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Green manures (Fabaceae) and bokashi: An alternative to replace inorganic fertilizers in corn cultivation

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ABSTRACT

Objective: To determine the production of forage, green corn and corn grain depending on the bokashi (BOK) and green manures - *Crotalaria juncea* (CROJUN), *Canavalia ensiformis* (CAJCAJ) and *Cajanus cajan* (CANENS) used exclusively or combined with native efficient microorganisms (NEM) and arbuscular mycorrhizal fungi (AMF), in order to identify the best alternatives to replace inorganic fertilizers (IF) in the H-520 corn cultivation.

Design/methodology/approach: The following treatments were evaluated: 28 t ha^{-1} of BOK+NEM+AMF, CROJUN, CAJCAJ, CANENS, CROJUN+NEM+AMF, CAJCAJ+NEM+MI, CANENS+NEM+AMF 100 and 50% of the IF 62-00-00 kg/ha of N-P_2O_5-K_2O (IF100 and IF50) and one unfertilized treatment.

Results: The biomass produced by CROJUN exceeded that of CAJCAJ, fertilization treatments had different effects on forage production, corn characteristics and yields of corn, totomoxtle, ears and grains, with BOK+NEM+AMF, CROJUN and CANENS standing out.

Limitations on study/implications: The study demonstrates that BOK and green manures are alternatives to replace IF. However, further research is needed to confirm these findings, adjust the amount of bokashi or to include other green manures, either exclusively or in combination with NEM and AMF.

Findings/conclusions: BOK combined with NEM and MI, as well as the green manures *C. juncea* and *C. ensiformis* with a biomass production of 2.1 or 6.3 t ha^{-1} together with the biomass of local weeds, are agroecological alternatives that can promote forage, green corn and corn grain yields similar or higher than those obtained with IF.

Keywords: C/N ratio, H-520, Nitrogen, Soil fertility.

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INTRODUCTION

Corn (*Zea mays* L.) is the main agricultural crop in Mexico, with 6.4 and 0.5 million hectares dedicated to grain and forage production, respectively. The state of Veracruz is the second-largest producer of grain corn, with 598,902 ha. The average grain yield at the

national level and in Veracruz is 4.3 and 2.3 t ha^{-1}, respectively (SIAP, 2023). Regarding forage, Veracruz reports an area of 2,228 ha with an average yield of 20 t ha^{-1}, which is lower than the national average yield of 34 t ha^{-1}.

The 69% of corn is produced under rainfed conditions, while the remaining 31% is grown in irrigated areas (SIAP, 2023). Corn is primarily produced through a conventional system that includes the use of agrochemicals and inorganic fertilizers (IF). In Veracruz, it has been reported that for every ton of grain produced, the plant extracts 27, 11, and 23 kg of nitrogen (N), phosphorus (as P_2O_5), and potassium (as K_2O), respectively (Vásquez Hernández *et al.*, 2014). These nutritional requirements can be met in some regions by the nutrients already present in the soil, as in the case of potassium (K), while others must be supplied through an external source, such as nitrogen (N) and phosphorus (P). Fertilization rates reported for the state of Veracruz include 156-46-30 and 129-23-23 kg ha^{-1} of N-P-K (Palafox-Caballero *et al.*, 2005; Capetillo-Burela *et al.*, 2021).

The production of plant-based foods through an agroecological system is a current necessity; therefore, it is essential to improve technologies focused on the nutrition of agricultural crops. Among the alternatives currently available to replace IF are the use of bokashi organic fertilizer (BOK), green manures (GM), native efficient microorganisms (NEM), and arbuscular mycorrhizal fungi (AMF).

