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Performance of corn (*Zea mays* L.) with application of poultry manure and leachates as organic fertilizer

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ABSTRACT
Objective: To evaluate different sources and forms of organic fertilization on production parameters in *Zea mays* L..
Design/methodology/approach: A completely randomized design was used where the treatments were the different combinations of doses and sources of organic fertilizers from animal excreta.
Results: The foliar applied compost plus leachate treatments were found to be superior to the chemical treatments.
Limitations of the study/implications: Further evaluation of the virtues of organic fertilizers in different crops is needed.
Findings/conclusions: Organic fertilization either in soil form with composts or leachates in a phytophilic form are competitive to chemical fertilization.

Keywords: manures, compost, yield performance, organic agriculture, food sovereignty.

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INTRODUCTION

Corn (*Zea mays* L.) is a staple crop for Mexican food; 6,904,042 hectares are planted annually, with a production of 26,553,239 million tons in the 32 states of the country and average yields of 3.90 t ha^{-1} (SIAP, 2023). The crop is grown under diverse agroecosystems and climatic conditions, which is why there are several problems due to different management practices, such as soil degradation, loss of biological biodiversity and, in general, negative effects on the environment and human health (SIAP, 2023). The crops that stand out within the Agrifood Chains of the Basic Food Basket are maize, which is a priority for INIFAP technology generation (Zamarripa *et al.* 2022). Among the factors affecting yield is agronomic management (Olvera-Rincón *et al.*, 2023), with fertilizer application being one of the most influential components in the expression of

crop production potential (Salgado-Velázquez *et al.*, 2020; Córdova-Sánchez *et al.*, 2023; Salgado-García *et al.*, 2023). However, the intensive use of agrochemicals has reduced to a minimum the living conditions of the diverse organisms and microorganisms that inhabit the soil.

In maize production, there is widespread application of chemical fertilizers, and sometimes manure is applied (Kato *et al.*, 2009). In this sense, the effect of alternative sources of fertilizers such as organic fertilizers has been studied as in Bravo (2016), where in the initial phase they showed a rapid response in the treatment with chemical fertilization, while with organic products they reach their greatest effect at 63 days since they are of slow release of their nutrients, evidencing their residual action in corn crop. Liquid organic fertilizers can be applied in the nutrition of agricultural crops, it has been proven that applied to the foliage in concentrations between 20 and 50% stimulates growth, improves the quality of the products and even has a certain repellent effect against plagues and can be applied to the soil in higher concentrations to promote root development (Bravo, 2016). In addition, beneficial effects have been observed on soil properties such as better structure, greater porosity, higher organic matter content, greater retention of exchangeable cations and less soil erosion, among others (Córdova-Sánchez *et al.*, 2023).

In the state of Tabasco, Mexico, is imperative the proper management of the manure produced in the livestock and poultry sector, in addition to the fact that it is a surplus input. The effect of corn fertilization with poultry manure on production has been studied by authors such as Sánchez *et al.* (2021), where the characteristic of organic fertilizers applied to the soil, act as reservoirs of nutrients and the organisms continue to work degrading the organic matter and releasing nutrients for the next cycle. In Velasco-Cruz *et al.* (2023), where height, stem diameter and number of leaves were significantly greater when irrigation with wastewater was applied, except for the variable number of leaves, which did not show significance, and forage biomass was significantly greater in the plots with wastewater, since it is an important source of nutrients.

Currently in Tabasco, Mexico, fertilization of corn crops is still predominantly from chemical sources, and given that local resources of residues from the livestock and poultry industries are available, there is a need to evaluate the effect of organic fertilizers on corn crops as fertilization alternatives, in addition to providing positive benefits to the soil. Therefore, the objective of this work was to evaluate the effect of composted pollination and animal excreta leachates applied to the soil and foliar application on corn crop and its effect on vegetative development and grain yield.

MATERIALS AND METHODS

Experimental Site. The experiment was carried out in the spring-summer cycle (2023), at the Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias, (INIFAP), in instalations of the experimental field of Huimanguillo, Tabasco, Mexico (17.847711, −93.396465 UTM). The soil type is Fluvisol where the crop was established, whose properties can be observed in Table 1. The analysis of the soil where the crop was established shows a slightly acid PH, with a good content of organic matter (OM), fertility

Table 1. Soil chemical properties of the experimental site.

pH H_2O	EC	OM	N t	P	K	Ca	Mg	Na	CIC	Fe	Cu	Zn	Mn	B
	dS m^{-1}	%		mg kg^{-1}	cmol kg^{-1}					mg kg^{-1}				
5.8	0.05	3.2	0.1	9.85	0.2	9.9	1.4	0.07	16	32	10.1	5.9	0.98	0.8

in the contents of nitrogen, phosphorus and potassium, in addition to the main minor elements required by the corn crop.

