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Note

Electromagnetic field and seed vigour of corn hybrids

R. Zepeda-Bautista[1*], *C. Hernández-Aguilar*[1], *A. Domínguez-Pacheco*[1], *A. Cruz-Orea*[2], *J.J. Godina-Nava*[2], *and E. Martínez-Ortíz*[1]

[1]National Politecnic Institute, Sepi-Esime, Zacatenco, Professional Unit 'Adolfo López Mateos', Col. Lindavista, Mexico D.F., CP 07738, Mexico
[2]Department of Physics, CINVESTAV–IPN, A. P. 14-740, Mexico D.F., CP 07360, Mexico

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A b s t r a c t. In order to increase maize productivity with environmentally friendly techniques, the effect of electromagnetic irradiation on seed vigour of maize hybrids, as well as the response of each genotype were assessed. There were differences ($p \leq 0.05$) between hybrids and electromagnetic field doses for emergence rate on the ninth day (VE9) and the dry mass of aerial part (PSP). With 15 min of electromagnetic field, VE9 and PSP increased by 14.96 and 14.38%, respectively, compared to the control. With 3 min, VE9 in hybrids San Jeronimo and San Juan increased by 16 and 19%, respectively, and with 6 min only 4 and 9% with respect to the control. In PSP, San Jeronimo grew by 16% with 3 min, and San Juan by 21% with 9 min, in San Jose there was no significant increment, compared to the control.

K e y w o r d s: corn hybrids, biostimulation, seed vigour, emergence rate

INTRODUCTION

Food production worldwide is lower than required to feed the population; especially in corn, with a production of 393.5 million t (FAO, 2007), there is a deficit. Therefore, it is necessary to increase corn productivity by means of using quality seed of improved and native varieties, which may guarantee quick and uniform crop establishment (Zepeda *et al.,* 2009), and ecofriendly production techniques, which will have a bearing on quantity and quality of maize grain.

In order to produce quality seed, production technologies are used, which in many cases cause damage to the environment and human health because of the indiscriminate use of fertilizers and pesticides. An alternative to increase physiological seed quality as a pre-sowing treatment is the field application and electromagnetic irradiation, which may have a positive effect on germination percentage and growth rate (Pietruszewski *et al.,* 2007); 4 to 6 min of diode laser radiation at 650 nm increased wheat seed germination by 45.31% in comparison to the control (Hernández *et al.,* 2008); likewise, Hernández *et al.* (2007) found that, at radiating corn seed with laser light at 10 mW cm^{-2} during 1 min, establishment percentage was increased by 33%, and seedling dry mass by 14%, compared to the control. Irradiating corn seed at an intensity of 20 mW cm^{-2} during one minute also produced an increment of 43% in establishment percentage and 63% in seedling dry mass with respect to the control (Hernández *et al.,* 2006). Hernandez *et al*. (2009a) found that, atradiating corn seed with magnetic flux density of 100 mT during 7.5 min, in the corn hybrid CL-12 X CL-11, seedling emergence rate was increased by 123.2%, and seedling dry mass, 21 days after planting, by 30.1%, compared to the control. In the CL-4 X CL-1 genotype it was found a negative biostimulation for seedling emergence percentage; and in the CL-13xCL-1 genotype there was not any significant effect. Likewise, Irradiating maize seeds genotypes with a diode laser with output power of 27.4 mW at 650 nm wavelength, also showed that, everyone genotype needed radiation parameters different to induce positive biostimulation (Hernandez-Aguilar *et al*., 2009).

At treating tomato seed with stationary magnetic field, germination percentage and rate improved (Martínez *et al.,* 2009). Likewise, Flórez *et al.* (2007), at carrying out experiments with maize seeds at magnetic induction levels of 125 and 250 mT, employing permanent magnets at different times of exposure of the magnetic field, generally observed

*Corresponding author's e-mail: rzb0509@hotmail.com

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an increment in seedling height and mass. Irradiating maize seeds at magnetic induction levels of 160 and 560 mT, also produced an increment seed emergence rate and seedling emergence, and on seedling dry mass on the 17th day with respect to the control (Dominguez *et al.,* 2010).

In order to increase corn productivity through environmentally friendly techniques, the electromagnetic radiation effect on maize hybrid seed vigour as well as the response of each genotype were evaluated. The hypotheses were:

– the electromagnetic radiation will positively stimulate corn seed, which will result in quick and uniform seedling establishment;
– the response of each maize variety will be different, according to its particular genetic characteristics.

