Baby corn single-cross hybrids yield in two plant densities

Luís Roberto Franco Rodrigues*[1]; Norberto da Silva[2] and Edson Seizo Mori[2].
[1]Departamento de Genética, UNESP, Distrito de Rubião Júnior s/n, CEP 18618-000, Botucatu, SP; [2]Departamento de Produção Vegetal, UNESP, Fazenda Experimental Lageado, Caixa Postal 237, CEP 18603-970, Botucatu-SP.

ABSTRACT

Two experiments were carried out in order to evaluate the effect of plant density on baby corn yield. The traits evaluated were: plant height, ear height, number of ears/plot, weight, length, and diameter of husked and dehusked ears of 21 hybrids, 13 inbred lines, and one commercial control. The experiments were set up in a randomized complete block design with three replicates. The experimental plots consisted of rows with 25 and 50 plants, 5-m long, 0.90 m apart, in densities 1 and 2, respectively. The analysis of variance showed that plant densities significantly affected all traits ($P<0.05$), except for plant height and weight of husked ears. The hybrid 27Ax31B had the best performance in the density of 55,000 plants/ha, for husked and dehusked ears yield, while the 27Ax29B hybrid was better under 110,000 plants/ha, taking the same traits into consideration. The hybrids did not overcome the husked and dehusked ears yield of inbred 27A in both plant densities.

KEY WORDS: Baby corn, plant density, *Zea mays* L.

INTRODUCTION

Baby corn (*Zea mays* L.) is a diversified product composed of baby or young ears harvested before fertilization and consumed as a fresh or canned vegetable (Kumar and Kallo, 2000). It is rich in vitamins B and C, potassium, fibres and carotenoids, which helps in the prevention of coronary diseases. In cooking, it is prepared in the form of salads, soups, pickles and Chinese meals. In Brazil, this activity is explored by the family agriculture and there are no statistical data about the cultivated area (Pereira Filho, 2001)[1]. However, baby-corn is a very promising product for the internal and external market; in Brazil most part of the industrialized product is imported mainly from Asia. In addtion, a growing demand shows the potential of the Brazilian market and also an opportunity for the external market (Pereira Filho et al., 1998a).

Production of baby corn has been open-pollinated, of composites, hybrids, sweet corn, and popcorn. In order to use any of these materials some things are necessary, such as a high populational density, an early harvest and high quantities of fertilization N (Takur and Sharma, 1999). The sweet corn and popcorn provided best results due to the major acceptance by consumers (Pereira Filho et al., 1998b).

Seed cost, high production, early maturity, a higher number of ears/plant, tolerance to high density planting, synchronized ear emergence, low plant and ear height and yellow immature grains coloration with rectilinear alignment have been the main factors taken into account at the selection of cultivars or hybrids (Kumar and Kalloo, 2000; Takur et al., 2000).

Other traits, such as weight, length, and diameter of the commercial ears of baby-corn have been considered for the standard production destined to the international market. Population density has plays a major role in these traits (Sangoi, 1990; Dwyer et al., 1991; Russel, 1991). In general, an increase in the population density has caused a reduction in the size, length, diameter and weight of the ear, in the harvest index, grain yield, plant height and ear height in maize (Viégas, 1978; Pereira Filho et al, 1998c; Paiva Júnior, 1999).

This study evaluated 13 inbred lines and 21 single cross hybrids for the production of baby-corn at two plant densities.

MATERIAL AND METHODS

Two field experiments were conducted at the Fazenda Experimental São Manuel of Faculdade de Ciências Agronômicas of Universidade Estadual de São Paulo, Botucatu, Brazil (22° 44' S latitude, 48° 34' W longitude, and altitude 750 m) during the growing season 2000/01. The São Manuel climate is

[1]Pereira Filho, I. A. (Embrapa – Centro Nacional de Milho e Sorgo, Sete Lagoas, Mg) personal communication.

characterized as subtropical humid (Espindola et al., 1974).

Thirteen inbreds (21A, 23A, 25A, 27A, 29A, 31A, 21B, 23B, 25B, 27B, 29B, 31B, and 33B) and their twenty-one hybrids were used in the study (Table 1). These inbreds were obtained from crossings among segregating populations of indigenous popcorn and sweet grain corn and destined to baby corn production (Silva and Ikuta, 1995). The AL-34 commercial cultivar was used as a control.

The 35 treatments were compared in two plant densities, (D1, 55,000 plants/ha) and (D2, 110,000 plants/ha). In each experimental area, N, P and K fertilizers were applied at a rate of 20, 70 and 16 kg/ha, respectively before planting and 55 kg N/ha was applied when the plants had four to five leaves.

The experimental design was a randomized complete block with three replicates. In each experiment, the experimental units consisted of 5.0 m-long row-plots with 0.90 m between rows. Plots were over seeded on the 28th August and, after 22 days at the seedling stage they were thinned by hand to 25 seedlings/plot in experiment 1 and to 50 seedlings/plot in experiment 2. In each experiment, including the border, the tassels were pulled out on their emergence, after 79 days from the date of seeding. Weed control was obtained by hand weeding. In each experiment, pesticides were applied at recommended rates.

