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EFFECT OF PLANT GEOMETRY ON GROWTH AND YIELD OF HEIRLOOM CORN CULTIVARS UNDER TABUK CITY CONDITION

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Abstract

The study evaluates the effect of plant geometry on the growth and yield of heirloom corn cultivars (a1-purple corn cultivars, a2-white corn cultivar) under Tabuk City condition. Determine the effect of plant geometry (b1-50x30, b2-50 x 40, b3 – 60x30, b4 – 60x40 cm), and determine the interaction effect of plant geometry to heirloom corn cultivars. The experiment was laid out using a Randomized Complete Block Design (RCBD) in the Factorial experiment. The experiment result showed no significant difference was noted in terms of days to tassel, plant height, ear height, ear length, ear diameter, and biomass yield. A highly significant response showed in days to silking, days to maturity, and weight of 1000 kernel but effect and interaction were no significant differences. The yield and yield attributes of heirloom corn showed that the white corn cultivar produced the highest yield (kg/ha) with 7,030 kg and purple has 3,401 kg under plant geometry. Heirloom corn cultivars from plant spacing of 50 x 40 cm produced the highest yield (kg/ha) with 5,912 kg followed 60 x 30 cm, 50 x 30 cm and 60 x 40 cm with a mean of 5,557 kg, 4,956 kg and 4,437 kg. Interaction among the two factors showed highly significant results where white corn is far from yield attributes to purple corn cultivar. From this study, it may conclude that the adoption of 60 x 30 cm plant spacing is recommended for heirloom white corn cultivars since it produced highly significant results. For better yield for heirloom purple corn it is suggest to adopt 50 x 30 cm plant spacing. The research suggests more studies on plant spacing to determine its effect on the growth and yield of heirloom corn cultivars.

Key words: Heirloom corn cultivars, purple corn, white corn, open-pollinated varieties, plant geometry.

Introduction

Heirloom cultivars are characterized as traditional or older cultivars that are open-pollinated, passed down from gardener to gardener or handed down in families, and often not used in large-scale agricultural enterprises. The definition of heirloom varies, and the term itself does not carry precise scientific designations. One of the most typical concepts of an heirloom is its non-hybrid, or open-pollinated nature. Heirlooms can be from cross- or self-pollinated species, but if the crop species is cross-pollinated, then the heirloom is considered open-pollinated. Because of this fact, some heirloom

cultivars may be quite variable, and it is therefore apparent why heirlooms may not fit well into modern agricultural systems that place great value on uniformity. Heirloom cultivars also are associated with seed-saving, and, in fact, the generation-to-generation transfer of heirloom seed is often one of the defining features of an heirloom. (Dwivedi et al., 2019). Local/traditional varieties are still grown by some farmers along with improved open pollinated varieties (OPV) (Gerpacio, 2017).

Heirloom corn cultivars found in the province of Kalinga are white and purple. Both of these cultivars are open-pollinated (OPV), they are mostly characterize in asynchronous in growth, tasseling, and maturity. The maturity of these heirloom corn is approximately from 95 to 99 days of harvest. These heirloom corn cultivars have been traditionally planted by Indigenous People's in the province from generation to generation and passes to their children. As mentioned by (Gerpacio, 2017) that local varieties are mostly retained at home for human consumption and animal feed. This practice of farmers in Visayas is similar to the practice of farmers in the province where cobs are dried with or without husks, stored and milled as needed for immediate use or they were hung above their dirty kitchen. Today, these cultivars are likely diminished and left behind by farmers due

to potentially effect of new modern varieties. However, there is an on-going research on heirloom corn varieties in Kalinga province aimed to sustain and conserve this indigenous landraces.

Limited data and study were conducted on the effect of plant spacing on heirloom corn is evident in the review of related literature. Therefore, a study was designed to evaluate the effect of plant geometry on the growth and yield of heirloom corn cultivars. Furthermore, the study aimed to determine the agronomic characters and interaction effect of cultivars as influence by plant spacing.

Review Of Related Literature

Heirloom Corn

References

There are no sources in the current document.

