serve as selection indices for its improvement.

## 2 Materials and methods

### 2.1 Planting materials, field evaluation and data collection

The study was conducted at the Teaching and Research Farms, Federal University of Agriculture Abeokuta, Ogun State Nigeria (Latitude 7.2° N, Longitude 3.4° E) AS location 1 and the Vegetable Research Field of National Horticultural Research Institute (NIHORT) Idi-Ishin, Ibadan, Oyo State Nigeria (Latitude 7.4° N, Longitude 3.8° E) AS Location 2. Fifteen cultivars of cucumber were used in the experiments and arranged in a randomized complete block design with 3 replicates. Each cultivar was planted in a 2-row plot of 5 × 1m using an inter-row spacing of 0.5 m and intra-row spacing of 1 m. Two seeds were sown per hole and later thinned to one seedling per stand. Observations were made on number of days

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to emergence, number of days to 50% flowering, leaf length (cm), leaf width (cm), leaf area ($cm^2$), vine length (cm), fruit length (cm), fruit width (cm), number of fruits, number of days to maturity, fruit weight (g) and fruit yield (ton).

### 2.2 Data analysis

Data were subjected to analysis of variance using Statistical Analysis System (SAS), (2000) (ver. 8.1) software. Phenotypic, genotypic, and environmental variances were estimated according to Prasad et al. (1981). Broad sense heritability and genetic advance were calculated according to Johnson et al. (1955) and Allard (1960). Phenotypic and genotypic coefficients of variation were estimated with the formula of Johnson et al. (1955). Genotypic, phenotypic, and environmental correlations were computed according to Miller et al. (1958) and path coefficient analysis estimated as outlined by Dewey and Lu (1959).

## 3 Results and discussion

The combined analysis of variance (Table 1) revealed a significant ($p$ <0.05) interaction between cultivar × location effect for all characters except for fruit width, number of fruits, number of days to maturity and fruit yield. The effect of genotype X environment interaction and this implies that selection for such characters based on phenotypic performance will not be reliable. Hence, selection and recommendations for such characters should be location specific. High heritability estimates (Table 2) for number of days to germination, fruit length and fruit weight in both locations indicates the lesser role the environment plays in the phenotypic expression of these characters; hence selection for them is likely to be effective as also reported by Dubey et al. (2013) and Kumar et al. (2013). High estimate of genetic advance (GA) observed in fruit length and fruit weight in both locations and fruit yield in Abeokuta are indications of prospects for effective selection. High genotypic coefficient of variation (GCV) along with high heritability and genetic advance provides a better index for selection of genotypes as reported by Johnson et al. (1955). Hence, moderate to high GCV, heritability and genetic advance observed in number of days to germination, leaf area, fruit length, fruit weight and fruit yield could be attributed to additive gene action, which makes selection for them simple and reliable. Significant phenotypic correlations for most characters with fruit yield were recorded except for number of days to germination and number of fruits in both locations (Table 3). The leaves and fruit parameters showed a significant genotypic correlation with fruit yield in both locations (Table 4). The highly significant and positive phenotypic and genotypic correlations observed in fruit yield with fruit length, fruit width, number of days to maturity, fruit weight in both location implies that both characters can be improved simultaneously in a selection programme. These findings were similar to the earlier reports of Ullah et al. (2012) and Golabadi et al. (2013). The direct and indirect effect of characters on fruit yield in cucumber in both locations (Table 5) revealed that the highest direct effect was recorded for leaf length (0.87). However, leaf area showed a highest negative direct effect (-0.87).

**Table 1** Combined analysis of variance for agronomic and yield characters evaluated in fifteen cucumber cultivars in both locations

| Source | df | DTE | DTF | LL | LWD | LA | VL |
|---|---|---|---|---|---|---|---|
| **Block/location** | 4 | 0.49* | 10.48 | 3.76** | 4.51* | 750.77* | 1195.91** |
| **Location** | 1 | 4.01** | 132.01** | 8.71** | 19.19** | 3193.66** | 10113.67** |
| **Cultivar** | 14 | 4.40** | 27.37** | 5.01** | 8.69** | 1446.21** | 847.14** |
| **Location × cultivar** | 14 | 0.13 | 11.27** | 2.15** | 5.76** | 958.34** | 484.26** |
| **Error** | 56 | 0.19 | 3.85 | 0.83 | 1.43 | 237.77 | 159.49 |