The experiments were periodically irrigated. The harvest was initiated after 84 days of seeding, when the stylo-stigma presented a length varying from 1 to 2 cm. Eight hand harvests with intervals of one day were realized. The following agronomic traits were assessed: plant height (PH), in meters from soil surface to the base of the flag averaged for five competitive plants in each plot; ear height (EH), in meters from the soil surface to the first ear bearing node average of five competitive plants in each plot; (NE) number of ears/plot; weight of husked ears (WHE), weight of dehusked ears (WDE), both estimated in ton/ha; diameter of husked ears in centimeters (DHE), diameter of dehusked ears in centimeters (DDE), both obtained from the ratio between the total diameter of ears per plot and the respective numbers of ears; length of husked ears in centimeters (LHE), length of dehusked ears in centimeters (LDE), both obtained from the ratio between the total length of ears per plot and the respective numbers of ears. The number of ears/plot was transformed in square root according to Steel and Torrie (1980). For each plant density, a preliminary analysis of variance procedure was performed for all the traits. The analysis of variance was performed using PROC ANOVA (SAS Institute, 1995). The means were compared by the Tukey test.

RESULTS AND DISCUSSION

The effects of treatments were significant for all traits ($P<0.05$). Plant density was not significant for plant height and weight of husked ears. The ratio treatments x densities was significant for all traits ($P<0.05$), except for the weight of husked and dehusked ears (Table 1). The effects of treatments within each density were significant for all traits. The plant heights of hybrids 21Ax29B, 23Ax25B, 27Ax31B, 29Ax33B, 23A, 25A, 33B, and of cultivar AL-34 were affected by the plant density (Table 1).

At the smallest plant density (D1), the hybrids 21Ax29B, 21Ax31B, 27Ax33B, 29Ax31B, 29Ax33B and 31Ax33B differed significantly in respect to the control group and did not differ among them (Table 2). Mean plant height for hybrids was 2.08 m and 1.87 m for inbreds. Therefore, these groups were shorter than the control groups (2.32 m). Inbreds 25A, 27A and 23B did not differ from AL-34 cultivar, in contrast with most inbreds.

At the highest plant density (D2), the hybrids 21Ax25B, 23Ax27B, 25Ax27B, 25Ax29B, and 27Ax31B differ from the control group and were higher. They did not differ among them. Inbreds 27A and 29A showed differences among them and in respect to the control group. Mean plant height of hybrids was 2.09 m and control was 1.91 m. At a density of 110,000 plants/ha, 11 hybrids and seven inbreds were higher than at 55,000 plants/ha. This result is probably due to the high competition among plants for light interception. (Dwyer et al., 1991). However, the remaining group of hybrids and inbreds was lower in higher plant density. In this case, limiting environmental factors such as temperature, soil humidity and availability of nutrients may be involved (Resende et al., 1990; Magalhães and Paiva, 1993). In constrast with plant height, plant density significantly affected ear height (Table 1) - the ear height of 21Ax31B, 23Ax27B, 23Ax31B, 25Ax27B, 25Ax33B, 27Ax31B, 27Ax33B, 29Ax31B, 29Ax33B, 23A, 27A, 29A, 23B, 27B, 29B, 31B, and 33B was affectd by plant density. At the smallest plant density, 29Ax31B differed in respect to 12 hybrids and cultivar AL-34, showing the lowest ear height

Table 1. Mean squares of analysis of variance combined for plant height (PH), ear height (EH), number of ears per plot (NE), weight of husked ear (WHE), weight of dehusked ear (WDE), diameter of husked ear (DHE), diameter of dehusked ear (DDE), length of husked ear (LHE) and length of dehusked ear (LDE) of thirteen inbreds and twenty-one hybrids of baby corn and one maize commercial control for the plant density of 55,000 (D1) and 110,000 plants/ha (D2). São Manuel, SP., 2000.

