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Impact of Crossbreeding on the Growth and Yield Improvement of two Cultivars of S. *aethiopicum* L. found in Anambra State

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ABSTRACT

The need for the adjustment of beneficial crop species for yield improvement and sustainability is paramount. Plant breeders employ the techniques of crossbreeding in the control of plant attributes and structure for man's needs and other purposes. Due to the relevance of vegetables to our diet which S. aethiopicum is inclusive, two cultivars of Solanum aethiopicum found in Anambra State (S. aethiopicum var "Anara Adazi" and S. aethiopicum var "Anara") were crossbred to produce a hybrid that may incorporate features from both parent cultivars to increase production and ensure sustainability. This was done manually using the artificial crossing. Data analysis was done using analysis of variance. Findings showed that the hybrid combined the features of the parental plants with other enhanced attributes. The F1 hybrid had the highest fresh fruit length and the highest number of fruits per plant when compared to the parental plants. This outcome might be the result of more branches, which would enable more fruits to be produced per plant and thus facilitate heterosis. Data obtained showed that a new hybrid with improved traits from both parent plants is created when two S. aethiopicum plants of distinct but closely related cultivars are crossbred. Therefore, in S. aethiopicum species, crossbreeding could be employed to increase yield and also in species breeding selection programs.

Keywords: *hybridization, growth, yield, sustainability, cultivars, S. aethiopicum, heterosis*

Introduction

The genus *Solanum* is nearly global, with over 1000 species and at least 100 native African species. Members of this genus grow in a variety of ways, including vines, shrubs, tiny trees, annuals, and perennials (Dressler *et al*., 2014). The majority of plant portions, particularly the green sections or immature fruits, are toxic to humans. However, a large number of plants in the genus have components that can be eaten, such as fruits, leaves, or tubers. For ages, three distinct crops have been produced worldwide for human sustenance through breeding and harvesting. Tomatoes, potatoes, and eggplant are all included (Dressler *et al*., 2014). Other species that are significant food crops geographically are Turkey berry (*S. torvum*), pepino melon (*S. muricatum*), Tamarillo (*S. betaceum*), and Ethiopian eggplant (*S. aethiopicum*), which is the focus of this research.

Solanum aethiopicum, a cultivated eggplant native to Africa, belongs to the genus *Solanum* and the family *Solanaceae* (Lester and Seck, 2004). It is usually known as scarlet eggplant, Ethiopian eggplant, "pumpkin on a stick," or "mock tomato" (Alsherbiny *et al*., 2018). This vegetable is well-liked in northeastern India, where it is referred to as samtawk in Mizo and khamen akhaba in Manipuri. In Nepal, Darjeeling, and Sikkim, they are referred to as Titay bii or just bii, and they are delicious with meat, especially pig. These titles come from its varied appearance; ripe fruit frequently resembles a hybrid between a tomato (also from *Solanum*) and an eggplant. The Ethiopian garden egg was so similar to the regular garden egg that some people mistakenly thought it was a *S. aethiopicum* variation called violaceum. In tropical Africa, it is one of the most popular vegetables (Schippers, 2000). The leaves have smooth or lobed borders and are placed in an alternating pattern on the stems. The maximum length of a leaf blade is 30 cm (11.8 in), and the maximum breadth is 21 cm (8.3 in). The elliptical or oval-shaped leaf petioles can grow up to 11 cm (4.3 in) in length. Plants bear up to twelve clusters of white flowers, which mature into berries that resemble eggs or spindles and range in color from red to orange. Depending on the cultivar, the berries may have a smooth or grooved surface. (Burkill, 2000).

S. aethiopicum's fruit, leaves, shoots, and roots are used for food and medicine; the particular usage varies depending on the region and/or variety of plants. For instance, *S. aethiopicum's* immature fruits are occasionally consumed raw or utilized as cooked vegetables. Additionally, the leaves and shoots can be cooked and served as vegetables. On the other hand, many African nations employ the fruits, leaves, and roots of bitter cultivars as medicine to alleviate conditions like colic, high blood pressure, and uterine issues (Lester and Seck, 2004; Sunseri et *al.* 2010; Adeniji et *al,* 2012). Eating the leaves of *Solanum aethiopicum* as a leaf vegetable is more nutrient-dense than eating the fruit (Venkateswarhu and Kashna, 2009). The leaves and fruits relative bitterness is a major factor in determining whether they are edible or poisonous.

