Effect of inorganic and organic fertilization in the performance of hybrid corn (Zea mays): 1052 and genotypes that form it

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Received July 14, 2017; Accepted November 21, 2017

Abstract

The objective of this study was to determine the fertilization formula (FF): inorganic or organic that increases the yield during grain or seed production of four genotypes (G) that integrate trilineal hybrid: 1052. Six fertilization formula (organic and inorganic) were evaluated: Worm humus, WH, (solid and liquid); NPK, Entec more micronutrients, Nitro Plus-9 and the following combinations: (½ inorganic + ½ organic) and (½ inorganic + ½ Nitro Plus-9), on five G of maize. The treatments were distributed in a factorial arrangement: 6 × 5 in a design: "Split Plots" with three replicates. The variable analyzed was the yield of grain (t ha^{-1}). The FF were the same in their effect on the G, however, the organic was numerically better to the chemical or inorganic. Eto 7) - 52 / A20 exceeded the average yield of G ($p < 0.05$). Likewise, the average weights of CS and CT were higher than those of the three lines that formed them ($p < 0.05$). The best performance was obtained by treatments integreted by: (Eto 7) -52 / A20 with the six types of fertilization evaluated.

Fertilization, Organic, Inorganic, Genotypes, Humus, Yields

Citation: CARRIZALES-MEJÍA, Norberto, ARELLANO-RODRÍGUEZ, Luís Javier, TORRES-MORÁN, José Pablo and SÁNCHEZ-MARTÍNEZ, José. Effect of inorganic and organic fertilization in the performance of hybrid corn (Zea mays): 1052 and genotypes that form it. ECORFAN Journal-Republic of Nicaragua. 2017, 3-5: 12-18

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1. Introduction

Tapia and collaborators (2013) reviewed information from the SIAP and indicated: of the basic grains in Mexico, corn is characterized as the most planted crop (7.8 million ha) with an average yield of 2.9 t ha-1. Likewise, they highlighted the value of corn production, calculated at: 72 billion pesos. Its constant production, both for grain and seed, requires an intensive supply of chemical fertilizer to make it perform under favorable conditions, however, this technology is expensive and causes pollution problems to the ecological environment.

Castellanos (1980) and Romero et al., (2000) cited by Tapia et al., (2013) mentioned: organic fertilizers have been used since ancient times and their influence on soil fertility has been demonstrated; the value of organic matter (OM) in the soil offers great advantages that can hardly be achieved with chemical or inorganic fertilizers, since its chemical composition, the contribution of nutrients to crops and their effect on the soil vary according to their origin, age , handling and moisture content.

In 2009 Clementelli and Zevallos reviewed information from FAO and indicated: fertilizers, when used together with other inputs such as: high yield varieties (genotypes) and irrigation water, cause a positive interaction by which it increases, even more, its contribution to the performance increase; they considered humus as M.O. degraded to its last state of decomposition (microorganisms) and chemically stabilized as colloid regulator of the dynamics of plant nutrition in the soil. The application of inorganic or organic chemical fertilizers to the soil completes the nutritional needs of maize (a common and necessary practice for the crop).

However, if a smaller quantity is applied, the yield potential of the genotype (G) is wasted and, if applies a greater amount of fertilizer, production costs increase; in addition it could provoke phytotoxic reactions reducing crop production (SAGARPA, 2015 a)

Soil degradation is a threat to more than 40% of the planet's surface: climate change has accelerated the rate of soil degradation and threatens food security as a result; More than 12 million ha of crops could be lost each year. However, M.O. in soils, it intervenes in four important ecosystem services: 1) resistance to soil erosion, 2) water retention, 3) plant fertility and 4) Biodiversity. (SAGARPA, 2015 b)

Tapia and collaborators in 2013 considered organic fertilization as an alternative to reduce the consumption of inorganic fertilizer and mentioned that organic nutrition is considered as a viable option to supply nutrients to crops of interest, for corn producers, in order to to decrease the dependence of chemical fertilizers and production costs.