Sources of Variation	D.F.	PH	EH	NE	WHE	WDE	DHE	DDE	LHE	LDE
		(m)		(nº/plot)	(ton./ha)			(cm)		
Blocks/Dens.	4	0.189[1/]	0.132ns	2.245[1/]	1.841[1/]	0.035	0.061ns	0.044[1/]	5.279[1/]	0.724 ns
Treatments [2/]	34	0.937[1/]	0.277[1/]	7.314[1/]	0.547[1/]	0.174[1/]	1.064[1/]	0.268[1/]	13.627[1/]	3.055 [1/]
Densities	1	0.028 ns	5.642[1/]	87.683[1/]	1.398 ns	0.264[1/]	1.943[1/]	0.282[1/]	447.934[1/]	6.985 [1/]
Treat. x Dens.	34	0.137[1/]	0.094[1/]	1.124[1/]	0.495 ns	0.015 ns	0.853[1/]	0.122[1/]	3.898[1/]	1.385[1/]
Treat./Dens.1	34	0.61[1/]	0.24[1/]	2.71[1/]	2.751[1/]	0.078[1/]	0.16[1/]	0.07[1/]	11.86[1/]	2.58[1/]
Treat./Dens.2	34	0.47[1/]	0.13[1/]	5.73[1/]	3.209[1/]	0.111 [1/]	1.76[1/]	0.32[1/]	5.67[1/]	1.86[1/]
Dens./Treat.1	1	0.02 ns	0.11 ns	3.76[1/]	0.333 ns	0.0094 ns	0.03 ns	0.03 ns	5.80 ns	0.74 ns
Dens./Treat.2	1	0.02 ns	0.12 ns	1.54 ns	1.545 ns	0.0045 ns	0.33[1/]	0.03 ns	20.54[1/]	1.40 ns
Dens./Treat.3	1	0.04 ns	0.01 ns	4.35[1/]	0.063 ns	0.0075 ns	0.28 ns	0.01 ns	17.34[1/]	0.17 ns
Dens./Treat.4	1	0.31[1/]	0.64 ns	2.33[1/]	0.489 ns	0.074[1/]	0.02 ns	0.001 ns	1.93 ns	0.001 ns
Dens./Treat.5	1	0.01 ns	0.78[1/]	4.33[1/]	0.0036 ns	0.011 ns	0.17 ns	0.01 ns	4.00 ns	0.001 ns
Dens./Treat.6	1	0.02 ns	0.001ns	7.04[1/]	0.0853 ns	0.038 ns	0.04 ns	0.01 ns	3.53[1/]	0.001 ns
Dens./Treat.7	1	0.33[1/]	0.13 ns	5.06[1/]	0.879 ns	0.007 ns	0.38[1/]	0.01 ns	40.40[1/]	10.94 ns
Dens./Treat.8	1	0.03 ns	0.19[1/]	2.63[1/]	0.052 ns	1.04 ns	0.28 ns	0.03 ns	19.44[1/]	9.13 ns
Dens./Treat.9	1	0.01 ns	0.13 ns	3.86[1/]	0.0001 ns	0.017 ns	0.11 ns	0.01 ns	9.38 ns	0.01 ns
Dens./Treat.10	1	0.001 ns	0.20[1/]	4.12[1/]	0.0409ns	0.023 ns	0.20 ns	0.001 ns	7.71 ns	0.20 ns
Dens./Treat.11	1	0.03 ns	0.01	3.47[1/]	0.181 ns	0.004 ns	0.13 ns	0.001 ns	16.01[1/]	1.40 ns
Dens./Treat.12	1	0.001 ns	0.20[1/]	6.39[1/]	0.00571 ns	0.022 ns	0.14 ns	0.02 ns	21.66[1/]	2.28 ns
Dens./Treat.13	1	0.01 ns	0.30[1/]	6.85[1/]	0.00339 ns	0.006 ns	0.43[1/]	0.001 ns	20.91[1/]	0.06 ns
Dens./Treat.14	1	0.12 ns	0.001	3.38[1/]	0.166 ns	0.002 ns	0.33 ns	0.03 ns	16.67[1/]	0.74 ns
Dens./Treat.15	1	0.02 ns	0.28[1/]	4.13[1/]	0.268 ns	0.008 ns	0.28 ns	0.03 ns	14.72[1/]	0.96 ns
Dens./Treat.16	1	0.10 ns	0.07 ns	2.79[1/]	0.00364 ns	0.044 ns	0.06 ns	0.001 ns	3.68 ns	0.20 ns
Dens./Treat.17	1	0.23[1/]	0.34[1/]	0.001 ns	2.720[1/]	0.047[1/]	0.04 ns	0.001 ns	2.16 ns	0.20 ns
Dens./Treat.18	1	0.001 ns	0.74[1/]	3.65[1/]	0.142 ns	0.027 ns	0.08 ns	0.03 ns	2.67 ns	0.01 ns
Dens./Treat.19	1	0.08 ns	1.26[1/]	0.26 ns	0.036 ns	0.036 ns	0.08 ns	0.03 ns	22.43[1/]	1.31 ns
Dens./Treat.20	1	0.39[1/]	0.82[1/]	4.33[1/]	0.499 ns	0.064[1/]	0.04 ns	0.001 ns	5.42 ns	0.28 ns
Dens./Treat.21	1	0.21	0.03 ns	7.04[1/]	0.605 ns	0.040 ns	0.14 ns	0.03 ns	24.00[1/]	0.54 ns
Dens./Treat.22	1	0.01	0.11 ns	8.91[1/]	0.00012 ns	0.035 ns	0.20 ns	0.04 ns	20.53[1/]	0.06 ns
Dens./Treat.23	1	0.21[1/]	0.19[1/]	0.02 ns	1.215 ns	0.004 ns	0.06 ns	0.001 ns	12.61[1/]	0.04 ns
Dens./Treat.24	1	0.27[1/]	0.04 ns	3.08[1/]	0.071 ns	0.015 ns	0.14 ns	0.001 ns	9.88[1/]	0.38 ns
Dens./Treat.25	1	0.08 ns	0.39[1/]	5.36[1/]	0.081 ns	0.025 ns	0.24 ns	0.03 ns	24.40[1/]	2.67 ns
Dens./Treat.26	1	0.09 ns	0.18[1/]	5.06[1/]	0.213 ns	0.057[1/]	0.06 ns	0.01 ns	9.38[1/]	0.11 ns
Dens./Treat.27	1	0.04 ns	0.05 ns	3.41[1/]	0.00057 ns	0.041 ns	0.06 ns	0.001 ns	58.28[1/]	0.33 ns
Dens./Treat.28	1	0.001 ns	0.06 ns	6.06[1/]	0.012 ns	0.018 ns	0.20 ns	0.001 ns	8.40 ns	0.33 ns
Dens./Treat.29	1	0.05 ns	0.20[1/]	0.43 ns	0.261 ns	0.007 ns	0.04 ns	0.02 ns	11.76[1/]	0.33 ns
Dens./Treat.30	1	0.02 ns	0.03 ns	3.08[1/]	1.974[1/]	0.038 ns	0.20 ns	0.11 ns	1.60 ns	3.84 ns
Dens./Treat.31	1	0.14 ns	0.24[1/]	1.08 ns	2.424[1/]	0.027 ns	0.17 ns	2.94[1/]	27.74[1/]	14.11[1/]
Dens./Treat.32	1	0.12 ns	0.21[1/]	1.79 ns	0.310 ns	0.0002 ns	2.94[1/]	0.33[1/]	45.93[1/]	1.13 ns
Dens./Treat.33	1	0.001 ns	0.20[1/]	0.01 ns	0.472 ns	0.005 ns	0.13	0.48[1/]	5.80 ns	0.01 ns
Dens./Treat.34	1	0.34[1/]	0.30[1/]	0.92 ns	0.260 ns	0.00071 ns	0.13	0.02 ns	17.68[1/]	0.02 ns
Dens./Treat.35	1	1.31 [1/]	0.09 ns	5.40[1/]	1.476 ns	0.025 ns	22.82[1/]	0.17[1/]	46.48[1/]	0.20 ns
Combined Effective Error	136	0.137	0.042	0.556	0.382	0.0111	0.080	0.027	2.183	0.771