The phenotypic variability of *S. aethiopicum* has led to the prior classification of some cultivars as distinct species, as well as confusion with *S. incanum* and other species. Four cultivar-groups are now recognised, as follows:-

S. aethiopicum Gilo Group. The fruits are consumed unripe,

cooked in stews, or even uncooked. They resemble hens' eggs or come in a variety of shapes and sizes. When mature, the fruits turn scarlet (Ken, 2014). *S. aethiopicum* Shum Group. The glabrous small-leaved shoots of this group are cooked like spinach and are farmed throughout tropical Africa, particularly in Cameroon and Uganda. *S. aethiopicum* Kumba Group. This group is grown in sub-Sahelian West Africa, particularly Senegal, in the wet season. Large, delicious, ribbed fruits are eaten raw or cooked in stews after the large, glabrous leaves are boiled like spinach (Ken, 2014). *S. aethiopicum* Aculeatum Group. These thorny ornamental plants are bred for their somewhat disease-resistant nature and their beautiful, but intensely bitter, scarlet fruits (Ken, 2014). Nonetheless, two *S. aethiopicum* cultivars are discovered and frequently cultivated in Anambra State: *S. aethiopicum* vars. "Anara Adazi" and "Anara".

S. aethiopicum var "Anara Adazi" is called “Anara Adazi” in Igbo because, it is cultivated and predominantly discovered in Adazi town within Anambra State, and the variety thrives and works effectively in Adazi town more than in any other location. It is usually cultivated for its edible fruit. It is about two meters tall. The hairy stem, branches, and leaves are typically tipped with prickles, making them inedible. The cultivar is primarily grown for its sweet, occasionally somewhat bitter, edible fruit. The fruit has an oval or hen's egg-like form with stripes. The majority of the time, it is eaten unripe, or pale green. The other variety is cultivated for its consumable leaves and fruits. It is grown by every farmer in Anambra State unlike “Anara Adazi”. It is about 1.5 meters tall; as a result, the variety "Anara Adazi" yields more branches and probably more fruits. Unlike "Anara Adazi," the stem, branches, and leaves have no hair or prickles, making them edible. The fruit is rounded and has ribs. The fruit has a diameter of 3–6 cm, which is smaller than that of *S. aethiopicum*. The leaves and fruits are somewhat bitter and more medicinal hence; old people prefer it to “Anara Adazi”. “Anara Adazi” is preferably used for cola to this cultivar. Comparatively speaking, this cultivar is more pest-resistant than the other Mwinuka *et al.* (2021) characterized this crop as a highly valuable and underappreciated horticultural species with significant commercial and therapeutic potential. Little to no attention has been paid to its breeding, particularly in Southeast Nigeria. Because vegetables, of which *S. aethiopicum* is a part, are so important to our diet, it is crucial to hybridize two cultivars that are frequently found in Anambra State. So as to produce a hybrid that may incorporate the attributes of the two cultivars for improvements in production. Such a hybrid of the two cultivars is probably more desirable in terms of quality and demand than either of the two parents. This research aimed to assess the effect of hybridization on the growth and yield of two cultivars (*S. aethiopicum* var “Anara Adazi” and *S. aethiopicum* var “Anara”) of *S. aethiopicum L.* found in Anambra State.

Materials and Methods

Study Area

The investigation was done at the Department of Botany research farm Nnamdi Azikiwe University Awka, Anambra State (6^0 12N/, 7^0 04E/) during the 2019 -2020 cropping seasons.

Experimental Design

Three replications of the Randomized Complete Block Design were used to set up the investigation.