The types of heirloom corn found in Kalinga are flint and glutinous white, yellow, and purple. Purple corn is not much given attention but in other parts of the world, it has been widely cultivated and consumed. It expresses one of the deepest purple shades found in the plant kingdom. Due to its richness in purple color, purple corn pigments have long been used to color foods and beverages. In South America, purple corn extracts are widely applied in coloring homemade desserts and beverages such as chicha Morada and mazamorra Morada, a popular drink and dessert prepared from purple corn (FAO, 2013). In 2013, phenolic-rich purple corn has been proposed by different commercial companies to have the status of a "superfood" due to its remarkable potential health benefits (Lao et al., 2017). It has been found out that anthocyanins of pigmented corn become a topic of increasing interest recently due to consumer awareness of their various health benefits. A better understanding on the gene effects to anthocyanin is an important for high antioxidants breeding programs (Harakotr et al., 2016).

Additional aspects of the heirloom cultivar experience are the unique flavors and culinary qualities that generations of people had come to know and appreciate. Such qualities may be absent in modern cultivars bred for modern cropping systems, creating a desire for the heirloom. An example of such a quality is the creamy mouth feel caused by high levels of water-soluble polysaccharides (also described as phytoglycogen) in heirloom sweet corn cultivars (Dwivedi et al., 2019).

Open pollinated variety (OPV) is the traditional white corn variety providing seeds which can be reused for every next planting cycle (Ocampo et al., 2013) cited by (Transon & Defourny, 2017). Thanks to this characteristic, this variety has been adapted many times to the different Philippine environments. In 2014, white corn constituted less than a third of the total production of the country (Philippine Statistics Authority, 2015) cited by (Transon & Defourny, 2017). This traditional variety was mainly used for home consumption as a carbohydrate substitute for rice in periods of shortage in Mindanao ((Gerpacio, 2017); Lanthier, 2013; Ocampo et al., 2013) cited by (Transon & Defourny, 2017). It also provides interesting nutrients and requires few inputs but also low production costs. OPV corn is more easily digested, contains more proteins, fibres, minerals and antioxidants than rice (Ocampo et al., 2013) cited by (Transon & Defourny, 2017). Moreover, OPV like heirloom corn has asynchronous growing. Therefore, OPV flowers and ears are appearing at different period into the same field. OPV plants are also reaching the maturity stage on different days (Transon & Defourny, 2017).

Effect of Plant Geometry of Corn

A study conducted by (Chauhan & Opeña, 2013) they stated that plant height and leaf production were not influenced by plant geometry. However, leaf area, biomass, and yield of corn per unit area yield 8.2 t/ha from the plants grown at 50x20 cm spacing. Moreover, they suggest that narrow rows and plant to plant spacing may increase grain yield by increasing crop growth rates. They further stated that corn plants planted in other environments with narrow spacing revealed an increase in corn yield because narrow spacing enhances available

soil moisture to the crop. It will also increase light interception and it may also result in early canopy closure and reduced weed growth by increased shading of weeds and thereby improvement in yield.

According from (Mathukia et al., 2014) stated that the response of sweet corn to plant geometry (60 cm x 15 cm, 45 cm x 20 cm, and 30 cm x 30 cm enhanced growth and yield attributes and thereby green cob and fodder yield along with the higher net return. Therefore, the spacing of 45 cm x 45 cm can improve the higher yield and return of investment as well as economically significant. Further study conducted by (Shafi et al., 2012) concluded that the effect of plant density on corn plant revealed a significant effect on LAI, plant height, ear length, number of grains, grain weight/ear, the weight of 100 grain, stover yield, and grain yield. He also concluded that growth and yield of variety were better than the other varieties under test when sown at a plant population of 65,000 plants. The results of the study conducted by (Chauhan & Opeña, 2013) suggest that narrows and plant to plan spacing may increase grain yield by increasing crop growth rates. The plant geometry could be modified to improve yield of corn and thereby increase productivity. It was concluded in the study of (Chauhan & Opeña, 2013) that use of equidistant row arrangement allowed dry land corn to compete with natural weed population while improving the grain yield of the corn.