MATERIALS AND METHODS

The experiment was established in the Protected Horticultural Area of the University of Chapingo, Chapingo, Mexico. Three maize hybrids were used, produced during the agricultural cycle spring-summer of 2007. The emergence rate vigour test was used under greenhouse conditions and natural light cycle. The average temperature was 20°C, minimum temperature was 9°C and maximum temperature was 30°C. A loamy clay soil was used as the substrate. Eighteen treatments were evaluated, product of the combination of three corn hybrids (San Jeronimo, San Jose, and San Juan) and 5 doses of electromagnetic radiation (3, 6, 9, 12, and 15 min with 480 mT electromagnetic field intensity (B)), and a control, in a complete randomised block design with four replications, the experimental unit consisting of 25 seeds. The seed was irradiated with an automated implementation and controlled by a computer with which time and intensity parameters of the electromagnetic field, induced by a solenoid, were conducted. The seed was placed in the coil centre to be radiated, and sown and irrigated in 9 and 18 h, respectively, after being radiated. Gauss/Teslameter model 5070 was used to measure the intensity of electromagnetic field (B).

On November 22, 2008, the seed was sown, to this purpose, the furrows were given a layout of 10 cm distance between each other, and 80 cm length; the seed was placed, introducing the pedicel into the substrate, leaving the crown outside, then it was covered with a layer of substrate of 5 cm, and watered. It was irrigated every three days at the same hour. The seedlings were extracted on December 13, 2008 (21th day after sowing). The assessed variables were:

– emergence rate at the end of the test (VE) and on the 9th day (VE9); once the emergence initiated, every day at 10:00 a.m., counts were made until the number of seedlings remained constant, and VE was calculated with the formula proposed by Maguire (Copeland and McDonald, 1995);
– establishment percentage (PE) based on the normal seedlings, present at the end of the trial;
– length of the aerial part of the seedling (LPA) was measured in cm, starting from root insertion point to the apex of the largest leaf;
– dry mass of the aerial part (PSA) in grams after 72 h of drying in an oven at 70°C. Only normal seedlings according to the ISTA rules (1993) were evaluated.

An analysis of variance was applied to the variables by means of the PROC GLM procedure of the Statistical Analysis System (SAS, 1989), and for the variables whose mean squares turned out to be significant, the Tukey multiple comparison test of means (α = 0.05) was used.

RESULTS AND DISCUSSION

Highly significant differences ($p \leq 0.01$) were observed among hybrids for percentage of establishment, emergence rate on the ninth day, and length and dry mass of aerial part of seedlings (Table 1), due to their particular genetic characteristics. The San Juan hybrid had the highest establishment percentage (PE), followed by San Jose, and 10.81% higher than San Jeronimo. In spite of San Jeronimo hybrid having the lowest establishment percentage with respect to San Juan and San Jose, it had the highest emergence rate on the ninth day, length, and seedling dry mass due to the fact that the seed is larger by 100% than that of San Juan and San Jose, and the amount of reserves for establishment and growth was greater, since the kernel is totally floury. This agrees

T a b l e 1. Comparison of means of seed vigour in maize hybrids with electromagnetic radiation at pre-sowing

Hybrids	PE (%)	VE	VE9	LPA (cm)	PSA (g)
San Jose (G1)	93.83 a	2.74 a	2.58 a	20.25 b	2.43 b
San Juan (G2)	94.75 a	2.63 a	2.35 b	21.36 b	3.35 a
San Jeronimo (G3)	84.50 b	2.77 a	2.68 a	25.10 a	3.45 a
DMS (0.05)	3.41	0.15	0.23	1.23	0.23
Significant	*	NS	*	*	*

* Significant at 0.01%, means with the same letter in each column are statistically equal (DMS). PE – establishment percentage, VE and VE9 – final emergence rate and on day 9 (number of seedlings on the day), PSA – seedling dry mass, DMS – minimal significant difference.

T a b l e 2. Comparison of means of electromagnetic radiation in seed of maize hybrids at pre-sowing

Time (min)	PE (%)	VE	VE9	LPA (cm)	PSA (g)
Control	90.16 a	2.56 b	2.34 b	23.08 a	2.78 b
3	89.66 a	2.78 ab	2.68 a	21.48 a	3.08 ab
6	92.66 a	2.75 ab	2.55 ab	22.66 a	3.13 a
9	92.00 a	2.74 ab	2.63 ab	22.17 a	3.25 a
12	89.33 a	2.61 ab	2.32 b	22.04 a	3.03 ab
15	92.33 a	2.82 a	2.69 a	21.97 a	3.18 a
DMS (0.05)	4.83	0.2235	0.32	1.74	0.33
Significant	0.59	0.15	0.08	0.52	0.11

Explanations as in Table 1.

with the results pointed out by Zepeda *et al.* (2002) who also found differences among genotypes at assessing the physiological quality of two hybrids and one line.

