# Short communication: Phosphorus and nitrogen fertilisation in sweet corn *(Zea mays* L. var. saccharata Bailey)

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## Abstract

To evaluate the effect of combining different levels of P and N fertilisation on yield and uniformity of a sweet corn crop hybrid Freshy, a factorial trial combining three levels of N (0, 100 and 200 kg of N ha$^{-1}$) and three levels of P (0, 40 and 80 kg of $P_2O_5$ ha$^{-1}$) was carried out. Total leaf number, height up to ear insertion, leaf width and length, leaf area, plant height, stem diameter, biomass production, shoot dry matter content, harvest index and yield with and without husk, husk proportion and ear diameter were measured. Significant differences in leaf width and length, leaf area, plant height, ear diameter, biomass production and yield with and without husk were observed with N fertilisation. On the other hand, significant differences in leaf length, unit leaf area, ear diameter and biomass production were observed with P fertilisation. A N × P interaction was only observed for shoot dry matter content.

**Key words:** mineral nutrition, yield, growth.

## Resumen

**Fertilización fosforada y nitrogenada en el cultivo de maíz dulce *(Zea mays* L. var. saccharata Bailey)**

El objetivo de este trabajo fue evaluar el efecto de la fertilización fosforada y nitrogenada sobre la uniformidad y rendimiento del cultivo de maíz dulce híbrido Freshy. Los tratamientos de fertilización fueron: 0, 100 y 200 kg de N ha$^{-1}$ combinados con 0, 40 y 80 kg de $P_2O_5$ ha$^{-1}$. Se utilizó un diseño en bloques completamente aleatorizados con tres repeticiones. Las mediciones y determinaciones fueron número total de hojas, altura hasta inserción de la espiga, ancho y longitud de hoja, área foliar, altura de planta, diámetro de tallo, producción de biomasa, porcentual de materia seca en vástago, índice de cosecha y rendimiento con y sin chala, proporción de chala y diámetro de espiga. Con la aplicación de nitrógeno se encontraron diferencias significativas para ancho y largo de hoja, área foliar, altura de planta, diámetro de espiga, producción de biomasa aérea y rendimiento con y sin chala. Por otra parte, con la aplicación de fósforo se verificaron diferencias significativas en largo de hoja, área foliar unitaria, diámetro de espiga y producción de biomasa aérea. Solamente se comprobó interacción nitrógeno × fósforo para el porcentual de materia seca del vástago.

**Palabras clave:** nutrición mineral, rendimiento, crecimiento.

## Introducción

Sweet corn (*Zea mays* L. var. saccharata) is the same botanical species as common corn, the main difference being that the endosperm in the grains of fresh sweet corn have a greater polysaccharide content at commercial maturity. To ensure a high profitability crop management large yields have to be obtained in the field with good quality. Nutrient management by fertilisation is one of the most important variables that must be controlled to reach this objective (Chiesa *et al*., 1999).

Nitrogen and phosphorus determine setting and maintenance of the photosynthetic potential of the canopy and the plant reproductive capacity. On the other hand, both nutrients must be supplied in adequate amounts and timing to ensure an optimum physiological state at flowering, the stage around which the number of grains per unit surface area is established (Andrade *et al.,* 1996). Nitrogen deficiencies reduce grain yield by affecting both grain number and weight. The number of ears per plant and the number of grains obtained per differentiated ovule are the most affected variables (Uhart and Andrade, 1995b).

The effect of phosphorus availability has not been as well studied as that of nitrogen. Spence and Welch (1977) found that a high phosphorus availability shortens both the emergence-flowering period and the period of flowering-physiological maturation. Fontanetto (1993), however, found no significant differences in crop phenology, and observed that the amount of dry matter in the aerial biomass was significantly reduced by phosphorus deficiencies. The growth rate of the crop during flowering was significantly reduced by phosphorus deficiency, resulting in a poorer grain set and lower yield, although the harvest index was not affected (Uhart and Andrade, 1995b). Fontanetto (1993) found in another experiment that phosphorus deficiency reduced the number of ears per plant, the number of grains per ear and the grain yield.

The aim of the present work was to assess the effect of different levels of phosphorus and nitrogen fertilisation on yield and uniformity of a sweet corn cultivar widely used in Argentina.