The main climatological conditions during the crop cycle are shown in Figure 1. Precipitation in the critical period of the crop at 60 days presented an accumulated rainfall of 386 mm, corresponding to 71.46% of the total 541.5 mm of the cycle. The maximum, minimum and average daily temperature, maintained approximately a regularity characteristic of this tropical season, within the 60 days and at the end of the crop, so it is considered that these factors did not influence the growth and yield of the crop and were not affected by climate change.

Previously, leachates derived from the compost were obtained in the organic module by the aerated static pile method (Sumano et al., 2020). The liquid ferments of the compost after 30 days were collected and stored for application. The physical and chemical properties of the composted poultry manure are presented in Table 1 and of the leachate in Table 2.

Methods: Analyses of pH, EC, OM, Nt, Ratio. C/N, Ash, Moisture, CO and Da (Mexican Official Standard NMX-FF-109-SCFI-2008) and K, Ca, Mg, Na, CIC, Fe, Cu, Zn, Mn (Mexican Official Standard NOM-021-RECNAT-2000).

Soil preparation was mechanized with three harrow passes; the maize H-520 hybrid was used for sowing. It should be noted that this is the third consecutive crop cycle sowing

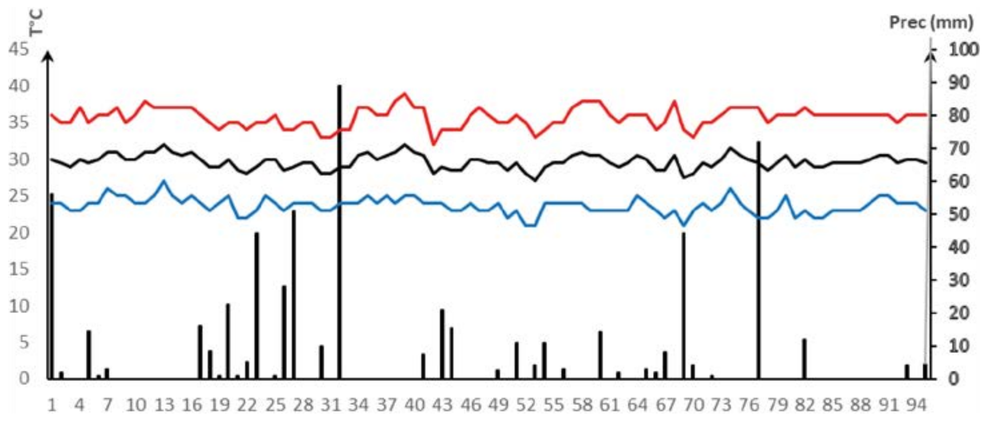

Figure 1. Environmental conditions at the study site in Huimanguillo, Tabasco, Mexico. (Barrón, 2023).

Table 2. Analysis of the physical and chemical properties of poultry manure.

pH*	CE	MO	N	P	K	Ca	Mg	Na	CIC	Fe	Cu	Zn	Mn
	dS m^{-1}	%		mg kg^{-1}	cmol (+) kg^{-1}					mg kg^{-1}			
7.29	2.87	70	2.69	48.80	2.40	5.66	1.68	0.31	49.98	145.03	60.07	12.13	11.45

Table 3. Chemical properties of leachates derived from compost.

Manure	K	Ca	Mg	Na	CIC	P	B	S	Fe	Zn	Mn	MO	N Tot
	Cmol(+) kg^{-1}					mg kg^{-1}		ppm	mg kg^{-1}				
Bovine	37.9	21.6	26.8	4.1	80.5	>BDL*	22.8	>BDL*	42.0	46.7	11.1	39.1	0.35

*BDL: below the detectable limit.

the same variety in the same site under the same treatments, to observe the residual organic material composted pollinasse, hereinafter referred to as compost (C). It was sown manually on July 7, 2023 in strips with furrows separated at 80 cm and depositing three seeds every 40 cm to leave 2 plants per clump and ensure a density of 62,500 plants ha^{-1}. Pests such as codling moth were controlled with two applications of the insecticide cypermethrin (6 and 14 days after planting) and a third application (Palgus) after 22 days; weed control was carried out with two manual hoeing at 12 and 22 days and a third application of hilling with machinery.

Fertilization with corn leachates was carried out with a 50% concentration diluted in water. Three applications were made to the plant foliarly and to the soil in the first 40 days after establishment. The previously prepared leachate treatments were applied on three occasions, 16, 28 and 44 days to the soil and foliage as appropriate for each treatment, the application was done manually, with a manual spray pump, bathing the entire plant to the foliage and soil, opening the nozzle to throw a continuous flow in a band at the foot of the plant, equivalent to 200 l ha^{-1}. The chemical treatment (TQm) whit nitrogen, was applied in two parts (50%): the first at 12 days after sowing, and the second at 21 days and in a single application of phosphorus at plant emergence with the formula 120 40 00 of N, P, K respectively, in a band at 10 cm from the plant.