Corn has what may be called an open canopy, as much of the sunlight reaching the surface of a growing corn crop penetrates the corn canopy. In many cases, 50% or more of the incoming radiation reaches the soil surface. In comparison, narrow-row soybeans have a closed canopy; less than 1% of the incoming radiation reaches the soil surface. Incoming radiation that reaches the soil surface increases the soil temperature, germinates weed seeds, and causes loss of soil moisture through evaporation. Plant growth and development depends on four main inputs: sunlight, water, carbon dioxide, and plant nutrients (from fertilizers and from the soil). The average carbon dioxide concentration in the atmosphere is now about 330 ppm, an increase of about 10% over the last 30 years. So, any attempt to obtain higher corn yields must consider the plant canopy and the incoming radiation distribution with the canopy (Iii, 1990). Corn is a crop with an enormous potential for the extraction of anthocyanins which, given their bioactive properties and their ability to act as a natural dye, nowadays are a secondary metabolite of wide interest. In Mexico, several variants of corn that accumulate this flavonoid have been found among corn landraces of blue, red, pink, purple or black kernels (Huang et al., 2015).

Objectives

Specifically, the study aimed to:

1. Evaluate the effect of plant geometry on the growth and yield attributes of heirloom corn cultivars;
2. Determine the agronomic characters of heirloom corn cultivars on plant geometry, and
3. Determine the interaction effect of variety as influenced by plant geometry.

Materials and Methods

This study was conducted at the Demo Farm of the Center for Development Program in the Cordillera (CDPC), Lacnog, Tabuk City, Kalinga. The soil at the experimental site had a pH of 6.88 and has clay loam soil. The site was dry cultivated using disc plow mounted to hand tractor before heirloom corn planting. There were two heirloom corn cultivars (V_1-Purple corn and V_2-White corn), four spacing treatments (T_1 – 50x30, T_2-50 x 40, T_3 – 60x30, and T_4 – 60x40). The experiment was arranged in a randomized complete block design with three replications. The data collected were tabulated and subjected to RCBD in factorial using Analysis of Variance (ANOVA). Duncan's Multiple-Range Test was used to compare treatment means at 1% and 5% level of significance according to (Gomez & Wiley, n.d.). The crop was planted by hand on March 17, 2020, and immediately irrigated with light irrigation. An incorporation of 20 bags of rice hull was done during the initial plowing. The application of 6.2 kg of vermicompost was done 14 days before the sowing of seeds. Nitrogen was applied as urea at 16 DAS in 2.0 kg per plot. The size of each plot was 2 x 3 m.

The days to tasseling were recorded when 50% of the plants produce tassel and the same procedure was done for days to silking. Days to maturity of the plant were taken from seed sowing to days to harvesting. Plant height

was measured from the ground label to the base of the tassel. Ear height was measured from ground level to the node bearing the uppermost ear. Ear length was measure from the end parts of the peduncle up to the tip of the ear and ear diameter was measured using a caliper. The weight of 1000 kernels was weight using an analytical balance with 14% MC. The whole plant's parts were weighed at fresh and sun-dried to reduce water content. After sun drying it was weighed to get the biomass yield. The computed yield per 1 m^2 was converted to yield per hectare and this was taken after drying the kernel at 14MC.

Weeds were controlled using a mechanical weeder and manual weeding was done at the vegetative and reproductive stage of the heirloom corn. Bush cutter was used to cut weeds as hosts for insect pests. No herbicide was applied entirely to the duration of the study. Tassel bagging and silk bagging was done to prevent cross-pollination of both the heirloom corn cultivars. The occurrence of corn borer and beetles were observed in every stage of the crop, however, they were controlled using insecticides such as Chicks, Lannate, and General. Application of Virtako 40 WG Insecticide at 10 g/16 knapsack sprayer was done to control Lepidoptera, sucking, and soil pests in a wide range of crops. Rodents were controlled using rodenticide following the dosage indicated in the product. Heirloom corn was harvested in asynchronous wherein white corn was harvested first at 89.67 DAS days and purple at 94.42 DAS. A 1 x 1 meter was measured per plot was first to harvest as harvesting area. The harvested white and purple corn was husked and dried at three days to reach its 14% moisture content.

