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Growth, yield, and yield components of sweet corn hybrids organically grown in a tropical highland

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Abstract

The development of organic sweet corn varieties is ideally addressed to have a good adaptation to a variety of environmental conditions. This study aimed to evaluate the performance of 17 sweet corn hybrids, consisting of 15 promising hybrids and 2 commercial hybrids grown organically in the highlands. The study was conducted in Batu City, East Java (1160 m above sea level) and arranged in a randomized complete block design with three replications. Evaluation was carried out on growth performance, productivity, and yield quality. The findings of the study showed that all tested hybrids exhibited good growth performance, as indicated by robust plant and a lot of leaves. Nevertheless, Caps 2 x Caps 22, Caps 5 x Caps 17B, Caps 17B x Caps 23, and Caps 22 x Caps 23, emerged as the best hybrids in terms of overall growth performance. In terms of the productivity and quality of the ears produced, the hybrids Caps 5 x Caps 17B, Caps 5 x Caps 22, Caps 15 x Caps 17A, Caps 17A x Caps 17B, and Caps 17B x Caps 22 demonstrated their superiority in ear yields while meeting all established market quality standards. These findings suggest that, for organic production, these five hybrids can serve as alternative for commercial varieties for conventional production. Further evaluation on the yield stability across environmental conditions is needed to make these hybrids more predictable and dependable for the organic growers.

INTRODUCTION

Sweet corn (*Zea mays* saccharata L.) is a horticultural crop widely consumed worldwide, including in Indonesia. Fresh cut sweet corn kernels have sweet taste, soft texture, and many nutrients, including carbohydrates, sugar, fiber, protein, fat, vitamin A, vitamin B9, iron, magnesium, and potassium (Odeyemi et al., 2024). In addition to being consumed fresh, sweet corn has also been processed into various products, including crackers, vermicelli, nuggets, milk, ice cream, drinks, and snacks (Abdullah and Prahestiwi, 2023).

In tropical areas, air temperature decreases by 0.6°C for every 100 meters above sea level, so the lower the altitude of a place, the lower the air pressure. As a warm-season crop, sweet corn thrives in temperatures that range from 21°C to 30°C (Gotame et al., 2018). Although it can withstand higher temperatures, continuous exposure to intense heat, particularly during the flowering stage, may lead to decreased yields and quality (Teng et al., 2022). In previous research, Sudjatmiko and Chozin (2024) reported that higher elevations lead to longer plant growth, fewer growing degree-day requirements, and increased ear yield. Furthermore, sweet corn is a heavy consumers of plant nutrients, especially nitrogen, for optimal growth and yield (Muktamar et al., 2017). It is also susceptible to various pests and diseases that can significantly impact yield and quality (Ekman, 2015). Thus, the productivity of the crop is highly dependent on the cultural management practices used.

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Conventional crop production is a common approach for sweet corn production by involving the use of synthetic materials. On the one hand, this approach enables the maximization of plant productivity based on its genetic capabilities. This occurs because the nutritional requirements and pest management of plants can be easily satisfied and applied through the use of agrochemical products (Souto et al., 2021). However, prolonged and intensive application of agrochemical products may adversely affect health and the environment (Parven et al., 2025).

Raising public awareness regarding the adverse effects of agrochemical-based production practices has spurred the growth of organic farming. The yield of vegetable crops, such as sweet corn, grown organically is generally lower than that of those grown using conventional methods (Revilla et al., 2021). Nonetheless, through the use of natural production methods, organic farming is more sustainable and poses no harm to the health of either farmers or consumers (Gamage et al., 2023).

Reduced crop yields can be caused by the use of seeds that are from varieties bred for conventional production that fail to demonstrate their genetic potential when grown organically. Hence, it is essential to develop varieties that can adapt and achieve high yields under organic farming conditions. The objective of this study was to compare the characteristics and productivity of 17 sweet corn hybrids grown organically in the tropical highland.

MATERIALS AND METHODS

Experimental site and time

This study was carried out from September to December 2024 in the highlands of Batu City, East Java (1160 m above sea level). The weather conditions during the growing season are presented in Table 1. Based on the initial soil analysis, the soil in the experimental site contains total nitrogen of 0.34% (medium), organic carbon of 9.32% (medium), available phosphor of 9.98 ppm (low), available potassium of 0.19 me/100g (low), and pH of 5.42 (slightly acidic), as described by Eviati et al. (2023).