[1/] Significant at 0.05 percent level of probability; [2/] Treat.1: 21Ax23B; Treat.2: 21Ax25B; Treat.3: 21Ax27B; Treat.4: 21Ax29B; Treat.5: 21Ax31B; Treat.6: 21Ax33B; Treat.7: 23Ax25B; Treat.8: 23Ax27B; Treat.9: 23Ax29B; Treat.10: 23Ax31B; Treat.11: 23Ax33B; Treat.12: 25Ax27B; Treat.13: 25Ax29B; Treat.14: 25Ax31B; Treat.15: 25Ax33B; Treat.16: 27Ax29B; Treat.17: 27Ax31B; Treat.18: 27Ax33B; Treat.19: 29Ax31B; Treat.20: 29Ax33B; Treat.21: 31Ax33B; Treat.22: 21A; Treat.23: 23A; Treat.24: 25A; Treat.25: 27A; Treat.26: 29A; Treat.27: 31A; Treat.28: 21B; Treat.29: 23B; Treat.30: 25B; Treat.31: 27B; Treat.32: 29B; Treat.33: 31B; Treat.34: 33B e Treat.35: AL-34.

(Table 2). While AL-34 cultivar showed a mean ear height of 1.14 m, the hybrids showed a variation from 0.76 to 1.20 m and the inbreds, from 0.80 to 1.28 m. The inbreds 29A and 29B showed the lowest ear heights and did not differ between them and with respect to control.

Baby corn harvest is only possible if it is manually done; in this case, height plant and height ear can affect the yield and harvest costs. Optimum height for baby corn varies from 2 to 2.5 m with a preferable ear height of 0.50 m and 1.98 m for lower and upper ears, respectively (Kumar and Singh, 1999).

At 55,000 plants/ha, the hybrid 29Ax31B showed the lowest ear height and the highest significant number of ears/plot and weight of dehusked ears in respect to the control group (Table 2). Therefore, this hybrid can be important for future studies. At a higher plant density, hybrids and inbreds did not differ among them and in respect to control. While AL-34 showed a mean ear height of 1.25 m, the hybrids showed a range from 1.10 to 1.31 m, and the inbreds from 1.16 to 1.34 m. At 110,000 plants/ha, 19 hybrids and 11 inbreds showed higher ear heights than at 55,000 plants/ha. In this case, it is probable that the same

Table 2. Means from plant height (PH), ear height (EH), number of ears per plot (NE), weight of husked ear (WHE), weight of dehusked ear (WDE), diameter of husked ear (DHE), diameter of dehusked ear (DDE), length of husked ear (LHE) and length of dehusked ear (LDE) of thirteen inbreds and twenty-one hybrids of baby corn and one maize commercial control for density of 55,000 (D1) and 110,000 plants/ha (D2). São Manuel, SP., 2000 [1/].