Treatments evaluated. The levels of composted pollinasse (C) were applied to the soil (S) at different doses: 2.5, 5.0, 7.5, and 10 t h^{-1}. Foliar application (F) was carried out with the leachates (L) diluted 50% in water in three applications (Table 4). The experimental unit was in strips of 6 furrows (4.80 m wide by 40 m long). In the poultry manure treatments, the plot was divided into three furrows where the leachate was applied to the soil and the other three furrows where foliar fertilization was applied.

Table 4. Treatments Compost (C) applied to the soil and leachates (L) at 50%.

T_1 Compost (C) 10 t ha^{-1}+Leachate (L) to Soil (S)	T10CLS
T_2 Compost (C) 10 t ha^{-1}+Leachate (L) to Foliar (F)	T10CLF
T_3 Compost (C) 7.5 t ha^{-1}+Leachate (L) to Soil (S)	T7.5CLS
T_4Compost (C) 7.5 t ha^{-1}+Leachate (L) to Foliar (F)	T7.5CLF
T_5Compost (C) 5 t ha^{-1}+Leachate (L) to Soil (S)	T5CLS
T_6Compost (C) 5 t ha^{-1}+Leachate (L) to Foliar (F)	T5CLF
T_7 Compost (C) 2.5 t ha^{-1}+Leachate (L) to Soil (S)	T2.5CLS
T_8 Compost (C) 2.5 t ha^{-1}+Leachate (L) to Foliar (F)	T2.5CLF
T_9 Chemical Fertilization (120 40 00), N, P, K respectively	TQm
T_{10} Absolute treatment (000), no fertilizer	T000

Experimental design. The statistical analysis was carried out with a completely randomized design (DCA), six experimental units were established in the field: chemical fertilization (TQm), the absolute control (T000), and the remaining four for the levels of compost (C) to the soil: 2.5, 5.0, 7, 5 and 10 t ha^{-1} where each one was divided in two parts of three furrows to apply the leachates (L) to the soil (S) and foliar (F) treatments. 5 and 10 t ha^{-1} where each of them was divided into two parts of three furrows to apply the leachate treatments (L) to the soil (S) and foliar (F): the central furrow of 40 m, as replicates 15 plants were taken at random by complete competition along the experimental unit.

Study variables. The variables evaluated were: the vegetative development of the plant from the 7th week after earling (constant height) and green matter yield. Plant height to spike (cm), leaf length (cm) taken under the ear along the midrib lamina, and the average leaf width of the same leaf (middle part of the leaf), all variables measured with a tape measure. Stem diameter at 10 cm from ground level (cm), by means of a vernier (Truper). Cob height (cm) from ground level to cob; cob length (cm), from the base of the stalk to the apex of the cob and cob weight (g); and cob diameter in (cm) in the middle part of the fruit; all by means of a vernier in (cm). Grain yield (g cob^{-1}) and bacal weight in (g), after shelling; weights with a digital balance.

Data analysis. Analysis of variance and multiple comparisons of means were performed with the minimum significant difference (LSD) test with an alpha less than or equal to 0.05, both tests by using the SAS statistical program (Statistical Analysis System, 2021).

RESULTS AND DISCUSSION

Plant height. Figure 2 and Table 5 show the results obtained and the effects of the different treatments. The application of the highest doses of composts to the soil+foliar fertilization corresponded to treatments T7.5CF, T10CF, T10CS and T7.5CS t ha^{-1} in descending order, with 282.67±10.2, 282.27±12.9, 278.00±7.94 and 272.67±10.8, respectively. Each experimental treatment surpassing TQm with an intermediate value (249.67±3.69 cm) for plant height, although results were statistically equal to T5CF, T5CS and T2.5CF, and higher according to the DMS test ($p \leq 0.05$). T7.5CS shows 19.1% greater

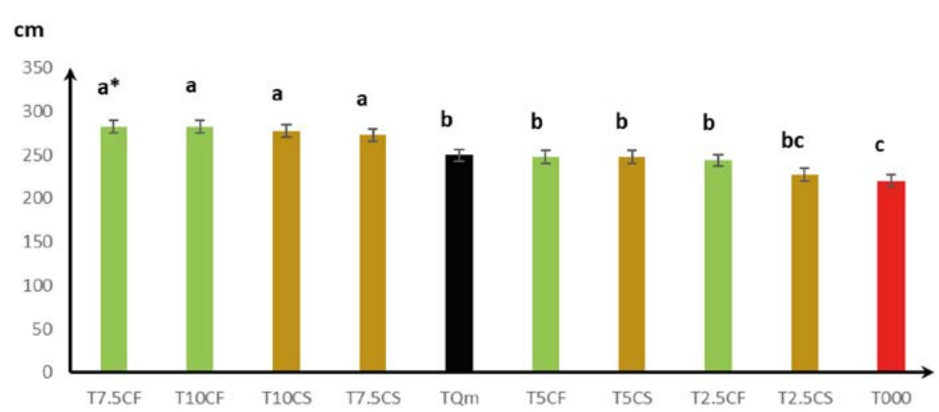

Figure 2. Height (cm) of corn plant with different applications of Compost to the Soil and Leachates to the Foliage (E.F. Huimanguillo Cycle P-V 2023). *Treatments with the same letter are not significant (α=0.05 p.), C.V. Coefficient of Variation **SE=standard error of the mean.