Experimental design

The experiment was arranged in a completely randomized block design with three replications involving 17 hybrid sweet corn varieties as the treatments, consisting of (1) Caps2 x Caps5, (2) Caps2 x Caps22, (3) Caps3 x Caps17A, (4) Caps5 x Caps17B, (5) Caps5 x Caps22, (6) Caps15 x Caps17A, (7) Caps15 x Caps22, (8) Caps15 x Caps23, (9) Caps17A x Caps17B, (10) Caps17 x Caps22, (11) Caps17B x Caps23, (12) Caps22 x Caps23, (13) Caps3 x Caps17B, (14) Caps15 x Caps17B, (15) Caps2 x Caps17A, and two commercial hybrids (Paragon and Bonanza) as the check varieties. Each hybrid was randomly allocated to the 3 m x 3 m experimental unit.

Land preparation and crop management

The experimental area was divided into three blocks spaced 1 m apart, and each block was further divided into 17 experimental plots, with inter plot spacing of 75 cm. Cow manure at 5 t/ha was amended a week prior to planting. The seeds of each genotype were row planted in the corresponding experimental unit at 75 cm inter row spacing and 25 cm within row spacing, resulting in a plant population of 48 plants in each experimental unit. Additional liquid organic fertilizer at a concentration of 0.5% was applied at 2, 4, 6, and 8 weeks after sowing.

Data collection and analysis

Observations were made on samples of five plants chosen randomly from the central rows in each experimental unit for plant height, stalk diameter, first ear height, tasseling and silking dates, unhusked and husked ear traits (length, diameter, and weight), kernel row number, kernel number per row, and total soluble solid. The collected data from all variables were subjected to analysis of variance using SAS V9.4 (SAS Institute Inc. Cary, NC). The Scott-Knott cluster analysis was performed using DSAASTAT for genotypic mean grouping.

Table 1. Weather conditions in the experimental site during the growing season

Weather component	September	October	November	December
Mean daily temperature (°C)	22	23	25	25
Humidity (%)	79	77	80	84
Monthly precipitation (mm)	10	19	284	330

RESULTS AND DISCUSSION

Growth characteristics

The analysis of variance showed highly significant variation among the hybrids for the observed plant growth variables, indicating that the genetic makeup of the assessed hybrids plays a crucial role in the plant growth performances under organic crop management. A similar finding was also reported by Chozin et al. (2019). Table 2 lists the mean performances of the 17 hybrids for those variables, and the Scott-Knott cluster analysis classified the hybrids into 2 groups, although the grouped hybrids among variable were not always consistent. A closer inspection revealed that hybrids exhibiting tall plant posture, more leaves, and larger stalk diameter were represented by 4 hybrids, namely Caps 2 x Caps 22, Caps 5 x Caps 17B, Caps 17B x Caps 23, and Caps 22 x Caps 23.

Yield and yield components

Analysis of variance on yield and yield components showed that differences in genetic composition between hybrids were only expressed in 2 of the 7 variables observed, namely the length of both unhusked and husked ears. Such phenomena differ from the findings of the studies by Sela et al. (2019) and Hutasoit et al. (2020). The distinction may arise due to the variation in the genetic material utilized and the growing conditions. In the previous study, Ardelean et al. (2012) showed the significance of the genotype-environment interaction (GEI) effect on sweet corn yield to indicate that genotypes respond differently to a specific environmental condition.

Further examination utilizing Scott-Knott cluster analysis at 5% led to the identification of two hybrid groups based on the trait of ear length, both husked and unhusked (Table 2). However, the findings regarding hybrid grouping were not always uniform when the variables varied, with the exception that Caps 5 x Caps 17B, Caps 5 x Caps 22, Caps 15 x Caps 17A, Caps 17A x Caps 17B, and Caps 17B x Caps 22 were consistently classified as hybrids exhibiting long ears whether husked or unhusked. Caps 2 x Caps 22, Caps 15 x Caps 22, Caps 15 x Caps 17B, Caps 2 x Caps 17A, and Bonanza were included in the same groups as those five hybrids for husked ear length but not for unhusked ear length. The opposite situations were observed for Caps 2 x Caps 5, Caps 17B x Caps 23, and Caps 22 x Caps 23. Meanwhile, Caps 3 x Caps 17A, Caps 15 x Caps 23, Caps 3 x Caps 17B, and Paragon are hybrids that feature short ears both with and without husks.