Collection and Verification of Plant Materials

The two cultivars of *S. aethiopicum* vars. "anara Adazi" and "anara" were gathered from Adazi town in Anambra State in March and April of 2022. The cultivars were verified at Nnamdi Azikiwe University's Botany Department in Awka.

Determining the soil sample's pH

A few soil samples were placed in a dry, clean plastic jar for the nursery. For improved results, stones were removed and clumps were pulverized. A total of three characteristic samples were collected to ensure accurate soil validation. After adding distilled water to enfold the soil, about ¾ of the jar was furnish with sample sand. The jar was covered, and it shook actively sometimes. To melt the salts in the soil, the mixture was kept for ten minutes. Using buffer solutions with pH values of 7 and 10, the pH tester was calibrated. After taking off the jar cover, the pH tester was submerged in the moist soil slurry. After that, the pH was determined and noted.

Test for Seed Viability

Once the seeds were acquired, they underwent a viability test. To do this, a beaker filled with distilled water was used to immerse a handful of each cultivar for about three minutes; the water was then agitated and given time to sink. The seeds that drifted on the water's surface were thrown away; whereas the ones that submerged to the beaker's bottom were chosen.

Land Preparation and Planting

A matchet was used to clear the area where the seedlings would be raised, and the rubbish was boxed up and burned. Using a measuring tape, measuring rope, and pegs, a nursery bed measuring 2.4 x 3.0 m and spaced 0.5 m apart was measured and fine-tilted. During this activity, farm yard manure was added at a rate of 30 tons per hectare. A spacing of 40 cm by 60 cm was used to sow 3 seeds per stand and subsequently thinned when they were between 8 and 10 cm high, to one seedling per stand. The experiment was conducted without weeds in any of the plots. Both hand-pulling and hoeing techniques were applied.

About three to four weeks after transplanting, flowering began, and crossing took place at this time. Since *Solanum aethiopicum* is a self-pollinating crop, the artificial crossing was used. This required taking the *S. aethiopicum* var. "anara Adazi" cultivar's anthers out with a pair of forceps, thus using it as a female parent prior to its dehiscence and covering it with a sturdy bag (foil) to prevent insects from naturally crossing it. This was accompanied by the assembling and transferring of mature pollen grains from the male parent, *S. aethiopicum* var "anara," to the stigma of the emasculated plant var *(“anara Adazi”)*. Only a small number of the crossings that were attempted actually succeeded. This pollination technique was accompanied by fertilization and the ensuing production of fruits (the F_1 hybrid). This method is as outlined by (Ilodibia *et al*., 2017 and 2024). The seeds of the parental plants and the F1 hybrid collected from the 2019 cropping season were sown and used to evaluate growth and yield during the 2020 cropping season.

Results

The results were presented in Tables 1-2 and Figures 1-5

Table 1: Average growth characters of the parent plants and the F1 hybrid

Treatments	No of branches (cm)	Plant height (m)
Var "anara Adazi"	09.10 ± 1.00	2.05 ± 1.05
Var "anara"	08.00 ± 0.00	1.85 ± 1.00
F1 hybrid	09.50 ± 0.10	9.80 ± 1.04

Results are in mean ± standard deviation

The Table 1 above revealed that the F1 hybrid had the highest number of branches per plant(09.50 ± 1.00) while *S. aethiopicum* var "anara Adazi" had the highest plant height (2.50 ± 1.05) *S. aethiopicum* var "anara" had the least number of branches per plant and the least height of plant (08.00 ± 0.00 and 1.85 ± 1.00) respectively (Table 1).