Table 5. Vegetative growth of corn plant at 60 days, in height, leaf length and width, and stalk diameter.

Treatment	Height (cm)	Length (cm)	Width (cm)	Stem (mm)
T7.5CLF	262.67±5.2 EE**a*	102.93±1.5 EE ab	8.80±0.2 EE ab	22.40±0.7 EE abc
T10CLF	255.60±4.9 EE a	100.26±1.7 EE ab	8.47±0.2 EE bc	22.20±0.6 EE bcd
T10CLS	273.33±4.2 EE a	102.06±1.6 EE ab	8.92±0.1 EE ab	23.53±0.4 EE a
T7.5CLS	256.00±4.9 EE a	99.40±1.6 EE ab	8.73±0.2 EE ab	22.80±0.9 EE ab
TQm	249.67±3.6 EE b	104.13±1.4 EE a	8.97±0.1 EE ab	23.06±0.6 EE abc
T5CLF	248.06±4.2 EE b	103.46±1.6 EE ab	8.80±0.2 EE ab	21.86±0.6 EE bcd
T5CLS	246.73±3.9 EE b	100.80±1.8 EE ab	9.32±0.2 EE a	22.73±0.8 EE abc
T2.5LCF	224.40±4.3 EE b	92.73±1.3 EE c	8.62±0.2 EE b	19.93±0.7 EE d
T2.5CLS	227.20±4.7 EE bc	95.80±1.7 EE b	9.02±0.2 EE ab	21.66±0.7 EE bcd
T000	221.86±4.3 EE c	87.26±1.6 EE c	7.77±0.2 EE c	18.33±0.5 EE cd
C.V.	11.88	9.34	9.83	15.27

*Treatments with the same letter are not significant (α=0.05 p.), C.V. Coefficient of Variation **SE=standard error of the mean.

height compared to T000 220.53±3.92 cm and with respect to the latter treatment, the other values showed greater plant height.

The vegetative variables are important to obtain the response of the crop treatment effects, also in the morphological characterization of the plants, for their possible use as fodder. Mariscal-Nava (2019), mentions that corn needs nitrogen, phosphorus and potassium, highlighting in the early stages of development is very sensitive to the lack of water and nutrients and in soils poorly fertile, do not have the ability to provide nutrients for efficient plant growth, to the detriment of yield, so it is necessary to resort to the use of chemical or inorganic fertilizers. In Cerón (2019), the effect of liquid fertilizers on the growth and yield of corn was evaluated, its response in growth curves is very similar in vegetative growth obtained, also mentions that they are useful to observe the effect of treatments and further explain the growth process. In other crops, the application of leachates in corn at 55 days, at a dose of 500 L ha^{-1} was the maximum biomass yield with 37.5 t ha^{-1} and in the sorghum crop of 4.8 t ha^{-1} of grain (Patishtan *et al.* 2023). It has been reported that the application of 20 t ha^{-1} of poultry manure, the highest yields in plant height were obtained (Perez, 2012).

Regarding the evaluation of organic leachates in corn plant height, the treatment leached with vermicompost obtained 205.67 cm, and commercial leachate with 218.50 cm, without statistical difference compared to T000 (221.86±4.3 cm), these were below in this work (Lopez, 2021). Organic leachates were evaluated in corn, plant height found no significant differences between the control 198 cm, vermicompost leachate 280 cm and plantain rachis leachate 286 cm (Villalobos-Gonzalez *et al.*, 2019). In evaluation with different corn genotypes under rainfed conditions and chemical fertilization in Campeche, in plant height the tallest material was purple creole maize with 370 cm, and the shortest was white cock maize with 274 cm height. Values higher than the highest of the treatment above T7.5CF (262.67±5.2 EE cm), this may be due to chemical fertilization and the potential of the genetic material.