Treatments	Genealogy	PH (m)		EH (m)		NE		WHE ($ton.ha^{-1}$)		WDE ($ton.ha^{-1}$)		DHE (cm)		DDE (cm)		LHE (cm)		LDE (cm)	
		D1	D2	D1	D2	D1	D2	D1	D2	D1	D2	D1	D2	D1	D2	D1	D2	D1	D2
1	21Ax23B	2.13a-e[1]	2.08a-j	1.09a-d	1.21a	71.00a-j	100.14a-b	8.22a-g	7.17a-h	1.13a-d	1.31c-h	2.36b	2.21b	1.26ab	1.11a	21.13a-d	19.10a-f	8.06a-d	7.36b-e
2	21Ax25B	2.26a-c	2.20a-d	1.16ab	1.28a	76.33a-i	94.87a-c	9.50a-e	7.26a-h	1.29a-d	1.17d-i	2.60ab	2.10b	1.33ab	1.22a	23.46a-d	19.70a-e	8.86a-d	7.90b-e
3	21Ax27B	2.25a-c	2.18a-f	1.20ab	1.23a	62.33a-j	92.05a-c	8.16a-g	7.710a-g	1.25a-d	1.41b-g	2.56ab	2.10b	1.30ab	1.22a	23.50a-d	20.10a-d	8.36a-d	8.03b-e
4	21Ax29B	1.74j-l	1.94f-l	0.92b-e	1.21a	80.00a-h	103.81ab	7.56a-g	8.83a-d	1.21a-d	1.70a-d	2.30b	2.21b	1.26ab	1.23a	20.16b-d	19.00a-f	8.16a-d	8.20b-e
5	21Ax31B	1.83f-k	1.86i-n	0.92b-e	1.24a	80.00a-h	113.33ab	7.81a-g	7.91a-f	1.22a-d	1.40c-g	2.33b	2.01b	1.26ab	1.23a	19.63c-e	18.00c-g	7.66a-d	7.63b-e
6	21Ax33B	2.04a-i	2.09a-i	1.11a-c	1.10a	61.67a-j	100.31ab	5.14e-g	6.81a-I	0.89c-e	1.19d-i	2.23b	2.02b	1.20b	1.14a	19.76c-e	18.20b-g	7.70a-d	7.66b-e
7	23Ax25B	2.30ab	2.08a-i	1.18ab	1.31a	76.33a-i	111.63ab	9.01a-f	7.33a-h	1.28a-d	1.43b-g	2.56ab	2.02b	1.33ab	1.21a	22.46a-e	17.30d-g	10.00a-c	7.30b-e
8	23Ax27B	2.20a-d	2.25a-c	1.13a-c	1.29a	92.67ab	119.30a	10.81a-c	9.54a-c	1.61a-de	1.61a-e	2.43b	2.03b	1.33ab	1.22a	23.63a-d	20.00a-d	10.53a	8.06b-e
9	23Ax29B	2.20a-d	2.04a-k	0.98b-e	1.11a	84.33a-f	116.30ab	8.99a-f	8.98a-c	1.31a-d	1.54b-e	2.43b	2.12b	1.30ab	1.23a	22.30a-e	19.80a-e	7.46a-d	7.40b-e
10	23Ax31B	2.14a-d	2.14a-h	1.06a-d	1.28a	70.33a-j	100.87ab	7.36a-g	7.48a-h	1.02b-e	1.30d-h	2.43b	2.01b	1.26ab	1.21a	21.56a-e	19.30a-f	8.03a-d	7.66b-e
11	23Ax33B	2.05a-i	1.99c-k	1.12a-c	1.20a	81.67a-f	111.32ab	7.30a-g	6.52b-i	0.91b-e	1.02h-k	2.23b	1.93b	1.20b	1.11a	21.96a-e	18.72b-g	7.36a-d	6.40c-d
12	25Ax27B	2.26a-c	2.28ab	1.11a-c	1.16a	70.00a-j	108.66ab	8.82a-f	8.95a-c	1.25a-e	1.52b-f	2.43b	2.14b	1.30ab	1.21a	22.90a-e	19.11a-f	8.90a-d	7.66b-e
13	25Ax29B	2.18a-d	2.21a-d	1.00a-e	1.30a	85.09a-e	129.16a	10.80a-c	10.89ab	1.77ab	1.91a-c	2.60ab	2.02b	1.30ab	1.22a	23.80a-d	20.01a-d	7.93a-d	7.73b-e
14	25Ax31B	2.20a-d	2.07a-j	1.16ab	1.14a	80.67a-g	109.83ab	8.89a-f	8.15a-e	1.27a-e	1.34c-h	2.53b	2.02b	1.26ab	1.11a	22.00a-e	18.60b-g	7.90a-d	7.20b-e
15	25Ax33B	2.16a-d	2.10a-i	1.10a-c	1.30a	68.67a-j	98.70ab	7.75a-g	6.81a-h	0.98b-e	1.14d-h	2.43b	2.02b	1.23ab	1.12a	23.40a-d	20.22a-d	8.16a-d	7.36b-e
16	27Ax29B	2.09a-g	1.97d-l	1.04a-e	1.14a	87.00a-e	114.24ab	11.09ab	11.23a	1.71a-c	2.09ab	2.50b	2.32b	1.33ab	1.31a	22.40a-e	20.82a-c	8.13a-d	8.50a-c
17	27Ax31B	2.08a-h	2.25a-c	1.00a-e	1.21a	102.00a	101.12ab	11.90a	8.96a-c	1.97a	1.58a-e	2.16b	2.23b	1.33ab	1.32a	21.46a-e	20.23a-d	8.06a-d	8.43a-d
18	27Ax33B	2.01b-j	2.02b-l	0.96b-e	1.27a	77.00a-i	106.65ab	7.63a-g	8.31a-e	1.14a-e	1.44b-g	2.46b	2.42b	1.26ab	1.14a	18.76de	20.13a-d	7.56a-d	7.50b-e