BOK is a fertilizer that allows for the utilization of plant residues, manure, and regional minerals. There is no single recipe; therefore, the amount of nutrients it can provide to the soil will vary in each production unit. The GM technology involves using plants (mainly Fabaceae) as an exogenous source of N. The Fabaceae species form a symbiosis with nitrogen-fixing bacteria, and the fixed nitrogen is transferred to the Fabaceae plants. Once these plants are cut and deposited in the soil, the mineralization process begins. At this point, the nutrients become available to be utilized by the crop of interest (Matías-Ramos *et al.*, 2023). Both the effects of BOK and GM depend on the amount of nutrients they supply to the soil and the synchronization between the release of nutrients and the nutritional demand of the agricultural crop (Watthier *et al.*, 2023). NEM and AMF are microorganisms that help plants tolerate biotic and abiotic stress due to the production of secondary metabolites and the extension of the root system. They also contribute to the mineralization of organic residues, increasing the availability of nutrients for plants (Gómez-Leyva *et al.*, 2023; Oberholzer *et al.*, 2024). The effect of agroecological nutrition alternatives is directly related to climate behavior, and for rainfed conditions, the main factor is rainfall. Water availability will affect the mineralization process and nutrient transport. Therefore, production under rainfed conditions remains a challenge for corn cultivation, as nearly 70% of production occurs under these conditions. The objective of the study was to determine the production of forage, ear, and grain corn depending on the use of BOK and different species of GM applied in combination with NEM and AMF, with the aim of identifying the best alternatives to replace IF in corn production under rainfed conditions in the central coastal region of Veracruz, Mexico. The initial hypothesis is that at least one agroecological alternative will be identified that allows for a 100% replacement of IF in corn cultivation.

MATERIALS AND METHODS

Area of Study

The experiment was conducted at the Cotaxtla Experimental Field, belonging to the National Institute of Forestry, Agricultural, and Livestock Research (INIFAP), located in Medellín, Veracruz, Mexico (18° 49”59”’N; 96° 22”59”’W). The soil had a pH of 5.62, with 2.88% organic matter, and a loam texture (11, 41, and 48% clay, sand, and silt, respectively). The concentrations of N (nitrate), $P\text{-}PO_4^-$, $S\text{-}SO_4^{-2}$, K^+, Ca^{2+}, Mg^{2+}, Fe^{2+}, Zn^{2+}, Cu^{2+}, Mn^+, and B^{3+} were 106.6, 60.0, 20.0, 680.0, 1990.0, 510.0, 45.3, 4.6, 5.3, 18.6, and 0.52 mg kg^{-1}, respectively. Temperature and precipitation data were recorded throughout the duration of the experiment (Figure 1).

Experimental design and treatments

The treatments consisted of the exclusive use of the green manures *Cajanus cajan* (CAJCAJ), *Canavalia ensiformis* (CANENS), and *Crotalaria juncea* (CROJUN), or their combination with NEM and seeds inoculated with the AMF *Rhizophagus intraradices* (40 spores g^{-1}) (CAJCAJ+NEM+AMF, CANENS+NEM+AMF, and CROJUN+NEM+AMF); BOK combined with NEM and AMF (BOK+NEM+AMF); IF applied at 100% and 50% of the recommended dose (IF100 and IF50); as well as a non-fertilized treatment (Control).

An experimental design in randomized blocks with three replications was used. The experimental unit consisted of 15 furrows, each 6 meters long. The IF dose was estimated using the rational method (Mata *et al.*, 2015). The target yield was 9 t ha^{-1}, with the assumption that for every ton of grain, 27, 11, and 23 kg of N, P_2O_5, and K_2O would be extracted (Vásquez Hernández *et al.*, 2014), which is equivalent to a requirement of 243, 103, and 206 kg ha^{-1} of N, P_2O_5, and K_2O. Considering a soil bulk density of 1 g cm^3 and a depth of 0.2 m, the soil availability of N, P_2O_5, and K_2O was estimated at 212, 275, and 1638 kg ha^{-1}, respectively. The inorganic fertilization included only the application of N, with a relative efficiency of 50%. The 100% and 50% doses corresponded to 62 and 31 kg ha^{-1} of N.