Stem diameter. The results of this variable and their respective values are presented, in which the effects of the treatments can be observed (Table 5). Similar tendencies to the previous variable of the corn crop can be observed in the variable stem diameter at the base of the plant at 10 cm from the soil. The application of the highest doses of compost to the soil plus foliar fertilization corresponded to T10CS and T7.5CS t ha^{-1} with values of 24.93±1.10 EE and 24.13±1.40 EE mm of stalk respectively, as those with the highest stalk diameter surpassing TQm with 22.72 mm the rest of the treatments were below these values statistically surpassing T000 according to the DMS test ($\alpha \leq 0.05$). Arnesto and Benavides (2003), reported the application of 20 and 10 t ha^{-1} of poultry manure, obtained the largest stem diameters at 61 days with 2.54 and 2.59 cm by 2.13 cm (control) respectively without statistical difference between doses, but different from the control. And compared to the chemical control with the dose of 150 kg N ha^{-1} (2.42 cm) stem diameter. Quintanilla *et al.* (2013) for their part, coincided with identical values in corn stalk thickness between the poultry manure and chemical treatments with 1.65 cm. The application of organic fertilizers increases the availability of nutrients in the soil, more completely than with chemical fertilizers, due to the fact that organic fertilizers contain nutrients that can be assimilated by the plant.

Leaf length. The results for leaf length (cm) are shown in Table 5. The values of the treatments can be appreciated, although in this cycle it differs from the tendency of the previous variables because TQm 104.13±1.4 cm was the one that presented the best result, although statistically equal to T5CF, T10CS, T7.5CF, T10CF, T7.5CS although inferior according to the DMS test ($\alpha \leq 0.05$). A greater leaf length development was obtained compared to (T000), exceeding 16.4%. The rest of the treatments resulted with intermediate values within this range, with the exception of the lowest dose T2.5CF which was outside the above mentioned range with the lowest value (87.03±5.70 cm height).

A particular physiological characteristic of corn that favors its adaptation to tropical zones where evapotranspiration is sometimes high, is the anatomical structure of its leaves, in which there are two types of cells (epidermal and stomatal) with different biochemical and structural organization, which during the photosynthetic process allows them to fix CO_2 (Ramirez and Goyes 2004). The leaves are generally lanceolate, long and thin, reaching 120 cm in length, it should be noted that the treatments T7.5CS and the lowest in compost T2.5CS and T2.5CF along with T000 were below 100 cm. Lopez (2024), when evaluating leachates, reported leaf length values under the corn in treatments TL50% and TL75% with very similar values 104.00±3.9 and 104.3±2.3 cm, respectively. T7.5CF, T10CF T10CS TQm T5CF and T5CS were able to equal or exceed those reported by this author, which may suggest a better plant utilization of leachates. Golik *et al.* (2018), reported that the lamina is 60 to 90 cm long, ribbed, with wavy edges longer than the midrib, yellowish and prominent. In comparison to this author's report, all treatments exceeded this range with the exception of T000 87.26±1.6 cm, which can be attributed to the lack of nutrients.

Leaf width. The results obtained for this variable are shown in Table 5. Their corresponding values, the effects of the different treatments show the same tendency as the other variables mentioned for the average leaf width variable of the corn crop. The application of compost and foliar doses that obtained the best results corresponded to T5CS, T2.5CS, TQm, T10CS, T5CS, T7.5CF, T7.5CS, in descending order respectively, with 9.32±0.22, 9.02±0.26, 8.97±0.16, 8.93±0.17, 8.92±0.19, 8.83±0.24, 8.72±0.27 cm of corn leaf mean width, statistically equal, although T5CS is superior according to the DMS test ($\alpha \leq 0.05$) where the T5CS treatment was 15.2% wider in leaf mean width compared to T000, while the other treatments showed greater leaf width. In the case of the compost (C), leachate (L) and chemical (TQm) treatments, the organics compete with each other and there is a marked tendency to surpass the control (T000) in leaf width value. Casarrubias-Castillo *et al.* (2019), mentions that in maize leaves stomata are located at the plant-atmosphere interface, regulate photosynthesis and water use efficiency, which translates into these cells can be determining factors to increase plant productivity, therefore stomata can absorb part of the applied foliar nutrients.

Weight of plant in fresh. The results of the variable fresh weight (kg) and their respective values are presented in Table 6. The applications of the highest doses of compost to the soil plus foliar fertilization corresponded to T10CS T7.5CS, T7.5CF, T10CF, and t ha^{-1} in descending order respectively, with 0.80±0.02, 0.78±0.04, 0.73±0.04, 0.73±0.04 EE kg of maize plant wet matter. Each treatment outperforming TQm with a lower value (0.63±0.04 kg) and statistically with respect to T000 (0.43±0.03 EE) according to the DMS test ($\alpha \leq 0.05$). The T10CS showed 46.71% higher green matter compared to T000 and with respect to T000 the other values showed higher plant fresh weight. Matheus *et al.* (2007), mentions that the growth of corn plants was at 63 days the highest amount of biomass was registered; from there on, production decreased in a progressive and very accentuated way. The greatest effect of the treatment with chemical fertilization reached its maximum level in the initial phase of the trial, while the treatments with organic products reached their greatest effect at 63 days, evidencing their greatest residual action. Lopez

Table 6. Characteristics in fresh corn plant at 60 days, in fresh weight, corn kernel weight, soil-ear height and ear length.