19	29Ax31B	1.77i-l	1.87h-m	0.76e	1.17a	95.66ab	103.88ab	8.12a-g	8.51a-e	1.25a-e	1.59a-e	2.46b	2.22b	1.33ab	1.23a	22.70a-e	18.82b-f	8.06a-d	7.13b-e
20	29Ax33B	1.95d-k	2.17a-f	0.98a-e	1.31a	89.00a-d	123.91a	7.95a-g	9.22a-c	1.25a-e	1.71a-d	2.33b	2.12b	1.23ab	1.21a	20.63a-e	18.72b-g	7.13a-d	7.56b-e
21	31Ax33B	1.92d-k	2.09a-i	1.07a-d	1.14a	65.00a-j	103.98ab	5.76d-g	7.17a-h	0.90b-e	1.26c-h	2.33b	2.02b	1.26ab	1.12a	21.96a-e	17.93c-g	7.43a-d	6.80c-e
22	21A	1.85e-k	1.88g-l	1.28a	1.16a	55.67c-j	97.93ab	5.64d-g	5.66c-i	0.83de	1.17d-i	2.40b	2.12b	1.33ab	1.12a	21.33a-e	17.61d-g	7.33a-d	7.10b-e
23	23A	1.98e-j	2.15a-h	1.04a-e	1.19a	92.00a-c	94.25a-c	8.67a-f	6.70b-i	1.21a-e	1.10d-i	2.30b	2.13b	1.16b	1.11a	21.50a-e	19.23a-f	7.40a-d	7.23b-e
24	25A	2.12a-f	1.93e-l	1.28a	1.20a	66.00a-j	90.28a-c	6.99b-g	6.51b-i	0.93b-e	1.15d-i	2.43b	2.22b	1.26ab	1.21a	21.83a-e	19.23a-f	6.50d	7.00b-e
25	27A	2.20a-d	2.30a	0.99a-e	1.22a	75.33a-j	111.27ab	10.43a-d	10.90ab	1.94a	2.23a	2.66ab	2.21b	1.43ab	1.31a	24.96a-c	20.93a-c	10.33ab	9.00ab
26	29A	1.69kl	1.68n	0.80de	0.96a	68.33a-j	101.56ab	7.02b-g	7.86a-f	1.07b-e	1.50b-f	2.46b	2.13b	1.33ab	1.22a	21.36a-e	18.84b-f	7.50a-d	7.20b-e
27	31A	1.68kl	1.76 l-n	0.99a-e	1.07a	65.67a-j	91.55ac	6.41b-g	6.45b-i	0.89c-e	1.25c-h	2.36b	1.92b	1.43ab	1.31a	23.16a-d	16.91e-g	7.30a-d	7.76b-e
28	21B	1.78i-l	1.81j-n	0.99a-e	1.08a	43.00j	72.94a-d	3.69g	4.31d-i	0.54e	0.79f-k	2.30b	2.12b	1.26b	1.22a	19.66c-e	17.30d-g	7.40a-d	6.90b-e
29	23B	2.08a-h	2.00e-l	1.18ab	1.34a	55.67d-j	62.95b-d	5.03e-g	4.10e-i	0.68e	0.84f-k	2.30b	2.04b	1.13ab	1.21a	21.03a-d	18.20c-g	6.86cd	7.33b-e
30	25B	1.98c-k	1.92f-l	1.11a-c	1.18a	47.00i-j	36.26d	4.83e-g	2.28i	0.77ed	0.42k	2.36b	2.12b	1.40ab	1.12a	16.93e	17.92c-g	8.00a-d	6.40c-e
31	27B	2.02b-j	2.15a-g	0.95b-e	1.19a	47.33g-j	36.10d	5.92d-g	3.10hi	0.82ed	0.53hk	2.50b	2.02b	1.70ab	1.34a	26.16ab	21.82a	7.30a-d	10.36a
32	29B	1.52l	1.64mn	0.80de	0.97a	47.33h-j	62.53b-d	4.59fg	3.59f-i	0.71e	0.69hk	3.46a	2.22b	1.60ab	1.13a	21.33a-e	15.80g	7.06b-d	6.20e
33	31B	1.80h-k	1.79k-n	0.86c-e	1.00a	48.33f-j	49.19cd	4.49fg	3.24g-i	0.81ed	0.68hk	2.53b	1.94b	1.83a	1.22a	19.26c-e	17.30d-g	7.26a-d	7.33b-e
34	33B	1.80h-k	2.00b-l	1.01a-e	1.21a	52.00e-j	63.89b-d	4.23fg	3.31g-i	0.48e	0.46jk	2.20b	2.15b	1.16b	1.02a	20.00c-e	16.50fg	6.40d	6.30de
35	Control AL-34	2.32a	1.91f-m	1.14a-c	1.25a	54.67d-j	75.19a-c	6.05cg	7.19a-h	1.14a-e	1.25c-h	2.70ab	3.63a	1.66ab	1.32a	26.60a	21.0ab	8.00a-d	7.63b-e
	Means	2.01	2.02	1.04	1.30	70.40	94.57	7.50	7.11	1.13	1.28	2.4	2.2	1.30	1.20	21.8	18.9	7.8	7.52
	C.V.%	10.27	9.68	20.32	10.68	7.80	8.58	19.76	19.52	20.80	16.34	11.37	12.96	14.5	10.06	8.59	4.84	13.31	8.77
	L.S.D.	0.29	0.27	0.29	0.39	34.85	54.52	4.84	4.53	0.87	0.68	0.90	0.95	0.63	0.41	6.12	2.99	3.43	2.15