Table 2. Performances for growth and developmental traits of 17 sweet corn hybrids organically grown in a tropical highland

No	Hybrid	Plant height (cm)	Number of leaves	Stalk diameter (mm)
1	Caps 2 x Caps 5	224.2 b	12.7 b	31.7 a
2	Caps 2 x Caps 22	244.1 a	13.2 a	30.9 a
3	Caps 3 x Caps 17A	213.5 b	13.4 a	29.8 a
4	Caps 5 x Caps 17B	231.8 a	13.1 a	29.8 a
5	Caps 5 x Caps 22	214.4 b	13.3 a	31.0 a
6	Caps 15 x Caps 17A	224.5 b	12.9 b	31.8 a
7	Caps 15 x Caps 22	231.3 a	12.9 b	27.2 b
8	Caps 15 x Caps 23	243.7 a	12.6 b	27.3 b
9	Caps 17A x Caps 17B	227.5 b	12.7 b	28.4 b
10	Caps 17B x Caps 22	245.4 a	13.0 b	29.0 b
11	Caps 17B x Caps 23	244.2 a	13.8 a	31.3 a
12	Caps 22 x Caps 23	264.7 a	13.6 a	31.8 a
13	Caps 3 x Caps 17B	248.1 a	13.5 a	28.9 b
14	Caps 15 x Caps 17B	212.1 b	12.1 b	26.4 b
15	Caps 2 x Caps 17A	242.9 a	12.6 b	27.9 b
16	Paragon	217.1 b	12.5 b	29.6 a
17	Bonanza	218.1 b	12.9 b	26.6 b

Remarks: Means for each variable followed by the same letters indicate statistical similarity according to the Scott-Knott cluster analysis at the 0.05 significance level.

Although the hybrids can be grouped based on ear length, the largest range of differences is only 4 cm, making them visually indistinguishable and still fall into the long ear category (Ainiya et al., 2019). Likewise, variables other than ear length shared by all hybrids are also quite consistent. According to the average values of all measured variables, ears generated from all hybrids can be classified as marketable ears. The criteria for determining marketable sweet corn ears are based on ear size (length, diameter, and weight) and ear yield per hectare, which is generally 5–15 cm long, 1–2 cm in diameter, 200-300 grams in weight, and 14-18 tons per hectare (Syarifah et al., 2022). Based on these criteria, the Caps 5 x Caps 22 and Caps 15 x Caps 17A hybrids exhibited the best performance and reliably met all market quality criteria. The check variety Paragon also demonstrated outstanding yield, establishing it as a standard for other sweet corn hybrids, but it had comparatively shorter ear, both unhusked and husked, than those two hybrids when grown organically.

Yield quality

The main indicators commonly used to determine sweet corn quality include the number of kernel rows, the number of kernels per row and the level of kernel sweetness. Of the three variables evaluated, the number of kernels per row and the level of kernel sweetness showed highly significant variation among genotypes. On the other hand, the variability arising from genotype differences was not significant for the number of seed rows. In a previous study, Maryamah et al. (2017) reported significant variation among hybrids for all three variables.

Table 4 presents yield quality performance of all hybrids evaluated and their groupings based on Scott-Knott cluster analysis at 5%. For the number of rows of kernels per ear, the hybrids were similar in appearance and could not be clearly distinguished for clustering. The number of kernel rows per ear of sweet corn generally ranges between 10 and 18, although in previous studies it was reported to range between 14 and 16 (Hutasoit et al., 2020). In this study, the average number of kernel rows per ear of all hybrids was around 14 rows, which was also reported by Chozin et al. (2017). Based on the number of kernels formed in each row, the hybrids evaluated can be divided into two groups. Generally, each row of kernels on the ear is composed of 31.8 to 46.4 kernels (Hutasoit et al., 2020), and in this study, an average of 35.2 kernels was recorded,

Table 3. Yield and yield components of 17 sweet corn hybrids organically grown in a tropical highland

Hybrid	Unhusked ear length (cm)	Unhusked ear diameter (mm)	Unhusked ear weight (g)	Husked ear length (cm)	Husked ear diameter (mm)	Husked ear weight (g)	Ear yield (t/ha)
Caps 2 x Caps 5	30.5 a	60.8 a	347.3 a	17.6 b	46.8 a	171.5 a	18.5 a
Caps 2 x Caps 22	28.1 b	60.7 a	347.0 a	20.2 a	46.0 a	201.3 a	18.5 a
Caps 3 x Caps 17A	28.0 b	58.9 a	338.8 a	18.5 b	46.8 a	177.9 a	18.1 a
Caps 5 x Caps 17B	31.1 a	60.7 a	379.4 a	20.4 a	46.9 a	208.0 a	20.2 a
Caps 5 x Caps 22	30.8 a	61.5 a	392.7 a	20.3 a	47.5 a	205.8 a	20.9 a
Caps 15 x Caps 17A	31.9 a	63.1 a	395.3 a	19.9 a	46.2 a	191.4 a	21.1 a
Caps 15 x Caps 22	29.6 b	59.8 a	352.7 a	20.5 a	45.9 a	189.1 a	18.8 a
Caps 15 x Caps 23	29.7 b	59.3 a	347.0 a	18.8 b	48.2 a	187.8 a	18.5 a
Caps 17A x Caps 17B	31.6 a	62.9 a	372.8 a	20.8 a	43.6 a	182.9 a	19.9 a
Caps 17B x Caps 22	30.3 a	60.7 a	374.0 a	21.9 a	45.7 a	203.5 a	19.9 a
Caps 17B x Caps 23	32.3 a	58.9 a	316.4 a	17.3 b	44.6 a	159.5 a	16.9 a
Caps 22 x Caps 23	32.1 a	58.5 a	350.2 a	18.5 b	44.5 a	165.2 a	18.7 a
Caps 3 x Caps 17B	27.6 b	57.6 a	308.0 a	18.3 b	45.1 a	170.2 a	16.4 a
Caps 15 x Caps 17B	29.3 b	55.7 a	334.7 a	20.1 a	45.7 a	183.6 a	17.9 a
Caps 2 x Caps 17A	27.5 b	61.3 a	325.2 a	19.4 a	47.8 a	197.9 a	17.3 a
Paragon	29.2 b	61.3 a	371.8 a	18.9 b	49.5 a	227.8 a	19.8 a
Bonanza	28.3 b	56.3 a	319.0 a	20.0 a	44.6 a	201.6 a	17.0 a