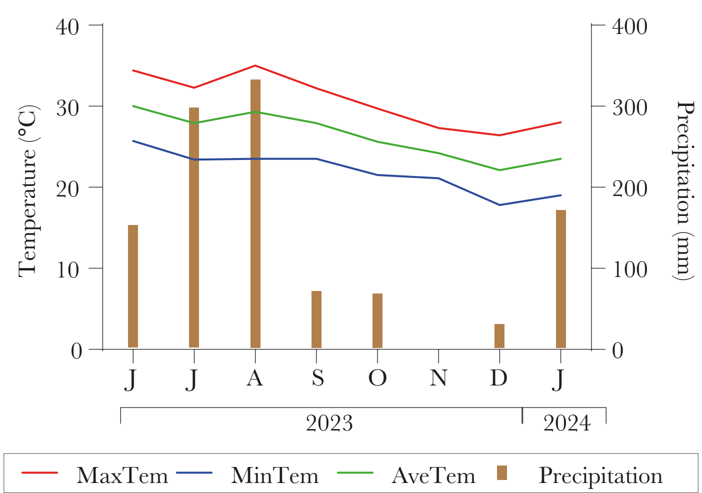

Figure 1. Behavior of maximum temperature (MaxTem), minimum temperature (MinTem), average temperature (AveTem), and precipitation from June 2023 to January 2024, in Medellín, Veracruz, Mexico.

Green manure

Soil preparation consisted of mechanical weeding, two harrowing passes, and furrowing. The distance between furrows was 0.8 m. For *C. juncea* and *C. cajan*, 4 grams of seed were used per linear meter (50 kg/ha). For *C. ensiformis*, 10 seeds were used per linear meter (125 kg/ha). The three GM species were sown on the same date (06/16/2023). No pest, disease, or weed control was carried out. Irrigation was solely dependent on rainfall. The cutting of above-ground biomass from the GM and weeds was carried out 56 days after sowing, using a mechanical weeder. In each experimental unit, the fresh weight of the GM and weeds was recorded in a 2 m^2 area.

To determine the dry biomass, representative samples of the GM and weeds were taken and dried in a forced air oven (at 70 °C) until a constant weight was reached. Using the data from the GM and weeds, the amount of plant biomass produced per hectare was estimated.

Corn establishment

Seven days after the biomass cutting, six passes of harrowing were performed to shred and incorporate the plant residues into the first 20 cm of soil. After 20 days of incorporating the biomass, two more passes of harrowing were carried out, and then the field was plowed. The distance between rows was 0.8 m. The corn H-520 was established (14/09/2023) at a density of 50,000 plants ha^{-1} (with a plant spacing of 0.25 m). Two supplementary rolling irrigations were performed during the vegetative stage and at the beginning of corn flowering, which corresponded to 12 and 51 days after corn sowing (DAS). The control of lepidopteran pests was carried out through an application of the active ingredient cypermethrin at a commercial dose, 20 DAS.

Corn fertilization

FI100 and FI50 were applied foliarly in three applications (15, 25, and 35 DAP). In each application, 1 or 0.5 g of urea (46% N) per plant was used, diluted in approximately 8 ml of water, corresponding to a volume of 400 L ha^{-1}. The BOK was prepared (on 11/02/2023) using chicken manure, cow manure, pangola grass, soil, and sand, in a 2:2:2:1:1 (volume/volume) ratio, with a mixture of molasses and water (10% molasses). The characteristics of the BOK were as follows: 19.52% organic matter and 11.32% C; pH of 6.61, a C/N ratio of 12.58, and the following concentrations: 0.9% total N, 1.17% P_2O_5, 0.84% K_2O, 2.67% CaO, 0.68% MgO, 0.95% Fe^{2+}, 0.03% Zn^{2+}, 0.00% Cu^{2+}, 0.05% Mn^{2+}, and 0.03% B^{2+}. The amount of BOK applied was determined based on its N concentration and a relative efficiency of 25%. To supply 62 kg ha^{-1} of N, an equivalent of 28 t ha^{-1} of bokashi in dry weight (551 g $plant^{-1}$) was applied. The BOK was applied once, 5 DAS, near the corn stalk and incorporated into the soil at the time of hilling.

The NEM used were prepared according to Rebolledo *et al.* (2012), using microorganisms obtained from local grass weed species. For every 150 L of water, the following inputs were used: molasses (15 L), grass residues (2 kg), corn flour (2 kg), wheat bran (2 kg), and charcoal (0.5 kg). For the treatments that included the application of NEM, a 5% concentration was used, applying 8 mL per plant of the solution every 10 days, starting 5 DAS and concluding at the flowering stage (a total of five applications).