This study was proposed in order to evaluate the response of corn to FF: chemical, traditional or inorganic and organic, in terms of its effect on grain yield and seed production for planting, of five Genotypes: (three lines , a simple cross and a triple cross) formators of corn hybrids CS: (Eto 7) - 52 / A20 and CT: 1052 to produce and grow in Western Mexico.

1.1 Objectives

1.1.1 General objectives

Know the adequate FF (organic and inorganic) to increase the yield of maize (t ha-1) during seed production of the G (lines, CS and CT) of the hybrid: 1052.

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1.1.2 Objetivos específicos

a. Determine the adequate FF (organic and inorganic) to increase the yield of the hybrid: 1052 and its parents.
b. Generate information on the benefits of the use of organic FF that propitiate the significant increase of grain and seed yield of the hybrid: 1052 in Western Mexico.

1.2 Hypotesis

a. With the use of organic FF, for seed production, the corn G of the hybrid: 1052 increase or maintain its yield (t ha-1) compared to the use of traditional FF (chemical or inorganic)
b. The use of organic FF and / or the combination of: inorganic FF plus organic FF, in the seed production of the G, could give a grain yield (t ha-1) higher than that obtained with the use of Inorganic or chemical FF.

2. Materials and methods
2.1Materials

The study was carried out in the Experimental Field of the University of Guadalajara (UdeG) located in: Zapopan, Jalisco, in the University Center of Biological and Agricultural Sciences (CUCBA) during the cycles: Spring-Summer (2013 and 2014)

Five G of corn were used: three lines, one CS and one CT, See Table 1. As a source of elements for FF (NPK and micronutrients) organic fertilizer was used: Worm Humus (HL) solid and liquid in doses of four t ha-1 and 60 L ha-1, respectively. Also used traditional or inorganic chemical fertilizer (Urea, DAP, micronutrients) plus the product: Entec and a liquid fertilizer, soil improver, identified as: Nitro Plus-9; is last in a dose of 35 L ha-1 (Table 2)

No.	Genotype.
1	* A-20
2	* (Eto 7) -52
3	* AVN
4	** (Eto 7) - 52 / A20
5	**1052
** = Línea.*	*** = CS y CT*

Table 1 Corn genotypes evaluated with FF (organic and inorganic). Cycles: P.V. 2013 and 2014. Zapopan, Jal. Mexico. (UdeG-CUCBA)

Number.	Formula.
1	(220 - 80 – 00)
2	(110 - 40 - 00) + ½ Nitro Plus-9
3	(110-40-0)+ ½ Fert. Organic.
4	Nitro Plus-9 *
5	Organic fertilizer. **
6	Entec (inorganic)
** 35 liters per hectare (L ha-1) ** four (t ha-1) plus 60 L ha-1 ½ = half dose.*	

Table 2 Fertilization formulas (organic and inorganic,) for corn G, evaluated during the cycles: P.V. 2013 and 2014. Zapopan, Jal. Mexico. (UdeG-CUCBA)

2.2 Methods
2.2.1 Experimental design

Two factorial experiments (6 x 5) were carried out under a design: "Split plots" with three repetitions (Little and Jackson, 1976). The repetition consisted of 30 plots of four rows of 0.80 m wide by five m long, each one (4 m2); the experimental plot (PE) was 16 m2 and the useful plot (PU) were the two central furrows (8 m2). The large plots (PG) were six FF (organic and inorganic). See Table 2. The small plots (PCh) corresponded to five G of corn. (Picture 1)

2.2.2 Treatments

30 treatments were designed. To be evaluated in each replica of the experiment; The treatments were integrated with the following factors: Fertilization formula (FF) and Genotypes (G). See Table 3.