Results And Discussion

The response of heirloom corn cultivars

The data presented in Table-1 indicated the response of heirloom corn to plant geometry. Results show that the cultivar produced tassel almost at the same time regardless of the distance of planting with means ranging from 53.33-53.67 days after sowing (DAS) with no significant differences noted. A highly significant difference is noted where purple cultivars produced silk at 59.92 days while white cultivar produced silk at 57.17 days. The same trend that the number of days to silking where the purple cultivar was late to produced silk with a mean of 94.42 days and the white cultivar of 89.67 days with a highly significant difference between the two cultivars was noted. Purple corn cultivars are taller than white cultivar with a mean of 239.16 cm while white corn cultivar obtained the lowest mean of 236.48 cm. As shown in Table 1, the purple corn cultivar obtained a mean of 139.71 cm while the white corn cultivar has 132.58 cm with no significant difference in the response of heirloom corn cultivar was noted. White corn cultivar obtained the longest mean ear height of 13.73 cm and purple corn has 13.07 cm. A significant difference at the 5% level was noted in the response of heirloom cultivars on plant geometry. Results show that the white corn cultivar obtained a larger diameter of 4.04 cm while the purple corn cultivar has a mean of 3.94 cm. Statistical analysis revealed no significant difference among the cultivar tested. Data shows that kernel from white corn cultivar obtained the heaviest with a mean of 272.84 g while the purple corn cultivar has 248.53 g. A highly significant difference was noted in the weight of 1000 kernel from white and purple corn cultivar. Meaning, white corn cultivar is highly comparable to purple in terms of their agronomic characters. As to the data, it was revealed that the highest biomass yield was obtained in the white corn cultivar with a mean of 675.57 g and 652.83 g. No significant difference among the cultivars was noted. Results revealed that white corn cultivars obtained a yield (kg/ha) with a mean of 7,030 kg and Purple corn has a mean yield of 3,401 kg. Results showed that a highly significant difference among the two cultivars tested was noted. Furthermore, it was observed that days to tasseling, silking, and maturity are asynchronous which is similar to the findings of (Transon & Defourny, 2017).

Table 1. The response of heirloom corn to plant geometry

Heirloom corn cultivars

Parameters	a_1-Purple *(Mean)*	a_2-White (Mean)
Days to tasseling	53.33	53.67
Days to silking	59.92[a]	57.17[b]
Days to maturity	94.42[a]	89.67[b]
Plant height	239.16	236.48
Ear height	139.71	132.58
Ear length	*13.07*	13.73
Ear diameter	*3.94*	4.04
Weight of 1000 kernel	248.53	272.84
Biomass yield	652.83	675.58
Computed yield (kg/ha)	3,401[b]	7,030[a]

Note: Means not sharing letter in common differ significantly (DMRT)

Effect of plant geometry on the agronomic character

The effect of plant geometry on heirloom corn cultivars is presented in Table-2, it was revealed b_1 produced longer tassel with 54.83 followed by b_2, b_4, b_3 with a mean of 53.33, 53, and 52.83 days, respectively with no significant differences was noted. As to tassel, results show that b_1 produced tassel with a mean of 58.83 followed by b_2, b_4, and b_3 with a mean of 58.50, 58.50, and 58.33 days, respectively. No significant difference between the four distances of planting was noted. The results on the days to maturity showed that b_1 and b_4 obtained the same mean of 92.17 days followed by b_3 and b_1 with a mean of 92 and 91.83 days, respectively. It means that different distances of planting did not affect the days to maturity of heirloom corn cultivars.

Table 2. Effect of plant geometry on the agronomic character of heirloom corn cultivars

Treatments	**Days to tasseling**	**Days to silking**	**Days to maturity**
Plant Geometry			
b_1 – 50 x 30 cm	*54.83*[a]	58.83[a]	92.17[a]
b_2 – 50 x 40 cm	53.33[a]	58.50[a]	91.83[a]
b_3 – 60 x 30 cm	52.83[a]	58.33[a]	92.00[a]
b_4 – 60 x 40 cm	53.00[a]	58.50[a]	92.17[a]

Note: Means not sharing letter in common differ significantly (DMRT)
Results: Not significant
Source: Two-way table (a and b)