| Source | FL | FWD | NoF | DTM | FWT | FYLD |
|---|---|---|---|---|---|---|
| **Block/location** | 4.13 | 1.87 | 37.26** | 38.21 | 5529.28** | 1034.71* |
| **Location** | 1.48 | 3.44 | 108.90** | 149.51** | 25934.58** | 240.36 |
| **Cultivar** | 191.41** | 12.32** | 12.04 | 47.64** | 18601.00** | 2676.02** |
| **Location × cultivar** | 6.98** | 1.91 | 8.50 | 30.06 | 1466.07* | 581.22 |
| **Error** | 2.65 | 1.41 | 7.97 | 20.01 | 654.71 | 316.53 |

** significant at $P \leq 0.01$, * significant at $P \leq 0.05$, DTE – number of days to emergence, DTF – number of days to 50% flowering, LL – leaf length (cm), LWD – leaf width (cm), LA – leaf area ($cm^2$), VL – vine length (cm), FL – fruit length (cm), FWD – fruit width (cm), NoF – number of fruits, DTM – number of days to maturity, FWT – fruit weight (g), FYLD – fruit yield ($tons.ha^{-1}$)

**Table 2** General mean estimates of variance components, broad sense heritability and genetic advance in both locations for fifteen cucumber varieties

| Character | Location | Mean | PV | GV | PCV | GCV | Hb | GA |
|---|---|---|---|---|---|---|---|---|
| **DTE** | 1 | 4.36 | 0.72 | 0.67 | 19.48 | 18.84 | 93.49 | 37.52 |
| | 2 | 4.78 | 0.79 | 0.71 | 18.57 | 17.60 | 89.81 | 34.37 |
| **LL** | 1 | 9.24 | 0.95 | 0.82 | 10.54 | 9.82 | 86.78 | 18.84 |
| | 2 | 9.86 | 1.44 | 1.01 | 12.16 | 10.21 | 70.48 | 17.66 |
| **LWD** | 1 | 12.21 | 2.49 | 2.31 | 12.91 | 12.46 | 93.12 | 24.77 |
| | 2 | 13.13 | 2.33 | 1.55 | 11.62 | 9.48 | 66.47 | 15.92 |
| **LA** | 1 | 103.20 | 413.62 | 385.16 | 19.71 | 19.02 | 93.12 | 37.80 |
| | 2 | 115.12 | 387.90 | 257.85 | 17.11 | 13.95 | 66.47 | 23.43 |
| **VL** | 1 | 110.49 | 372.43 | 293.09 | 17.47 | 15.50 | 78.70 | 28.32 |
| | 2 | 89.28 | 71.37 | 44.38 | 9.46 | 7.46 | 62.19 | 12.12 |
| **DTF** | 1 | 34.56 | 7.46 | 5.94 | 7.9 | 7.05 | 79.67 | 12.97 |
| | 2 | 32.13 | 5.43 | 4.38 | 7.25 | 6.51 | 80.66 | 12.05 |
| **FL** | 1 | 17.03 | 24.37 | 22.95 | 28.99 | 28.13 | 94.17 | 56.23 |
| | 2 | 17.29 | 41.75 | 41.41 | 37.37 | 37.22 | 99.17 | 76.36 |
| **FWD** | 1 | 14.43 | 1.89 | 1.30 | 9.51 | 7.91 | 69.08 | 13.54 |
| | 2 | 14.83 | 2.86 | 2.50 | 11.4 | 10.67 | 87.46 | 20.55 |
| **NoF** | 1 | 15.42 | 3.77 | 0.20 | 12.59 | 2.93 | 5.43 | 1.41 |
| | 2 | 13.22 | 3.28 | 1.73 | 13.7 | 9.96 | 52.88 | 14.92 |
| **DTM** | 1 | 61.64 | 15.15 | 8.50 | 6.31 | 4.73 | 56.08 | 7.30 |
| | 2 | 59.07 | 10.75 | 4.06 | 5.55 | 3.41 | 37.80 | 4.32 |
| **FWT** | 1 | 168.44 | 4470.70 | 4277.14 | 39.7 | 38.83 | 95.67 | 78.23 |
| | 2 | 202.39 | 2218.32 | 1975.40 | 23.27 | 21.96 | 89.05 | 42.69 |
| **FYLD** | 1 | 5029.34 | 754145.71 | 645903.97 | 34.53 | 31.96 | 85.65 | 60.93 |
| | 2 | 5226.22 | 230826.93 | 147634.13 | 18.39 | 14.70 | 63.96 | 24.22 |