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Entrance.	Treatment.
1	A20 + (220-80-00)
2	Eto7)-52 + (220-80-00)
3	AVN + (220-80-00)
4	Eto7)-52 / A20 + (220-80-00)
5	1052 + (220-80-00)
6	A20 + (110-40-0) + ½ NitroPlus-9
:	: : :
10	1052 + (110-40-0) + ½ NitroPlus-9
11	A20 + (110-40-00) + ½ Humus.
:	: : :
15	1052 + (110-40-0) + ½ Humus.
16	A20 + Nitro Plus-9
:	: :
20	1052 + Nitro Plus-9
:	: :
22	Eto7)-52 + Humus.
:	: :
29	Eto7)-52 / A20 + Entec.
30	1052 + Entec.
Note: HL in doses of four t ha-1 (solid) plus 60 L ha-1 (liquid) Nitro Plus-9 in a dose of 35 L ha-1 ½ = half dose of the product used.	

Table 3 List of 30 treatments evaluated (P.V. 2013 and 2014). Zapopan, Jal. Mex. (UdeG-CUCBA)

2.2.3 Planting method

The land preparation, in both experiments, was done with a "fallow" and two crossed steps of "harrow" to ensure a good "planting bed". The sowing was done when the bed was "coming earth": two seeds were deposited per point, a separation between points of 0.15 m, and ensure a population density of 82 000 plants ha-1 after making a thinning, 20 days after sowing

The cultural practices such as: weed control and pests were made according to the technological package for the cultivation of seasonal maize that is carried out in the area (SAGARPA, 2015 a)

2.2.4 Variables studied

1. Days to male flowering (♂): ten% initial to ten% final.
2. Days to feminine flowering (♀): ten% initial to ten% final.
3. Plant height (m)
4. Cob height (m)
5. Stem stalk (%)
6. Plant root (%)
7. Number of ears per plant.
8. Cob rot (%)
9. Grain yield (t ha-1) at 15% humidity.

2.2.5 Statistic analysis

We present the analysis of the variable: performance (t ha-1) made with the SPSS® statistical package, version (20. 0. 0). The honest significance test (DHS) of: Tukey ($\alpha = 0.05$) was used to indicate the significant statistical groups.

4. Results

Variation analysis of the experiments indicated: a significant statistical difference ($p < 0.05$) between the fertilization formulas (FF) of the experiment: P.V. 2013, however, the experiment (P.V. 2014) did not present a significant difference for this factor (PG). Both experiments showed a significant difference between the evaluated genotypes (G), however, the interaction variation factor: PG * PCh or FF for G was not significant ($p < 0.05$) in the two experiments.

4.1 Fertilization formulas

Regarding FF, the 2013 experiment showed statistical difference, highly significant ($p < 0.05$) while, the 2014 experiment did not present a statistical difference for this factor. It should be noted that when applying the Tukey test (DHS), in the first experiment, no significant groups were detected between FF and, on the other hand, the organic FF: Solid Worm Humus (four t ha-1) plus Worm Humus liquid (60 L ha-1) was numerically more efficient in the two experiments and obtained an average production of 5.43 t ha-1 in the first experiment and 6.17 t ha-1 in the second.

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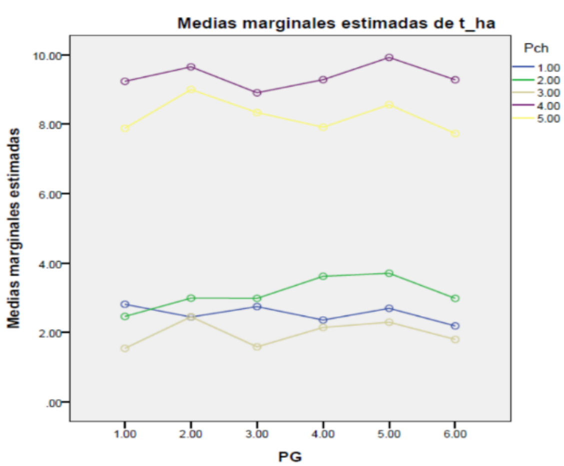
Likewise, the traditional FF (220-80-00) obtained a performance similar to that of the previous FF, during the cycle (P.V. 2014). The two inorganic (traditional) FFs: 220-80-00 and Entec with (15-22-12) plus micronutrients obtained the lowest numerical performance in the 2013 experiment (4.79 t ha-1). The lowest yield (P.V. 2014) corresponded to the inorganic FF: 110-40-00 plus 15 L ha-1 of Nitro Plus-9 with an average weight of 5.53 t ha-1.