Remarks: Mean values for each variable followed by the same letters indicate statistical similarity according to the Scott-Knott cluster analysis at the 0.05 significance level.

Table 4. Yield quality traits of 17 sweet corn hybrids organically grown in a tropical highland

Hybrid	Kernel-row number	Kernel number per row	Total soluble solids content (°Brix)
Caps 2 x Caps 5	13.8 a	29.7 b	10.5 b
Caps 2 x Caps 22	13.7 a	38.3 a	10.8 b
Caps 3 x Caps 17A	14.3 a	35.5 a	11.3 b
Caps 5 x Caps 17B	14.1 a	34.9 a	10.7 b
Caps 5 x Caps 22	14.9 a	37.2 a	11.3 b
Caps 15 x Caps 17A	14.6 a	36.1 a	10.7 b
Caps 15 x Caps 22	14.6 a	36.0 a	10.5 b
Caps 15 x Caps 23	14.4 a	33.0 b	10.9 b
Caps 17A x Caps 17B	13.9 a	35.9 a	10.3 b
Caps 17B x Caps 22	14.1 a	38.8 a	10.2 b
Caps 17B x Caps 23	13.9 a	31.3 b	11.4 b
Caps 22 x Caps 23	14.3 a	28.7 b	10.1 b
Caps 3 x Caps 17B	14.7 a	34.9 a	11.9 a
Caps 15 x Caps 17B	14.1 a	35.5 a	11.1 b
Caps 2 x Caps 17A	13.5 a	37.0 a	11.1 b
Paragon	14.6 a	35.1 a	13.1 a
Bonanza	15.1 a	40.9 a	13.3 a

Remarks: Mean values for each variable followed by the same letters indicate statistical similarity according to the Scott-Knott cluster analysis at the 0.05 significance level.

which is in accordance to the research of Sela et al. (2019). The number of kernel rows and the number of kernels per row are two significant variables in the assessment of ear quality. Ears having many kernel rows and high number of kernels per row will be preferred by consumers (Wiley et al. 2021).

In addition to the physical appearance of the ears and kernels, the quality of sweet corn is also characterized by the chemical characteristics of the kernels, especially their sweetness. Sweetness in sweet corn is controlled by genes that inhibit the conversion of sugar to starch in the seed endosperm, namely the sugary gene (su), the sugary enhancer gene (se), and the shrunken gene (sh2) (Panatee et al., 2024). The hybrids evaluated have a sweetness level at a modest range, between 10.1 °brix and 13.3 °brix, as reported by several researchers (Regyta et al., 2023; Setyowati et al., 2022) although the sweetness level of sweet corn kernels can reach 17.94 °brix (Kusparwanti et al., 2022). It is true that the check hybrids produce sweeter kernel than the developed hybrids evaluated, but the difference was not large, especially when compared to Caps 3 x Caps 17B.

CONCLUSIONS

Of the 17 hybrids evaluated, Caps 2 x Caps 22, Caps 5 x Caps 17B, Caps 17B x Caps 23 and Caps 22 x Caps 23 showed the best growth performance under organic management practice in highland. When it comes to productivity, all the hybrids were similar, but some had better yield traits, including Caps 5 x Caps 17B, Caps 5 x Caps 22, Caps 15 x Caps 17A, Caps 17A x Caps 17B, and Caps 17B x Caps 22. However, the sweetness of the kernels from all hybrids, including the check hybrids, was about the same. More testing is needed to see how well these hybrids perform in different growing conditions so that organic farmers can rely on them more confidently.

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