Forage and Corn Ear Production

At 82 DAS, in each experimental unit, plant density per hectare was estimated (in five linear meters), along with fresh biomass of forage, fresh weight of leaves, stems, and corn ears with husk. To determine corn ear quality, measurements were taken for ear diameter, fresh weight of ears with husk, ear length, number of grain rows, and estimated ear yield per hectare. Representative samples of each maize plant organ were collected and dried in a forced-air oven at 70 °C until reaching a constant weight. These data were used to estimate the dry weight of maize forage.

Corn Yield

At 152 DAS, grain harvest was carried out. In each experimental unit, the number of plants and the number of ears per plant were counted in 13 linear meters. In 26 ears, measurements were recorded for ear weight with husk, ear weight without husk, husk weight, cob weight, and grain weight.

Data Analysis

The data were analyzed using the statistical software InfoStat. Analysis of variance and Tukey's mean comparison test were performed, both at a 95% probability level ($p \leq 0.05$).

RESULTS AND DISCUSSION

Regarding the vegetative biomass of GM, the dry matter of CROJUN was similar to that of CANENS+ME+AMF and CROJUN+ME+AMF but superior to the others. Similar dry matter of weeds and total dry matter were detected among treatments (Table 1). The yield of fresh and dry forage detected with BOK+NEM+AMF was similar to that of CANENS, CROJUN, CANENS+NEM+AMF, and CROJUN+NEM+AMF but superior to that of CAJCAJ (Table 1). Lower fresh weight, diameter, length, and yield of corn ears were detected with CAJCAJ compared to CANENS, CROJUN, and BOK+NEM+AMF (Table 2). At the time of corn harvest, the totomoxtle yield of CROJUN+NEM+AMF was higher than that of FI50. The cob and grain yield obtained with BOK+NEM+AMF was similar to that of CROJUN and CROJUN+NEM+AMF but higher than the rest of the treatments (Table 2). The maximum forage yields achieved with CANENS, BOK+NEM+AMF, CROJUN, CROJUN+NEM+AMF, and CAJCAJ+NEM+AMF (35, 34, 31, 29, and 28 t ha^{-1}, respectively) are similar to or even higher than the 22-30 t ha^{-1} reported by Sánchez Hernández *et al.* (2013; 2019) using the same planting density and variety, with the fertilization dose of 161-46-00 kg ha^{-1} of N-P-K. Regarding the ear, Ortiz-Torres *et al.* (2013) and Fernández González (2015) report that the desirable characteristics are a weight between 370 and 480 g, yields between 14 and 18 t ha^{-1}, diameters of 5 cm, and lengths of 18 to 20 cm, with 15 to 18 rows of grain. These values are reported for ear varieties such as V-525 and A7573. In this study, none of the treatments reached the desired parameters, which is attributed to the variety used,

Table 1. Dry matter (DM) of green manures and weeds, as well as green and dry forage of corn managed with 100% and 50% inorganic fertilizers (IF), or with bokashi (BOK) and weed residues, *Cajanus cajan* (CAJCAJ), *Canavalia ensiformis* (CANENS), and *Crotalaria juncea* (CROJUN), either exclusively or combined with Native Effective Microorganisms (NEM) and seed inoculated with arbuscular mycorrhizal fungi (AMF), in Medellín, Veracruz.

Treatments	DM of green manure (t ha^{-1})	DM of weeds (t ha^{-1})	Total DM (green manure + weeds) (t ha^{-1})	Corn green forage yield (t ha^{-1})	Corn dry forage yield (t ha^{-1})
1. CAJCAJ	0.8 b	7.2 a	8.0 a	20 c	6 c
2. CANENS	2.1 b	6.7 a	8.8 a	35 a	10 ab
3. CROJUN	6.3 a	5.8 a	12.1 a	31 ab	8 abc
4. CAJCAJ+NEM+AMF	0.8 b	8.6 a	9.4 a	23 bc	7 bc
5. CANENS+NEM+AMF	2.4 ab	6.9 a	9.3 a	28 abc	8 abc
6. CROJUN+NEM+AMF	4.8 ab	4.0 a	8.8 a	29 abc	8 abc
7. BOK+NEM+AMF	-	6.5 a	6.5 a	34 a	11 a
8. IF100	-	5.2 a	5.2 a	24 abc	7 bc
9. IF50	-	8.7 a	8.7 a	23 bc	7 bc
10. Control	-	7.2 a	7.2 a	26 abc	8 abc
Coefficient of variation	80.51	52.34	46.03	31.53	32.09

Different letters in the same column are statistically different according to the Tukey test ($p \leq 0.05$).

as genetically, the size of the ear of the H-520 is smaller compared to ear varieties (Ortiz-Torres *et al.*, 2013; Fernández González, 2015).