Treatment	Fresh weight (kg plant^{-1})	Weight of corn (g)	Soil-corncob height (cm)	Cob length (cm)
T10CLS	0.80±0.02 EE a*	305.18±15.25 EE abc	134.54±2.97 EE ab	15.77±0.61 EE c
T7.5CLS	0.78±0.04 EE a	332.27±23.59 EE ab	141.36±5.22 EE a	17.72±0.68 EE a
T7.5CLF	0.73±0.04 EE ab	338.55±17.28 EE a	128.81±3.90 EE bcd	17.54±0.45 EE ab
T10CLF	0.73±0.04 EE ab	340.91±9.90 EE a	141.63±5.35 EE a	17.18±0.46 EE abc
T5CLF	0.71±0.04 EE ab	316.36±18.69 EE abc	127.72±4.40 EE bcde	17.45±0.69 EE ab
T2.5CLS	0.65±0.05 EE bc	284.18±22.95 EE bcd	116.36±2.78 EE e	16.59±0.60 EE abc
TQm	0.63±0.04 EE bcd	292.36±22.11 EE abc	133.36±4.29 EE abc	15.77±0.52 EE c
T5CLS	0.58±0.03 EE cd	279.64±17.76 EE cd	120.54±3.06 EE of	16±0.43 EE bc
T2.5CLF	0.52±0.03 EE of	239.55±11.49 EE of	122.81±4.33 EE cde	15.59±0.53 EE c
T000	0.43±0.03 EE e	198.51±19.51 EE e	104.18±3.88 EE f	13.72±0.83 EE d
C.V.	12.31	20.82	10.71	12.12

*Treatments with the same letter are not significant ($\alpha = 0.05$ p.), C.V. Coefficient of Variation **SE=standard error of the mean.

(2024), evaluating the application of leachates, found that the best treatment obtained values within a range of 0.831 and 0.658 kg plant^{-1} corresponding to the treatments and TL25% respectively; compared to those obtained in this research, it exceeds the highest value of T10CLS 0.80±0.02 with respect to TL50%, the latter being slightly higher.

Corn weight. The results obtained in this variable are shown in Table 6. In the first place, T10CF was where the best results were observed in the variable fresh weight of corn with a weight of 340.91±9.90 g, the treatments that were in between T10CLS, TQm in descending order respectively 305.18±15.25 EE, 292.36±22.11 g are statistically equal to T10CF although inferior according to the DMS test ($\alpha \leq 0.05$). T10CF presented a higher fresh weight of corn in comparison with T000, exceeding it by 41.6%, and the other treatments had better weight gain in this variable. With respect to other works in this variable, López (2024), reported that when applying TL75% leachates, 279.20±21.30 g had the highest weight compared to the highest obtained in this work (T10CLF 340.91±9.90 g), which was 81.89% higher.

Soil-corncob height. The data acquired in this variable are presented in Table 6. And their corresponding values, the effects of the different treatments can be appreciated in the fourth cycle of corn cultivation in the variable soil-corncob height of maize. The application of compost and foliar doses with the best results corresponding to T10CF, T7.5CS, T10CS, followed by TQm, T7.5CF, in descending order respectively. With 141.63±5.35, 141.36±5.22, 134.54±2.97, 133.36±4.29, 128.81±3.90, soil-corncob height (cm) of maize, statistically equal DMS ($\alpha \leq 0.05$), although the T10CF was 26.4% higher in soil-corncob height compared to the control T000 104.18±3.88 EE cm, while the other treatments showed greater height in this variable. Córdova (2005) in corn, reports a range of 147.0 to 111.7 cm for the highest application 30 t ha^{-1} of poultry manure (plus 20 t ha^{-1} of worm castings) and control respectively in average ear height. The evaluation with different corn genotypes under rainfed conditions and chemical fertilization 110N-46P-00K at 30 days in Campeche, the cob height cm resulted higher in purple creole maize (218 cm), and the lowest was white cock maize with 274 cm height (Villalobos-González *et al.*, 2019)

Cob length. Table 6 shows the results of the variable cob length (cm), where the greatest length is distinguished by the treatments T7.5CS, 17.72±0.68 EE and T7.5CF 17.54 ±0.45 EE cm, respectively were those that presented better results in this variable and in other variables surpassing the T10CF, T10CS level, in this variable T7.5CS surpassed TQm 15.77±0.52 with 11% and 22.5% to T000 13.72±0.83 statistically inferior to T7.5CS according to the DMS test ($\alpha \leq 0.05$) since T000 was the lowest in this variable the other treatments had better fruit development. In this regard, Larios and Garcia (1999), reported the application of 15, 5 and 10 t ha^{-1} of poultry manure in the corn crop in the variety NB-6, where they obtained ear length values: 14.35, 13.46 and 14.75 (cm), respectively, these data are lower than those of the present work, even using less amount of poultry manure T7.5CS, T7.5CF, T5CF, greater lengths were obtained 17.72±0.68, 17.54±0.45, 17.45±0.69, being T7.5CS superior in 19% to the best treatment. Another work by Córdova (2005) on the application of poultry manure 20 t ha^{-1} plus earthworm humus, showed a range of 17.97 cm *vs.* 15.27 cm with respect to the control.