Growth attributes

The data furnished in Table-3 revealed that the tallest height was obtained in b_4 (60x40) with a mean of 240.05 cm followed by b3 (60x30 cm), b2 (50 x 40 cm), and b_1 (50 x 30 cm) with a mean of 238.28 cm, 237,78 cm, and 235.17 cm. As to ear height, b_1 (50 x 30 cm) obtained the highest mean of 143.72 cm followed by 136.48, 132.43, and 131.95 cm. No significant difference in the effect of plant geometry to heirloom corn was noted. Plants in b_4 (60 x 40 cm) obtained the longest mean ear length of 13.96 cm followed by b_1, b_2, and b_3 with a mean of 13.55, 13.27, and 12.81 cm. Statistical analysis revealed that no significant results among the treatment tested. Meaning, the mean ear length is numerically different but statistically, they are the same in terms of the effect of plant geometry on heirloom corn cultivars. The same results were observed from plant b_1 (50 x 30 cm) obtained a larger diameter mean of the ear with 4.10 followed b_2, b_3, and b_4. However, no significant difference was noted in the effect of plant geometry on heirloom corn cultivars.

Table 3. Effect of plant geometry on the growth attributes of heirloom corn cultivars

Treatments	**Plant height (cm)**	**Ear height (cm)**	**Ear length (cm)**	**Ear diameter (cm)**

Plant Geometry				
b_1 – 50 x 30 cm	*235.17*	136.48	13.55	4.10
b_2 – 50 x 40 cm	237.78	132.43	13.27	4.02
b_3 – 60 x 30 cm	238.288	131.95	12.81	3.86
b_4 – 60 x 40 cm	240.05	143.72	13.97	3.99
Results: Not significant				

Source: Two-way table (a and b)

Yield attributes

The data presented in Table-4 showed no significant differences that b_4 produced the heaviest kernel with a mean of 265.07 g followed by b_1, b_2, and b_3 with a mean of 263.50, 258.55, and 255.63 g, respectively. The same findings with the effect of plant spacing on the biomass yield of heirloom corn which revealed no significant difference was observed. The plant geometry of 50 x 40 cm plant spacing produced a yield of 5,912 kg/ha followed by 60 x 30 cm plant spacing, 50 x 30 cm plant spacing, and 60 x 40 cm plant spacing with a mean of 5,557 kg, 4,956 kg and 4,437 kg. Statistical analysis revealed the highly significant effect of plant spacing on the yield of heirloom corn under Tabuk City condition. The enhanced yield under 50 x 40 might be due to significant improvement in the growth of the crop from growth attributes and agronomic characters. (Mathukia et al., 2014) stated that a closer distance of plant spacing increases dry matter accumulation under increased photosynthetic deficiency.

Table 4. Effect of plant geometry on the yield attributes of heirloom corn cultivars

Treatments	**Weight of 1000 kernel**	**Biomass yield (g)**	**Computed yield (kg/ha)**
Plant Geometry			
b_1 – 50 x 30 cm	263.50^{ns}	670.00^{ns}	4956.00^{c}
b_2 – 50 x 40 cm	258.55^{ns}	656.67^{ns}	5912.00^{a}
b_3 – 60 x 30 cm	255.63^{ns}	635.67^{ns}	5557.00^{ab}
b_4 – 60 x 40 cm	265.07^{ns}	694.50^{ns}	4437.00^{c}

Note: Means not sharing letter in common differ significantly (DMRT)

Source: Two-way table

Interaction effect of heirloom corn and plant geometry (AxB)

An appraisal of data on the interaction effect of heirloom corn and plant geometry (Table-5) showed that days to tasseling, silking, maturity, plant height, ear height, ear length, ear diameter, the weight of 1000 kernel, biomass yield showed no significant difference. Data shows that a_2b_7 - 60 x 30 cm plant spacing produced the highest yield of 9,052 kg followed a_2b_6, a_2b_8, a_2b_5, a_1b_1, a_1b_2, a_1b_4, and a_1b_3 with a mean of 8,148 kg, 5,522 kg, 5,398 kg, 4,514 kg, 3,676 kg, 3,352 and 2,062 kg. Meaning a_2b_7 is highly significant to a_2b_6, a_2b_8, a_2b_5, a_1b_1, a_1b_2, a_1b_4, and a_1b_3. The same interaction for a_2b_5 and a_1b_1 was noted and the same with a_1b_2, a_1b_4, and a_1T_3.