The trail was carried out in an experimental field of the University of Lomas de Zamora (34° 48' LS, 58° 31' LW). Freshy sweet corn hybrid was used (yellow type). Sowing was done on December 26, 2000, on a Typic Argiudol containing 0.15% of total nitrogen, 17 ppm of extractable phosphorus and 14 ppm of $N-NO_3$ (water content 19% v/v), in a plot proceeding from leafy vegetable crops with no previous fertiliser or manure application. At the time of sowing, phosphate fertiliser was applied alongside and beneath the seed row as diammonium phosphate. Nitrogen fertiliser (urea 46:0:0) was applied by broadcast fertilisation four weeks later when the crop had between six and eight leaves fully expanded. Crop was drip-irrigated. Crop management was similar to those commonly applied to commercial crops in the area.

Fertilisation treatments consisted of three levels of P ($P_0=0$, $P_1=40$ and $P_2=80$ kg $P_2O_5$ ha$^{-1}$) combined with three levels of N ($N_0=0$, $N_1=100$ and $N_2=200$ kg N ha$^{-1}$). Sampling to determine the parameters analysed was carried out in most treatments when the ears reached commercial quality and size, corresponding to 77 days after sowing.

Total leaf number (LN), leaf number and height up to ear insertion, leaf width and length, plant height (H), aerial biomass production, stem diameter (SD), number of tillers per plant, number of tillers with ears, number of ears per plant, ear length and diameter and number of grain rows per ear were recorded. The fresh weight of the shoot (SFW) was measured. Samples were over-dried at 65°C for 72 h in a stove with air circulation and the dry weight of the shoots (SDW) was determined. The percentage of shoot dry weight (SD%), harvest index with and without husk (HI+H, HI-H), yield (fresh weight of ears) with and without husk (Y+H and Y-H, respectively) and the proportion of husk (H%) were calculated. The unit leaf area (ULA) was calculated according to Chaud and Sharma (1976), who described three models to estimate this parameter in sweet corn. The one used in this work calculates the leaf area by multiplying the leaf length by the maximum width, affected by a constant of 0.73708 that was considered to be the best fitting value.

A randomised block-design was adopted with three replicates. Each experimental unit had 3 rows 5 m long with a density of 5 plants per linear metre on sowing. Samples and measurements were taken from plants in the central row of each experimental unit. All the data were subjected to analysis of variance using Tukey's test ($p<0.05$) for comparison between treatments means.

As observed in Table 1, N fertilisation increased leaf length and width but not leaf number. Therefore, a larger unit leaf area and total leaf area was measured for $N_1$ and $N_2$ treatments, with no significant differences between them. In contrast, phosphorus fertilisation caused a reduction in unit leaf area as a consequence of a smaller leaf length. However, this was not reflected in the total leaf area in spite of the fact that the total number of leaves was not affected by phosphorus application.

The effect of nitrogen fertilisation on the variables related to leaf area was in agreement with those observed by Muchow (1988), and Uhart and Andrade (1995a), who concluded that a severe nitrogen deficiency does not affect the final number of leaves per plant, reducing only slightly the rate of leaf appearance. However, N deficiency led to a decrease in leaf area. As a consequence, the leaf area index and the duration of leaf area decreased up to 60 and 65%, respectively.

Both plant height and aerial biomass increased with nitrogen application (Table 1). However, phosphorus fertilisation did not affect plant height and less total biomass was measured in $P_2$ treatment. The stem diameter and height of ear insertion were not affected by the fertilisation treatments genotypically determined. A significant interaction was found between the nitrogen and phosphorus treatments for shoot dry matter content. Ear diameter increased with both levels of