4.2 Genotypes

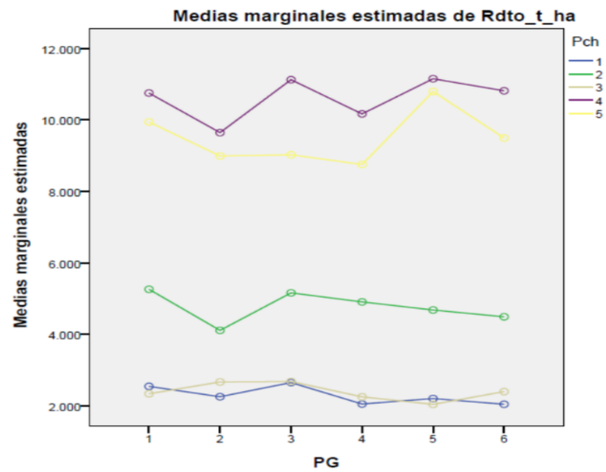
Both experiments presented significant statistical difference ($p < 0.01$) among the G. The CS: (Eto 7) - 52 / A20 obtained the best yield of grain or seed (9.38 and 10.61 t ha-, respectively) and was superior to the hybrid : 1052 with 8.24 t ha-1 (PV 2013) and 9.50 t ha-1 (PV 2014). See figures: 1, 2 and Table 4.

In both experiments, both hybrids exceeded the performance of the three lines ($p < 0.05$) whose performance varied from 1.97 t / ha-1 with: AVN in 2013, up to 4.77 t ha-1 with: (Eto 7) - 52 in PV2014 (See Table 4)



Lines: 1 = A- 20, 2 = (Eto 7) -52 and 3 = (AVN)
Hybrids: 4 = (Eto 7) - 52 / A20 and 5 = 1052

Graph 1 Response in yield (t ha-1) of five Corn Genotypes (PCh), before the effect of six Fertilization Formulas (PG). Cycle: P.V. 2013. Zapopan, Jal. Mexico. (UdeG-CUCBA)



Lines: 1 = A- 20, 2 = (Eto 7) -52 and 3 = (AVN)
Hybrids: 4 = (Eto 7) - 52 / A20 and 5 = 1052

Graph 2 Response in yield (t ha-1) of five genotypes of Corn (PCh), before the effect of six Fertilization Formulas (PG). Cycle: P.V. 2014. Zapopan, Jal. Mexico. (UdeG-CUCBA)

No. orden.	Genotype	P.V. 2013	P.V. 2014	Media
1	Eto 7)-52 / A20	9.38 **a**	10.61 **a**	9.99
2	1052	8.24 b	9.50 b	8.87
3	(Eto 7) - 52	3.12 c	4.77 c	3.95
4	A - 20	2.54 cd	2.29 d	2.42
5	AVN	1.97 d	2.40 d	2.19
Nota: cantidades con la misma letra son estadísticamente iguales entre sí al 5 % de probabilidad, según DHS de Tukey.				

Table 4 Average yield (t ha-1) of five maize genotypes evaluated with six FF. (P. V. 2013 and 2014). Zapopan, Jal. Mex. (UdeG-CUCBA)

4.3 Treatments

When not finding significant differences between the interactions: formulas of fertilization by genotypes (FF * G), Table 5 presents the average yields of the treatments evaluated in both experiments.