Insect pest infestation during the vegetative and reproductive stage of the heirloom corn can greatly affect the yield and yield attributes obtained in two cultivars as well as pollination of the crop including rodent infestation and calendar of planting. The study suggests that plant spacing of 50 x 40 cm greatly affects the yield of heirloom corn cultivars as shown in Table 4-5. The finding shows that as plant spacing between plant at 30 cm

and increased hill spacing of 60 has a direct impact on yield. According the findings of (Chauhan & Opeña, 2013) they suggests that growing corn in narrows may have the potential for improving weed management which can reduced-herbicide system. Similar to their study the plant height of the cultivars did not give significant results in which more research is needed to determine the effect of narrow rows on the growth and yield of heirloom corn. As shown in Table-1, the purple corn cultivar obtained a mean of 139.71 cm while the white corn cultivar has 132.58 cm with no significant difference in the response of heirloom corn cultivar.

Table 5. Interaction effect of heirloom corn cultivars to plant geometry under Tabuk city condition

Treatment combination								
Parameters	a_1b_1	a_1b_2	a_1b_3	a_1b_4	a_2b_5	a_2b_6	a_2b_7	a_2b_8
Days to tasseling	54.33	53.67	53.00	52.33	55.33	53.00	52.67	53.67
Days to tasseling	54.33	53.67	53.00	52.33	55.33	53.00	52.67	53.67
Days to maturity	94.33	94.67	94	94.67	90.00	89.00	90	89.67
Plant height (cm)	232.00	245.30	231.37	247.97	238.33	230.27	245.20	232.13
Ear height (cm)	140.76	141.93	131.47	144.67	132.2	122.93	132.43	142.77
Ear length (cm)	13.34	12.67	12.75	13.50	13.76	13.86	12.86	14.43
Ear diameter (cm)	4.07	4.00	3.63	4.05	4.12	4.03	4.08	3.92
Weight of 1000 kernel (g)	248.57	248.00	250.17	247.40	278.43	269.10	261.10	282.73
Biomass yield (g)	664.67	637	624	685	675	676	647.00	704
Computed yield (kg/ha)	4514^{bc}	3676^{c}	2062^{c}	3352^{c}	5398^{bc}	8148^{ab}	9052^{a}	5522^{abc}

Note: Means not sharing letter in common differ significantly (DMRT at 5% and 1%)

Summary

The experimental results revealed that purple produced tassel at 53.33 days and 53.67 days for white corn. Days to a tassel of the purple is 59.92 days and white produced tassel at 57.17 days, which they differ significantly. A significant difference in results showed that purple mature lately with a mean of 94.42 days while white mature early in 89.67 days. There was no significant difference noted on the plant height, ear height, ear length, and ear diameter of heirloom corn cultivars tested. The white heirloom corn produced the heaviest kernel with a mean of 272.84 g and purple heirloom corn with 248.53 g which results in a significant difference. The biomass yield of the heirloom corn cultivars revealed no significant results. Plant geometry of 50 x 40 cm produced significant yield with 5, 912 kg, followed 60 x 30 cm, 50 x 30 cm, and 60 x 40 cm with a mean of 5,557 kg, 4,956 kg, and 4,437 kg respectively. On the interaction effect of heirloom corn cultivars and plant geometry (Table-5), it was revealed that a highly significant yield produced from a_2b_7 with a mean of 9,052 kg, followed a_2b_6, a_2b_8, a2b5, a_1b_1, a_1b_2, a_1b_4, and a_1b_3 with a mean of 8,148 kg, 5,522 kg, 5,398 kg, 4,514 kg, 3,676 kg, 3,352 kg, and 2,062 kg respectively. This means that a_2b_7 (60 x 30 cm) is highly significant to a_2b_6, a2b8, a_2b_5, a_1b_1, a_1b_2, a_1b_4, and a_1b_3. The same interaction between a_2b_5 and $a_1b_1$was observed. The interaction effect for the purple corn revealed the least difference as presented in Table-5.

Conclusion

It was concluded that a higher yield (kg/ha) of heirloom (white) corn could be achieved by sowing the crop at 60 x 30 cm with a yield of 9,052 kg/ha which shows a highly significant difference. Sowing heirloom (purple) corn to 50 x 30 cm favors the yield attainment of 3,401 kg/ha under Tabuk City condition.

Recommendation

A planting pattern of 60 x 30 cm for heirloom corn (white) cultivars is highly recommended since it produces a yield of 9,052 kg/ha and 50 x 30 cm planting distance is recommended for heirloom (purple) corn under Tabuk City condition.

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