[1/] In each column, values followed by same letter are not significantly different at the 5% level of probability according to Tukey test.

limiting environmental factors previously mentioned for plant height may be involved.

For the number of ears/plot, the plant density effect was not significant for 21Ax25B, 27Ax31B, 29Ax31B, 23A, 23B, 27B, 29B, 31B and 33B (Table 1). At the smaller plant density, the hybrids 23Ax27B, 27Ax31B, 29Ax31B and inbred 23A differed significantly in respect to control, because they showed a greater number ears/plot and did not differ among them. The mean number of ears/plot was 78.89 for hybrids, 58.74 for inbreds and 54.67 for control. The number of ears / plant ranged from 2.26 to 4.08 for hybrids and 1.72 to 3.68 for inbreds. The mean number of ears/per plant was 3.16 for hybrids, 2.34 for inbreds and 2.17 for AL-34. So, hybrids were more prolific than inbreds and control. The fact that the hybrids were more prolific than the inbreds can be related to the largest dry matter accumulation. Although the leaf area index (LAI) has not been evaluated in this study, it is known that the increase in dry matter accumulation may be partially attributed to the increase in LAI at optimum plant density, and to higher leaf photosynthetic rates per unit area (Dwyer and Tollenaar, 1989; Dwyer et al., 1991). Dry matter accumulation increases if there is an increase in plant density, if light absorptance by the crop canopy increases; and dry matter accumulation declines as the crop canopy approaches complete light absorptance (Dwyer and Tollennar, 1989). It is probable that LAI is larger in the hybrid than in the inbreds; however this index needs to be evaluated in subsequent experiments in order to confirm this hypothesis. On the other hand, besides the influence of the environmental factors in yield ears, there is the involvement of absorption efficiency and use of nitrogen, phosphorus and potassium. Because this is a genetically controlled characteristic, there can be differences among genotypes of the same species. (Nielsen and Barber, 1978; Carlone and Russel, 1985; Silva et al., 1992; Araújo, 1997; Banziger and Lafitte, 1997).

At a higher plant density, no hybrids or inbreds showed significant difference in respect to number of ears/plot, although 25Ax29B has shown the best performance. The mean number of ears/plot was 107.81 for hybrids, 74.67 for inbreds and 75.19 for control. The number of ears/plant ranged from 1.84 to 2.58 for hybrids and from 0.72 to 2.22 for inbreds. The mean number of ears/per plant was 2.14 for hybrids, 1.49 for inbreds and 1.50 for AL-34 cultivar. The maximum reduction observed for the number ears/plant was 50% for the hybrid 27Ax31B, and 62% for the inbred 27B. All hybrids and inbreds showed a reduction in prolificacy at higher plant density. Similar results were obtained by Pereira Filho et al. (1998c) and Almeida et al. (2000). These authors observed that when plant density increased there was a reduction of number of ears/plant. It is known that increasing light interception in smaller plant densities and a high level of nitrogen fertilization increases the prolificacy in baby corn (Motto and Mall, 1983). But, in spite of the decrease in prolificacy, there was an increase of the number of ears/plot due to the higher density. The increase in mean for number of ears/plot was 37% for hybrids, 27% for inbreds and 37.5% for AL-34.

Plant density significantly affected the weight of husked ears of the hybrid 27Ax31B and inbreds 25B and 27B (Table 1). At a smaller plant density, the hybrids 27Ax29B and 27Ax31B showed the highest weight of husked ears and differed significantly in respect to the control group and to seven inbreds, but did not differ between them. Hybrids overcame inbreds in the weight of husked ears in 42% and Al-34 in 41%. At a higher plant density, all hybrids and the inbreds 23A, 25A, 27A, 31A, and 21B did not differ significantly in respect to control. The hybrid 27Ax29B showed a higher mean for weight of husked ears in respect to hybrids and overcame 27A inbred yield in only 2%. There was no significant difference between them. At a higher plant density, 11 hybrids and five inbreds showed an increase in weight of husked ears (Table 2).

The diameter of husked ears of 21Ax25B, 23Ax25B, 25Ax29B, 29B, and Al-34 was affected significantly by plant density. At a smaller plant density, hybrids did not differ among them and in respect to cultivar AL-34. Wider diameters were observed for hybrids 21Ax25B, 21Ax27B, 23Ax25B, 25Ax29B and for inbreds 27A and 29B. At 55,000 plants/ha, the diameter ranged from 2.33 to 2.60 cm for hybrids and from 2.30 to 3.46cm for inbreds. At a higher plant density, AL-34 significantly differed in respect to all hybrids and inbreds, which did not differ among them. Only the hybrid 27Ax31B and AL-34 showed an increase in diameter in a higher plant density. Other hybrids and inbreds showed a reduction. Results showed that the diameter had low influence concerning differences in the weight of husked ears among hybrids and inbreds.

As for the length of husked ears, plant density effect was significant for 12 hybrids, ten inbreds and AL-34. At a smaller plant density, 21Ax31B, 21Ax33B, 27Ax33B, 21B, 25B, 31B, and 33B differed significantly in respect to control, showing shorter husked ear lengths. Neither the hybrid nor the inbred group overcame control significantly for the same trait at 55,000 plants/ha. The hybrid 25Ax29B and inbred 27A showed a longer husked ear length, while 27Ax33B and 25B showed the lowest values for this trait. Husked ear length ranged from 18.76 to 23.80 cm for hybrids and from 16.93 to 24.96 cm for inbreds. At higher plant density, 21Ax31B, 23Ax25B, 31Ax33B, 21A, 31A, 25B, 29B, 31B, and 33B differed in respect to AL-34 significantly, presenting the shortest lengths of husked ears. Husked ear length ranged from 17.30 to 20.82 cm for hybrids and from 15.80 to 20.23 cm for inbreds. Results showed that the length of ears did not have a great influence in differences of husked ear weight observed among hybrids or inbreds. There is a possibility that the husk weight is the responsible factor for the differences, because there was an increase of number of ears / plot in higher plant density for all hybrids and inbreds, except for the 27Ax31B, 25B, and 27B. But in spite of this increase, the weight of husked ears was reduced for most of the hybrids and inbreds.