1 – Abeokuta, 2 – Ibadan, PV – phenotypic variance, GV – genotypic variance, PCV – phenotypic coefficient of variation(%), GCV – genotypic coefficient of variation(%), Hb – broad sense heritability (%), GA – genetic advance as % of the mean, DTE – number of days to emergence, DTF – number of days to 50% flowering, LL – leaf length (cm), LWD – leaf width (cm), LA – leaf area ($cm^2$), VL – vine length (cm), FL – fruit length (cm), FWD – fruit width (cm), NoF – number of fruits, DTM – number of days to maturity, FWT – fruit weight (g), FYLD – fruit yield ($ton.ha^{-1}$)

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**Table 3** Phenotypic correlation coefficients among the characters of cucumber cultivars evaluated in both locations

| Character | Location | LL | LW | LA | VL | DTF | FL | FW | NoF | DTM | FW | FYLD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **DTE** | 1 | 0.12 | 0.17 | 0.17 | -0.44** | 0.17 | -0.15 | -0.24 | -0.42** | 0.65** | 0.02 | -0.10 |
| | 2 | -0.21 | -0.32* | -0.32* | -0.05 | 0.43** | 0.00 | 0.01 | -0.46** | -0.09 | 0.10 | -0.21 |
| **LL** | 1 | | 0.95** | 0.95** | 0.30* | 0.04 | -0.51** | -0.60** | 0.32* | -0.39** | -0.80** | -0.76** |
| | 2 | | 0.95** | 0.95** | 0.53** | 0.15 | -0.30* | -0.43** | -0.34* | -0.03 | -0.34* | -0.61** |
| **LW** | 1 | | | 1.00** | 0.21 | -0.18 | -0.57** | -0.63** | 0.18 | -0.37* | -0.82** | -0.84** |
| | 2 | | | 1.00** | 0.52** | 0.10 | -0.35* | -0.40** | -0.23 | -0.10 | -0.43** | -0.63** |
| **LA** | 1 | | | | 0.21 | -0.18 | -0.57** | -0.63** | 0.18 | -0.37* | -0.82** | -0.84** |
| | 2 | | | | 0.52** | 0.10 | -0.35* | -0.40** | -0.23 | -0.10 | -0.43** | -0.63** |
| **VL** | 1 | | | | | 0.35* | -0.01 | 0.18 | 0.59** | -0.30* | -0.27 | -0.07 |
| | 2 | | | | | 0.12 | -0.27 | -0.15 | -0.14 | -0.19 | -0.24 | -0.33* |
| **DTF** | 1 | | | | | | 0.38** | 0.00 | 0.26 | 0.31* | 0.19 | 0.33* |
| | 2 | | | | | | -0.22 | -0.18 | 0.07 | -0.15 | -0.25 | - 0.18 |
| **FL** | 1 | | | | | | | 0.51** | 0.07 | 0.15 | 0.75** | 0.81** |
| | 2 | | | | | | | 0.79** | -0.33* | 0.79** | 0.90** | 0.76** |
| **FWD** | 1 | | | | | | | | 0.07 | 0.21 | 0.67** | 0.75** |
| | 2 | | | | | | | | -0.13 | 0.48** | 0.82** | 0.82** |
| **NoF** | 1 | | | | | | | | | -0.51** | -0.37* | -0.07 |
| | 2 | | | | | | | | | -0.34* | -0.47** | 0.20 |
| **DTM** | 1 | | | | | | | | | | 0.51** | 0.40** |
| | 2 | | | | | | | | | | 0.66** | 0.48** |
| **FWT** | 1 | | | | | | | | | | | 0.94** |
| | 2 | | | | | | | | | | | 0.77** |

*,** significant at 5% and 1% level of probability, respectively, 1 – Abeokuta, 2 – Ibadan, DTE – number of days to emergence, DTF – number of days to 50% flowering, LL – leaf length (cm), LWD – leaf width (cm), LA – leaf area ($cm^2$), VL – vine length (cm), FL – fruit length (cm), FWD – fruit width (cm), NoF – number of fruits, DTM – number of days to maturity, FWT – fruit weight (g), FYLD – fruit yield (ton $ha^{-1}$)