Cob diameter. The results obtained in cob diameter (mm) can be observed more clearly in the fourth cycle of corn cultivation (Table 7), that the TQm and T000, were the ones that presented lower results 44.72±3.60, 44.36±1.24 mm therefore the other treatments were more efficient in comparison to these. T10CF was the one that obtained the highest values surpassing TQm and T000 by 14.1% and in the variable diameter (mm) of corn cob, T7.5CF, T10CS, T5CF, T7.5CS, T2.5CS, are statistically equal although inferior to T10CF, according to the DMS test ($\alpha \leq 0.05$). The results obtained by Lopez (2021), reports that the evaluation of vermicompost leachates and plantain rachis, in the variable corn cob thickness values of 45 and 47 mm, without statistical difference, these values are very similar to those obtained in this variable. In another work, Lopez (2024), reported a statistical response in the application of leachates at 25% (TL25%), the best ear thickness in the variety H520 with 19.30±0.50 cm, with statistical difference with respect to treatment TL00%, with 16.55±1.01.

Cob weight. The results obtained for cob weight (g) of corn, the effects of treatments of the third crop cycle are observed (Table 7). The highest compost application of T10CLF in turn, obtained the best response with 286.00±8.92, surpassing the control T000 (163.27±16.04 g) by 42.90% and by 12.4% to chemical fertilization (TQm), with 250.45±18.89 g, as the best treatment effect, leaving the TQm with an intermediate value with respect to other treatments based on compost resulting in significant differences ($\alpha \leq 0.05$). López (2024), suggest that the range of cob weight was found between application of leachate TL75% 144.80±8.48 g and TQm with 105.30±9.71 g respectively, a difference of 27.27%, and with an intermediate value the control control (T000 134.00±14.53 g), exceeding 50.62% of T10CLF this difference is attributed to the greater nutritional contribution of the compost. Salinas-Vargas *et al.* (2022), reported when evaluating different corn genotypes, that the highest cob weight was with the white maize (308 g) and the lowest was the blue variety (111 g), with chemical fertilization (180N 80P 00K) and irrigation, exceeding the highest value obtained from T10CLF by

Table 7. Corn plant cob characteristics: ear diameter, ear weight, kernel weight and ear weight.

Treatment	Cob diameter (mm)	Cob weight (g)	Grain weight (g)	Weight of cod (g)
T10CLF	52.09±1.23 EE a	286±8.92 EE a	159.54±4.26 EE a*	26.09±0.53 EE a*
T7.5CLF	49.18±0.93 EE ab	282.27±12.92 EE ab	159±6.64 EE a	25.36±1.25 EE ab
T10CLS	48.72±0.64 EE abc	244.36±11.64 EE bcd	140.54±7.60 EE ab	24.72±1.48 EE abc
T5CLF	48.72±0.54 EE abc	257.91±12.04 EE abcd	143.63±5.60 EE ab	21.27±0.98 EE bcde
T7.5CLS	49.63±0.66 EE abc	272.09±17.51 EE abc	144.91±9.55 EE ab	24.18±1.96 EE abcd
T2.5CLS	48.54±1.26 EE abc	233.18±17.0 EE cde	123.27±8.86 EE bc	20.18±1.62 EE def
T5CLS	45.63±0.76 EE bcd	228.09±14.06 EE of	127±7.95 EE bc	20.9±0.896 EE cde
T2.5CLF	44.90±0.99 EE cd	201±8.58 EE ef	111±5.14 EE c	18.09±1.17 EE ef
TQm	44.72±3.60 EE cd	250.45±18.89 EE abcd	141.36±11.20 EE ab	20.54±2.02 EE of
T000	44.36±1.24 EE d	163.27±16.04 EE f	83.82±9.14 EE d	16.27±1.94 EE f
C.V.	10.18	19.43	19.58	22.40

*Treatments with the same letter are not significant (α=0.05 p.), C.V. 10.18, SE=standard error of the mean.

92.85%. This difference is attributed to chemical fertilization and irrigation under the conditions of Guasave, Sinaloa. In cob weight, Escobar *et al.* (2013), determined that the organic mixture: coffee pulp+litter+chicken manure+cattle manure was the highest with 611.2 g, a value 46.79% higher than the highest value of T10CLF (286±8.92 g), which can be attributed to the maize genetic material, with greater potential.