As for the weight of dehusked ears, the plant density effect was significant for the hybrids 21Ax29B, 27Ax31B, 29Ax33B and inbred 29A. Hybrids and inbreds did not show any significant difference in respect to control in the smaller plant density. The lowest weights of dehusked ears were for hybrid 21Ax33B, and inbred 21A. The hybrids showed an ear yield, on average, 40.28% larger than the inbreds and 10.49% larger than control. At a higher plant density, 27Ax29B, and 27A were significantly different in relation to AL-34, with the highest means for this trait, and did not differ between them. Inbreds 25B, and 33B were inferior to the control. The hybrids showed an ear yield, on an average, 50% larger than the inbreds and 3.5% than control. In spite of the hybrids having shown a larger ear yield than inbreds, taking into account the average of the two plant densities, it was expected that no inbreds overcame the best hybrid combinations. However, inbred 27A, for example, as well as other inbreds did not show significant differences in relation to the best hybrids. In this case, it is probable that the hybrid x plant density interaction has contributed to that, so that the superiority of several single hybrids was not showed. Carlone and Russel (1987) reported highly significant densities X N levels X cultivars interactions. Therefore, we need to evaluate these hybrids and inbreds in other densities, locations, years and in several levels of fertilization, considering the same traits and others - mainly the weight and number of commercial dehusked ears. In this study, the number and weight of commercial dehusked ears was not evaluated. But this evaluation is an important indicator to determine if the net return obtained with the increase of the productivity pays off in higher densities. This indicator can determine if higher densities should be tested in subsequent studies.

When there was an increase in plant density from 55,000 to 110,000 plants/ha, the hybrids 21Ax25B, 23Ax27B, 27Ax31B, and inbreds 23A, 25B, 27B, 29B, 31B, and 33B showed a reduction in the dehusked ear weight.

In respect to diameter of dehusked ears, plant density effect was significant only for 27B, 29B, 31B, and AL-34. For industry established patterns, the observed significance among plants for this trait has no practical importance, once the variation in the two plant densities is within the range of 0.7 to 1.7 cm, except for 31B. At smaller and higher plant densities, hybrids and inbreds did not differ significantly among them and in respect to control. An increase in plant density reduced the diameter in all hybrids and inbreds, except for inbred 23B.

For the length of dehusked ear, plant density effect was significant for 27B inbred (Table 1). At a smaller plant density, hybrids and inbreds did not differ in respect to control. The variation in lenght of dehusked ears at 55,000 plants/ha for hybrids was from 7.13 to 10.53 cm and from 6.40 to 10.33 cm for inbreds. At a higher plant density, hybrids did not differ in respect to control, and inbred 27B differed from AL-34. The variation in length of dehusked ears at 110,000 plants/ha for hybrids was from 6.40 to 8.50 cm and from 6.20 to 10.36 cm for inbreds. When the plant density increased from 55,000 to 110,000 plants/ha, 26 treatments from a total of 35 showed a reduction in the length of dehusked ears.

The reduction in weight, diameter and length of husked and dehusked ears observed in a higher density can be attributed to the same limiting factors previously mentioned for plant height.

CONCLUSION

Based on the results we can conclude that:

In general, the majority of hybrids showed a higher yield in husked and dehusked ear weight at 110,000 plants/ha;

The hybrid 27Ax31B showed the highest yield in husked and dehusked ears weight in 55,000 plants/ha, while 27Ax29B showed the highest yield for the same traits at 110.000 plants/ha;

The prolificacy of all hybrids and inbreds was reduced in the higher plant density.

In both plant densities no hybrid overcame the yield in the husked and dehusked ear weight showed by the 27A inbred.

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RESUMO

Produção de híbridos simples de minimilho em duas densidades populacionais

Para a produção de minimilho (*baby corn*) são utilizadas altas densidades populacionais para a obtenção de maiores produtividades. Foram conduzidos dois experimentos com a finalidade de avaliar o efeito de diferentes densidades populacionais (55.000 e 110.000 plantas/ha) sobre: a altura da planta e da espiga, número de espigas/parcela, peso, diâmetro e comprimento de espigas com palha e sem palha de 13 linhagens, 21 híbridos e uma testemunha comercial. Os experimentos foram delineados em blocos ao acaso com três repetições. As parcelas foram constituídas de fileiras de 5 metros espaçadas de 0,90 m, com 25 e 50 plantas nos experimentos 1 e 2, respectivamente. A análise de variância constatou que as densidades populacionais afetaram significativamente ($P<0,05$) todas as características avaliadas, exceto a altura de planta e peso de espigas com palha. Na densidade populacional de 110.000 plantas/ha a maioria dos híbridos e linhagens apresentou maior rendimento de peso com palha e sem palha e menor número de espigas por planta. O híbrido 27Ax31B apresentou melhor desempenho de peso com palha e sem palha na densidade de 55.000 plantas/ha, enquanto o híbrido 27Ax29B foi o mais produtivo na densidade populacional de 110.000 plantas/ha para as mesmas características. Os híbridos não superaram a produção de espigas com palha e sem palha da linhagem 27A nas duas densidades populacionais.

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