**Table 4** Genotypic correlation coefficients among the characters of cucumber varieties evaluated in both locations

| Character | Location | LL | LW | LA | VL | DTF | FL | FWD | NoF | DTM | FWT | FYLD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **DTE** | 1 | 0.14 | 0.22 | 0.22 | -0.50** | 0.20 | -0.16 | -0.32* | -1.77** | 0.92** | 0.02 | -0.11 |
| | 2 | -0.32* | -0.45** | -0.45** | -0.04 | 0.48** | -0.01 | 0.00 | -0.79** | -0.21 | 0.16 | -0.25 |
| **LL** | 1 | | 0.99** | 0.99** | 0.29* | 0.10 | -0.58** | -0.86** | 0.85** | -0.48** | -0.86** | -0.92** |
| | 2 | | 0.98** | 0.98** | 0.62** | 0.17 | -0.37* | -0.61** | -0.70** | 0.04 | -0.44** | -0.98** |
| **LWD** | 1 | | | 1.00** | 0.19 | -0.19 | -0.63** | -0.81** | 0.53** | -0.45** | -0.87** | -0.97** |
| | 2 | | | 1.00** | 0.65** | 0.09 | -0.44** | -0.59** | -0.52** | 0.03 | -0.55** | -1.03** |
| **LA** | 1 | | | | 0.19 | -0.19 | -0.63** | -0.81** | 0.53** | -0.45** | -0.87** | -0.97** |
| | 2 | | | | 0.65** | 0.09 | -0.44** | -0.59** | -0.52** | 0.03 | -0.55** | -1.03** |
| **VL** | 1 | | | | | 0.52** | -0.05 | 0.11 | 2.68** | -0.43** | -0.31* | -0.10 |
| | 2 | | | | | 0.14 | -0.35* | -0.23 | -0.21 | -0.52** | -0.35* | -0.51** |
| **DTF** | 1 | | | | | | 0.48** | 0.13 | 1.27** | 0.46** | 0.19 | 0.40** |
| | 2 | | | | | | -0.25 | -0.21 | 0.07 | -0.11 | -0.20 | -0.14 |
| **FL** | 1 | | | | | | | 0.53** | -0.20 | 0.28 | 0.81** | 0.85** |
| | 2 | | | | | | | 0.83** | -0.47** | 1.30** | 0.96** | 0.95** |
| **FWD** | 1 | | | | | | | | -0.63** | 0.50** | 0.87** | 0.88** |
| | 2 | | | | | | | | -0.22 | 0.96** | 0.96** | 1.14** |
| **NoF** | 1 | | | | | | | | | -2.08** | -1.30** | -1.82** |
| | 2 | | | | | | | | | -0.78** | -0.61** | -0.11 |
| **DTM** | 1 | | | | | | | | | | 0.71** | 0.70** |
| | 2 | | | | | | | | | | 0.99** | 0.74** |
| **FWT** | 1 | | | | | | | | | | | 1.05** |
| | 2 | | | | | | | | | | | 0.87** |

**, * significant at 5% and 1% level of probability, respectively, 1 – Abeokuta, 2 – Ibadan, DTE – number of days to emergence, DTF – number of days to 50% flowering, LL – leaf length (cm), LWD – leaf width (cm), LA – leaf area ($cm^2$), VL – vine length (cm), FL – fruit length (cm), FWD – fruit width (cm), NoF – number of fruits, DTM – number of days to maturity, FWT – fruit weight (g), FYLD – fruit yield ($ton/ha^{-1}$)