Among electromagnetic radiation treatments, significant differences ($p \leq 0.05$) for emergence rate at the end of the trial and on the ninth day, and dry mass of seedling aerial part (Table 2), were observed; with 15 min they increased by 10.15, 14.90, and 14.38%, respectively, compared to the control, due to positive biostimulation of enzymatic activity accelerating seed germination and seedling growth (Mietchen *et al.,* 2005). In establishment percentage no considerable increment existed, but there was a tendency of improvement with respect to the control, while in the length of seedling aerial part no effect was observed whatsoever. Hernández *et al*. (2006, 2007) and Dominguez *et al.* (2010) also observed the increment of establishment percentage and dry mass of seedling aerial part at radiating corn seed.

Regarding emergence rate on the ninth day (VE9) (Fig. 1), with 3 min of electromagnetic irradiation in San Jeronimo and San Juan hybrids, it increased by 16 and 19%, respectively, whereas with 6 min, only by 4 and 9%, compared to the control; the San Jose hybrid, however, showed the highest VE9 on the ninth day (2.8) with 6 min application of electromagnetic field, and the lowest (2.2) with 12 min. Likewise, it was observed that in establishment percentage (Fig. 2) San Jeronimo increased by 4.8% at 6 min of electromagnetic irradiation and diminished at 12 min. In San Juan hybrid, it increased by 4.3% with an application of 9 min, on the other hand, in San Jose a decrease of 5.3% was observed, but with increasing time of exposure to the magnetic field it grew as well. With respect to dry mass of seedling aerial part (Fig. 3), the San Jeronimo hybrid presented an increment of 16% with 3 min of electromagnetic irradiation, whereas San Juan had the highest increment (21%) with 9 min of irradiation; however, in the San Jose hybrid no significant increments were observed under electromagnetic field application, including a decrease with 12 and 15 min, compared to the control, similar to the results obtained by Hernandez *et al*. (2009) and Hernandez-Aguilar *et al*. (2009) in corns geno-

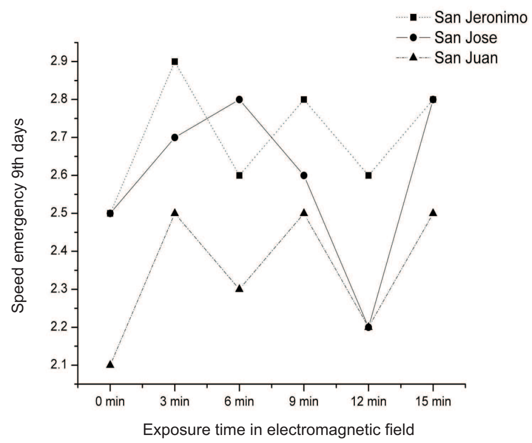

Fig. 1. Emergence rate on day 9 of maize hybrid seed with electromagnetic field.

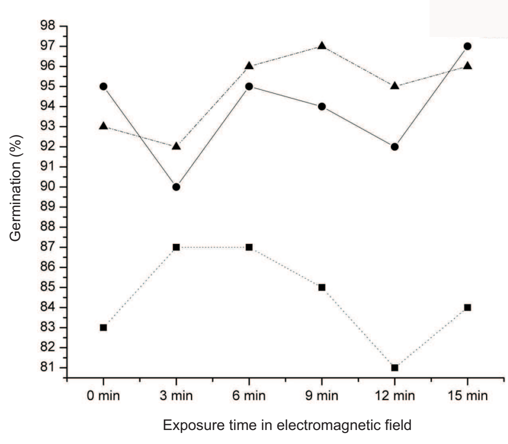

Fig. 2. Establishment percentage of maize hybrid seed with electromagnetic field. Explanations as in Fig. 1.

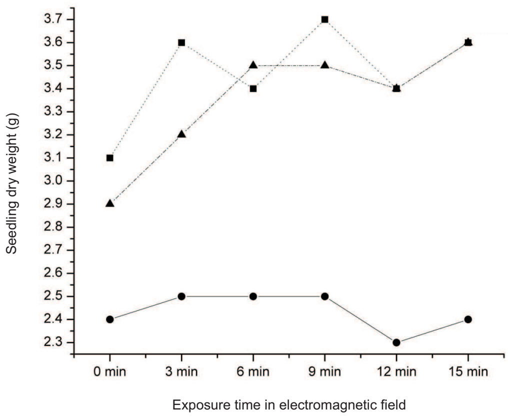

Fig. 3. Dry mass of seedling aerial part of maize hybrids with electromagnetic field.

types. This was due to positive or negative biostimulation in enzymatic activity during germination and seedling growth (Mietchen *et al.,* 2005), and to the difference between the structural components and kernel size.

CONCLUSIONS

1 Electromagnetic irradiation applied as a pre-sowing treatment increases corn seed vigour through emergence rate, establishment percentage, and dry mass of seedling aerial part, according to the combination of radiation intensity and time and the genotype.

2. The response of each genotype to electromagnetic radiation (combination of intensity and time) is different according to the particular characteristics of the genetic material.

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