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The greatest numerical weight corresponded to the treatments integrated by the simple cross: (Eto 7) -52 / A20, fertilized with all the FF tested; its weight varied from 9.65 t ha-1, from treatment nine: (Eto 7) -52 / A20 with 110-40-00 plus 15 L ha-1 of Nitro Puls-9, up to 10.54 t ha-1 of treatment 24: (Eto 7) -52 / A20 with four t ha-1 plus 30 L / ha-1 of HL (See Table 5). The hybrid: 1052 with the FF: 110-40-00 plus 15 L / ha-1 of Nitro Plus-9 produced nine t ha-1 and the lowest numerical performance was obtained with the treatments integrated by the G: AVN and the different FF, whose yield fluctuated from: 1.94 to 2.56 t ha-1 (Table 5)

			2013	2014	Med.
No. Ord.	No. Ent.	Treatment.	Rend.	Rend.	Rend.
1	24	Eto7)-52/A20 + Organic.	9,92	11,15	**10,54**
2	9	Eto7)-52/A20 + 110-40-00 + ½ NPlus-9	9,65	9,64	**9,65**
3	29	Eto7)-52/A20 +Entec.	9,28	10,81	**10,05**
4	19	Eto7)-52/A20 + Nitro Plus-9	9,28	10,17	**9,72**
5	4	Eto7)-52/A20 + (220-80-00)	9,23	10,75	**9,99**
6	10	1052 + 110-40-00 + ½ Nitro Plus-9	9,00	8,99	**9,00**
7	14	Eto7)-52/A20 + 110-40-00 + ½ Organic.	8,90	11,12	**10,01**
8	25	1052 + Organic.	8,56	10,79	**9,68**
9	15	1052 + 110-40-00 + ½ Organic.	8,33	9,02	8,68
:	:	:	:	:	:
11	5	1052 + 220-80-00	7,88	9,94	8,91
12	30	1052 + Entec.	7.73	9.49	8.61
13	22	Eto7)-52 + Organic.	3,70	4,68	4,19
:	:	:	:	:	:
17	12	Eto7)-52 + 110-40-00 + ½ Organic.	2,98	5,16	4,07
18	1	A 20 + 220-80-00	2,81	2,54	2,68
:	:	:	:	:	:
26	26	A 20 + Entec.	2,19	2,04	2,12
27	18	AVN + NitroPlus-9	2,14	2,25	2,20
:	:	:	:	:	:
30	3	AVN + 220-80-00	1,54	2,34	1,94
Note: amounts of treatments (bold) are the best numerical yields.					

Table 5 Yield (t ha-1) of 30 treatments, five G for six FF: inorganic and organic. (P. V. 2013 and 2014). Zapopan, Jal. Mex. (UdeG-CUCBA)

5. Conclusions

1. The FF evaluated were equal in their effect on the G tested; organic FF: Humus de Lombriz was more profitable in both evaluation cycles and could be quite economical, compared to traditional FF, evaluated in the study.

2. The G, in general, respond in a similar way to the FF used, as long as the natural capacity of the G's performance is taken into account; whether they are: CS or Trilinear hybrids such as: 1052.

3. Within the evaluated G, the CS: (Eto 7) -52 / A20 had the highest weight of grain or seed compared to the rest of G, including hybrid 1052. Likewise, the average yield of (Eto 7) -52 / A20 and CT: 1052 was much higher than that obtained by the other G that integrate them.

4. The line: AVN was the G least efficient of the three that were tested.

5. The best treatments (FF * G) were those integrated by CS: (Eto 7) -52 / A20 fertilized with the types of fertilization evaluated. Likewise, the least productive treatments were integrated by the G: AVN, fertilized with the types of fertilization evaluated. See Table 5.

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Gratitude

Ing. Angel Mendoza Sánchez for facilitating the genotypes of the hybrid: 1052 and being able to carry out the study. To Dr. Enrique Pimienta Barrios, Head of the Department of Agricultural Production - CUCBA - UdeG. For the support provided to carry out the study.

ISSN-On line: 2414-8830