**Table 5** Direct and indirect effect of some characters on fruit yield in cucumber in both locations

| Characters | Location | Direct effect | LL | LW | LA | VL | DTF | FL | FW | DTM | FW | Genotypic correlation coefficients |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LL | 1 | 0.87 | | 0.00 | -0.86 | -0.15 | 0.04 | 0.01 | -0.70 | 0.15 | -0.27 | -0.92** |
| | 2 | -2.73 | | 0.01 | 1.50 | 0.29 | 0.05 | -0.40 | 0.35 | 0.01 | -0.05 | -0.98** |
| LWD | 1 | 0.00 | 0.87 | | -0.87 | -0.10 | -0.08 | 0.01 | -0.66 | 0.14 | -0.28 | -0.97** |
| | 2 | 0.01 | -2.69 | | 1.52 | 0.31 | 0.03 | -0.48 | 0.34 | 0.00 | -0.07 | -1.03** |
| LA | 1 | -0.87 | 0.87 | 0.00 | | -0.10 | -0.08 | 0.01 | -0.66 | 0.14 | -0.28 | -0.97** |
| | 2 | 1.52 | -2.67 | 0.01 | | 0.31 | 0.03 | -0.48 | 0.34 | 0.00 | -0.07 | -1.03** |
| VL | 1 | -0.53 | 0.25 | 0.00 | -0.17 | | 0.22 | 0.00 | 0.09 | 0.14 | -0.10 | -0.1 |
| | 2 | 0.47 | -1.69 | 0.00 | 1.00 | | 0.04 | -0.38 | 0.13 | -0.09 | -0.04 | -0.51** |
| DTF | 1 | 0.41 | 0.09 | -0.00 | 0.16 | -0.28 | | -0.01 | 0.11 | -0.15 | 0.06 | 0.40** |
| | 2 | 0.30 | -0.46 | 0.00 | 0.14 | 0.07 | | -0.27 | 0.12 | -0.01 | -0.02 | -0.14 |
| FL | 1 | -0.02 | -0.51 | -0.00 | 0.55 | 0.03 | 0.20 | | 0.43 | -0.09 | 0.26 | 0.85** |
| | 2 | 1.09 | 1.00 | -0.00 | -0.67 | -0.16 | -0.08 | | -0.48 | 0.15 | 0.12 | 0.95** |
| FWD | 1 | 0.82 | -0.74 | -0.00 | 0.70 | -0.06 | 0.05 | -0.01 | | -0.16 | 0.28 | 0.88** |
| | 2 | -0.58 | 1.65 | -0.00 | -0.89 | -0.11 | -0.06 | 0.91 | | 0.11 | 0.12 | 1.14** |
| DTM | 1 | -0.32 | -0.42 | -0.00 | 0.39 | 0.23 | 0.19 | -0.00 | 0.41 | | 0.23 | 0.70** |
| | 2 | 0.11 | -0.12 | 0.00 | 0.05 | -0.25 | -0.03 | 1.41 | -0.56 | | 0.12 | 0.74** |
| FWT | 1 | 0.32 | -0.74 | -0.00 | 0.76 | 0.17 | 0.08 | -0.01 | 0.71 | -0.23 | | 1.05** |
| | 2 | 0.12 | 1.21 | -0.00 | -0.84 | -0.16 | -0.06 | 1.04 | -0.55 | 0.11 | | 0.87** |

*, ** significant at 5% and 1% level of probability, respectively, location 1 – Abeokuta, location 2 – Ibadan, residual effect location 1 = 0.27; location 2 = 0.63, DTF – number of days to 50% flowering, LL – leaf length (cm), LWD – leaf width (cm), LA – leaf area ($cm^2$), VL – vine length (cm), FL – fruit length (cm), FWD – fruit width (cm), DTM – number of days to maturity, FWT – fruit weight (g)

Number of days to 50% flowering, fruit width and fruit weight all had positive direct contributions to fruit yield suggesting that these characters can be used for direct selection to improve fruit yield in cucumber cultivars in Abeokuta (Location 1). Despite the strong positive correlation of fruit yield with number of days to maturity and fruit length, their direct effect on fruit yield was negative. This shows the ineffectiveness of selection based only on phenotypic correlation alone. The residual effect of (0.27) Abeokuta and (0.63) Ibadan implies that 73% and 37% of the total variation in fruit yield has been determined. It further portrays the occurrence of some factors not considered in this study contributed to fruit yield in cucumber.

## 4 Conclusion

This study revealed significant variation in the cucumber cultivars evaluated in both locations. Characters such as number of days to germination, leaf area, fruit length, fruit weight and fruit yield could be rewarding in the selection for improved yield. Also, high heritability estimates of number of days to germination, fruit length and fruit weight in both locations shows the reliability of selection of these traits for yield improvement. Fruit length, fruit width, fruit weight and number of days to maturity in both locations could be improved simultaneously for fruit yield. Also, direct selection for number of days to 50% flowering, fruit width and fruit weight would serve as good indices for improvement of fruit yield in cucumber.

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