Grain weight. The effects of treatments were more evident in the fourth cycle of corn cultivation in the variable grain weight (Table 7). The application of 10 and 7.5 (t ha^{-1}) compost to the soil plus foliar fertilization surpassed the absolute control (T000) by 52.53% and 47.47% to the chemical application (TQm), as the best responses, leaving the TQm with an intermediate value (250.45±18.89), with respect to other treatments based on compost resulting with statistical difference ($\alpha \leq 0.05$). The above results coincide with those reported by Vásquez *et al.* (2015), who found response to the application of raw and composted manures to supply the nutritional requirements of maize in the tropical region of Veracruz in grain (kg ha^{-1}) with the maize variety H-520. Wood *et al.* (1996), found that with the application of poultry manure to corn crops at a dose of 8 t ha^{-1} optimum yields were obtained, while at higher doses of 18 t ha^{-1} yields decreased. In another work, Microbial consortia were applied in liquid form, with doses of 10 ml at the foot of each corn plant at 20, 40 and 60 days after planting. The results were 11.59 t ha^{-1}, statistically superior to other treatments (Rosabal-Ayan *et al.* 2022). In this research, with lower doses of compost applied, the yield was acceptable, possibly due to the combination with leachates, in addition to the organisms that contribute and the residual nature of the compost, as mentioned by Sánchez (2021).

Weight of rachis (olote, bacal). The results obtained for the variable weight (g) of corn stool are presented in Table 7. The applications of the highest doses of composts to the soil plus foliar fertilization corresponded to T10CF T7.5CF, T10CS, T7.5CS, and t ha^{-1} in descending order respectively, with 26.09±0.53, 25.36±1.25, 24.72±1.48, 24.18±1.96, of weight (g) of bacal, for each treatment surpassing TQm with a lower value (20.54±2.02 g) and statistically with respect to the control T000 (16.27±1.94) according to the DMS test ($\alpha \leq 0.05$). The T10CF showed a 37.6% higher weight compared to the T000 and with respect to this the other values showed higher bacal weight. The results obtained indicate that there are favorable trends to the application of composts and leachates in the

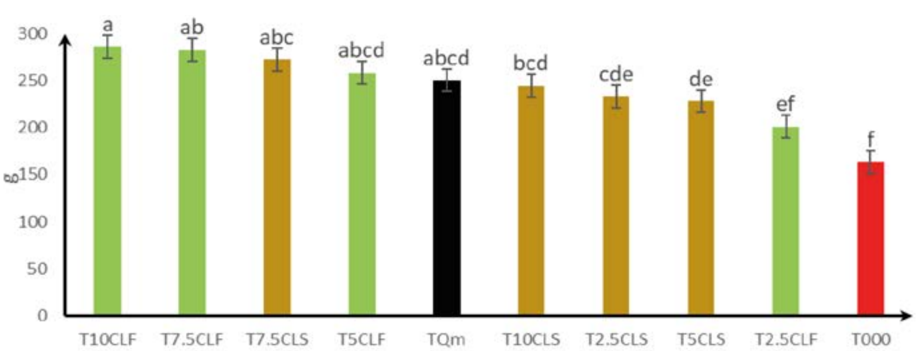

Figure 3. Cob weight (g) of corn with different applications of compost to the soil and leachates (E.F. Huimanguillo Cycle P-V 2023).

vegetative variables of corn growth and dry matter. Lopez (2024), in an investigation with organic fertilization with leachates of corn crop variety H520, found significant differences between treatments T25% with 30.20 and TQm 28.10 g respectively with a range between higher and lower values corresponding to 32.4%. Compared with the values obtained with respect to T10CLF (26.09±0.53 g) against the highest T25% (30.20 g), it resulted 86.39%, higher the application of only leachate, while for the lowest level T000 (16.27±1.94 g) against the TQm (28.10 g), this resulted in 57.90%, which may be related to the amount of grain per cob^{-1}, as a possible effect of treatments, which was reflected in higher cob weight to the detriment of grain.

CONCLUSIONS

The effects of the treatments in the third cycle of corn production were consistently manifested in the variables: height, stem diameter, average width and length of the leaf, length and average diameter of the corncob, grain weight and bacal; being superior with respect to the absolute control (T000) and the lowest treatment based on compost (T2.5CL), and compared to the chemical fertilization (TQm). On the other hand, the fertilization treatments T5CL, T7.5CL and T10CL were competitive in the different variables analyzed, and even superior in their values with the exception of the leaf length variable. It is evidently concluded that this type of fertilization is beneficial and can be an alternative to improve and practice agriculture with less application of chemical fertilizers to contribute to a cleaner and safer environment for humans.

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