Table 2: Average fresh fruit weight, fresh fruit length and No. of fruit per plant of S. aethiopicum Cultivars and F1 hybrid

S. Cultivars	Fresh fruit weight (g)	Fresh fruit length (cm)	No. of fruit per plant(cm)
Var "anara Adazi"	1.20 ± 2.05	5.80 ± 1.05	40.05 ± 1.00
Var "anara"	0.70 ± 1.02	5.70 ± 1.05	38.00 ± 0.00
F1 hybrid	0.90 ± 0.13	5.95 ± 0.04	45.02 ± 0.00

Results are in mean ± standard deviation

The Table 2 above revealed that *S. aethiopicum* var "anara Adazi" had the highest fresh fruit weight (1.20 ± 2.05) while the F1 hybrid recorded the highest fresh fruit length and the highest number of fruits per plant (5.95 ± 0.04 and 45.02 ± 0.00) respectively. *S. aethiopicum* var "anara" had the least fresh fruit weight, fresh fruit length and number of fruits per plant (0.70 ± 1.02, 5.70 ± 1.05 and 38.00 ± 0.00) respectively (Table 2).

Fig 1. S. aethiopicum var "anara Adazi"

Fig 3: F_1 hybrid

Fig 2. S. aethiopicum var "anara"

Fig 4: Fruits of parental plants and the hybrid

Discussion

The findings showed that when two *S. aethiopicum* plants of distinct but related cultivars are crossed, a new hybrid is created that has improved traits from both parent plants. This is heterosis in action. Secondly, when two plants having any pair of contrasting features are crossbreed, it is common for one of the characters to emerge in the hybrid while the other stays hidden. The average growth characters of the parental plants and the F1 hybrid indicated that *S. aethiopicum* var "anara Adazi" had the highest plant height while the hybrid recorded the highest number of branches. *S. aethiopicum* var "anara" had the least plant height and number of branches. This may be due to their genetic make-up.

Result of the average yield characteristics of the parental plants and the F1 hybrid revealed that the F1 hybrid had the highest fresh fruit length and the highest number of fruits per plant when compared to the parental plants. This outcome might be the result of more branches, which would enable more fruits to be produced by each plant and thus foster heterosis. *S. aethiopicum* var "anara Adazi" had the highest fresh fruit weight while *S. aethiopicum* var "anara" had the least fresh fruit weight, fresh fruit length and number of fruits per plant. These results are also consistent with Mendel's (1866) observation that in plants with two distinct traits, crossing them often results in one of the characters becoming visible while the other remains hidden. The trait that appeared or manifested he called the dominant trait while the trait that did not appear he called recessive traits. Accordingly, the results of the growth and yield of *S. aethiopicum* var "anara Adazi" and *S. aethiopicum* var "anara" in relation to F1 hybrid indicated that *S. aethiopicum* var "anara Adazi" had a number of dominant characteristics. Similarly, the weight of fruit in plants is determined by the number of dominant alleles of a certain genes (Acquaah, 2012). Thus, *S. aethiopicum* var "anara Adazi" had the highest fruit weight. These results tally with the findings of Anaso (1982) and Ilodibia (2014 and 2015) where they hybridized *S. aethiopicum* and *S. anomalum, S. annuum* and *S. frutescens, S. esculentum* and *S. pimpinellifolium* respectively, one of the parental plants performed better than the *F1* in certain traits. Anthony (1992) asserts that hybridization might cause a population's genetic variety to rise or decrease. Generally, the F1 hybrid combined the characters of *S. aethiopicum* var "Anara Adazi" and *S. aethiopicum* var "Anara" although the characters of *S. aethiopicum* var "Anara Adazi" dominated that of *S. aethiopicum* var "Anara". F1 hybrid had a better yield than the parental plants. Hybridization helps to integrate desirable traits from different varieties to produce hybrids with superior traits, such as increased yield, better quality, disease resistance, and environmental tolerance (Acquaah, 2012). Additionally, it contributes to the enhancement of quality factors that have the potential to improve people's lives throughout the world. This study offers the necessary information to choose between *S. aethiopicum* vars. "Anara Adazi" and *S. aethiopicum* vars. "Anara" in terms of genetic resources and in the breeding selection program.

Competing Interest

Authors have declared that no competing interest exists.

Conclusion

The findings showed that a new hybrid with improved traits from both parent plants is created when two *S. aethiopicum* plants of distinct but closely related cultivars are crossbred. Therefore, in *S. aethiopicum* species, crossbreeding could be employed to increase yield as well as in breeding selection programs. This study is beneficial to plant breeders and farmers.

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