**Table 1.** Width, length and total number of leaves, unit leaf area (ULA), total leaf area (TLA), plant height, ear diameter, aerial biomass, dry matter content, stem diameter, heigth to ear insertion, yield with and without husk and harvest index with and without husk of sweet corn plants under with different phosphorus and nitrogen fertiliser application levels

| Treatment | N | | | | P | | | | Interaction N × P |
|---|---|---|---|---|---|---|---|---|---|
| | $N_0$ | $N_1$ | $N_2$ | Mean | $P_0$ | $P_1$ | $P_2$ | Mean | Significance |
| **Leaf** | | | | | | | | | |
| — Width (cm) | 7.53[b] | 9.09[a] | 9.40[a] | 8.67 | 9.00[a] | 9.33[a] | 8.84[a] | 9.06 | ns |
| — Length (cm) | 55.19[b] | 68.59[a] | 70.22[a] | 64.67 | 67.70[a] | 65.93[ab] | 60.37[b] | 64.67 | ns |
| — Number | 9.58[a] | 10.16[a] | 10.36[a] | 10.03 | 9.88[a] | 10.50[a] | 10.25[a] | 10.21 | ns |
| — ULA (cm²) | 300.90[b] | 462.09[a] | 488.40[a] | 417.13 | 454.48[a] | 428.20[a] | 368.70[b] | 417.09 | ns |
| — TLA (cm²) | 2985.5[b] | 4707.3[a] | 5049.6[a] | 4247.5 | 4528.3[a] | 4470.0[a] | 3744.0[a] | 4247.4 | ns |
| Plant height (cm) | 196.02[b] | 215.74[ab] | 221.30[a] | 211.02 | 205.56[a] | 226.94[a] | 215.56[a] | 216.02 | ns |
| Ear height insertion (cm) | 51.00[a] | 54.15[a] | 60.26[a] | 55.14 | 53.33[a] | 60.89[a] | 56.22[a] | 56.81 | ns |
| Ear diameter (cm) | 4.79[b] | 5.26[a] | 5.31[a] | 5.12 | 5.21[ab] | 5.24[a] | 4.91[b] | 5.12 | ns |
| Aerial biomass (kg pl⁻¹) | 1.051[b] | 1.331[a] | 1.395[a] | 1.259 | 1.358[a] | 1.346[ab] | 1.073[b] | 1.259 | ns |
| Dry matter (%) | 18.59 | 16.85 | 20.40 | 18.61 | 19.33 | 18.61 | 17.90 | 18.61 | * |
| Stem diameter (cm) | 2.355[a] | 2.372[a] | 2.337[a] | 2.355 | 2.395[a] | 2.356[a] | 2.293[a] | 2.348 | ns |
| **Yield (kg ha⁻¹)** | | | | | | | | | |
| — With husk | 15032[b] | 18346[ab] | 22092[a] | 18490 | 18564[a] | 19982[a] | 20345[a] | 19630 | ns |
| — Without husk | 10360[b] | 13313[ab] | 15750[a] | 13141 | 13149[a] | 14588[a] | 14464[a] | 14067 | ns |
| **Harvest index** | | | | | | | | | |
| — With husk | 0.214 a | 0.207 a | 0.219 a | 0.213 | 0.216 a | 0.204 a | 0.218 a | 0.213 | ns |
| — Without husk | 0.146 a | 0.149 a | 0.154 a | 0.150 | 0.151 a | 0.149 a | 0.154 a | 0.151 | ns |
| Husk (%) | 30.95 a | 27.65 a | 29.13 a | 29.24 | 29.56 a | 26.93 a | 29.38 a | 28.62 | ns |

Mean values followed by different letters indicate statistically significant differences between treatments according to Tukey ($p < 0.05$). Interaction N × P: (*) significant, (ns) non-significant. $N_0$, $N_1$, $N_2$: 0, 100 and 200 kg N ha⁻¹, respectively. $P_0$, $P_1$, $P_2$: 0, 40 and 80 kg $P_2O_5$ ha⁻¹, respectively.

nitrogen application. In contrast, ear diameter was maximum for $P_1$ and minimum for $P_2$ (Table 1).

Nitrogen stress delayed crop phenology both for the vegetative and silking stages (Jacobs and Pearson, 1991; Uhart and Andrade, 1995a). It also reduced the dry matter content in aerial organs and roots, and increased the partitioning of dry matter and nitrogen to the roots. Nitrogen deficiency lengthens the period between anthesis-silking, which could affect ovule fertilisation (Uhart and Andrade, 1995a). However, a lack of pollen is rarely the cause of grain loss in plants under stress (Westgate and Basseti, 1990; Otegui, 1992).

Nitrogen deficiencies reduce biomass production because they reduce the radiation intercepted by the crop and the conversion efficiency into biomass. This reduction in intercepted radiation is mainly explained by the low photosynthetic rate, resulting from a low nitrogen content in the leaf (Novoa and Loomis, 1981). Lower values of intercepted radiation and conversion efficiency reduce the growth rate during flowering, the stage during which the number of grains per unit area is determined (Lemcoff and Loomis, 1986; Prioul *et al.,* 1990; Cox *et al.,* 1993; Andrade *et al.,* 1996). However, low growth rates before the critical period of grain setting did not produce a decreasing of grain number or yield as shown by Cirilo and Andrade (1994).

Husk proportion was not affected by any fertilisation treatment. Therefore, differences in both yield and harvest index were found with or without considering the husk as part of the product (Table 1).
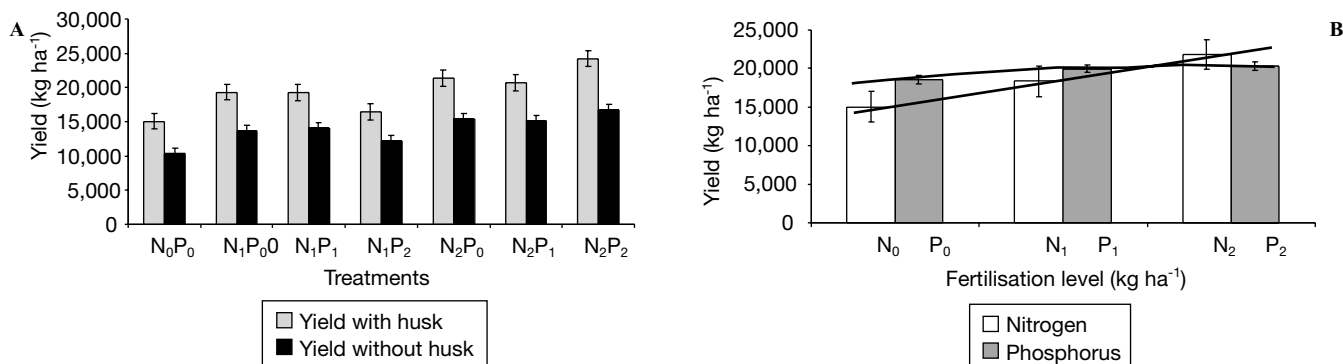
**Figure 1.** (A): Yield with and without husk in all the treatments. (B): Increase in yield with nitrogen and phosphorus fertilisation compared to an unfertilised crop. $N_0$, $N_1$, $N_2$: 0, 100 and 200 kg N ha$^{-1}$. $P_0$, $P_1$, $P_2$: 0, 40 and 80 kg $P_2O_5$ ha$^{-1}$.

The greatest yield was observed for the $N_2P_2$ treatment, and the lowest yield with $N_0P_0$ (Figure 1A). Yields only increased with nitrogen fertilisation. Phosphorus application did not affect yields. The smaller number of grain per ear was compensated by slightly heavier grains established in crops fertilised with phosphorus in previous experiments (Fontanetto, 1993).

For treatments fertilised with level $N_2$, both phosphorus application levels determined a significant increase in yield. It appears that phosphorus only becomes a limiting factor at the higher nitrogen levels. In contrast, within the $N_1$ level, lower yields were measured with the increase in phosphorus application (Figure 1A).

Figure 1B shows no significant differences between $P_1$ and $P_2$ with increased phosphorus fertilisation. Yield increased only 7.64 and 9.60% for $P_1$ and $P_2$, respectively, since an increase of phosphorus level had no additional effect on yield. On the other hand, nitrogen fertilisation increased yields relative to control in 22.05 and 46.97% for $N_1$ and $N_2$ respectively, showing a conversion efficiency of 35.30 kg ha$^{-1}$ of corn per kg of nitrogen applied, within this fertilisation range (Figure 1B).

Lower nitrogen fertilisation decreased the grain weight because it affects the number of endospermatic cells and starch granules in the early postflowering period, as well as reduces the source of assimilates during the filling period (Uhart and Andrade, 1995b).

## Acknowledgements

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