Regarding grain yield, the maximum values detected in this study (4.4-5.0 t ha^{-1}) with the application of BOK+NEM+AMF, CROJUN, CROJUN+NEM+AMF, CANENS, and CANENS+NEM+AMF are higher than the national average of 4.28 t ha^{-1} and the state of Veracruz's average of 2.29 t ha^{-1}. However, these values align with the average yield of the Veracruz District (5.4 t ha^{-1}), where production follows a conventional system that incorporates the use of mineral fertilizers (SIAP, 2023).

In this research, green manures, BOK, NEM, and AMF were alternatives used for agroecological maize nutrition. According to the results, the combination of BOK with NEM and AMF promoted the best outcomes, as 34 and 11 t ha^{-1} of green forage and dry forage surpassed or were similar to those obtained with mineral fertilization (23-24 and 7 t ha^{-1} of green and dry forage, respectively). Similarly, they promoted ears with greater weight (238 g) and size (5 and 16 cm in diameter and length), consequently achieving the highest yield of ears and grain per hectare (13 and 5 t ha^{-1}, respectively). The best effect of BOK is attributed to it being the treatment that supplied the greatest amount and diversity of nutrients to the soil. With 28 t ha^{-1}, it supplied approximately 4888, 2830, 225, 293, 210, 668, 170, 238, 13, 8, and 8 kg ha^{-1} of organic matter, C, total N, P_2O_5, K_2O, CaO, MgO, Fe^{2+}, Mn^{2+}, Zn^{2+}, and B^{2+}, respectively. With these amounts, an increase of 0.24% in organic matter levels is expected in the top 20 cm of soil, as well as an increase in

Table 2. Characteristics of the ear and yield of ear, husk, cob, and grain of corn managed with 100% and 50% inorganic fertilizers (IF), or with bokashi (BOK) and residues from weeds, *Cajanus cajan* (CAJCAJ), *Canavalia ensiformis* (CANENS), and *Crotalaria juncea* (CROJUN), either alone or combined with Native Effective Microorganisms (NEM) and seed inoculated with arbuscular mycorrhizal fungi (AMF), in Medellín, Veracruz.

Treatments	Fresh weight of ear with bractea (g)	Diameter of ear with bractea (cm)	Ear length (cm)	Number of rows kernels of the ear	Yield ($t\ ha^{-1}$)			
					Ear	Bractea	Cobs	Grain
1. CAJCAJ	128 c	3.8 b	13 b	12 a	7 b	0.7 ab	0.6 d	3.3 d
2. CANENS	218 a	4.9 a	16 a	12 a	12 a	0.7 ab	0.8 bcd	4.1 bc
3. CROJUN	221 ab	5.0 a	16 a	13 a	11 a	0.8 ab	0.9 ab	4.7 ab
4. CAJCAJ+NEM+AMF	173 abc	4.5 a	14 ab	13 a	9 ab	0.7 ab	0.8 bcd	3.8 cd
5. CANENS+NEM+AMF	191 abc	4.6 a	14 ab	13 a	10 ab	0.8 ab	0.8 bcd	4.0 bc
6. CROJUN+NEM+AMF	216 ab	4.9 a	15 ab	12 a	11 a	0.9 a	0.8 bcd	4.4 abc
7. BOK+NEM+AMF	238 a	5.0 a	16 a	13 a	13 a	0.8 ab	1.0 a	5.0 a
8. IF100	169 bc	4.4 ab	14 ab	13 a	9 ab	0.7 ab	0.7 cd	3.3 d
9. IF50	168 bc	4.4 ab	14 ab	12 a	9 ab	0.6 b	0.6 d	3.3 d
10. Control	180 abc	4.5 a	15 ab	12 a	9 ab	0.8 ab	0.7 cd	3.6 d
Coefficient of variation	27.57	12.17	13.18	12.98	33.53	60.14	33.60	37.35

Different letters in the same column are statistically different according to the Tukey test ($p \leq 0.05$).

cation exchange capacity. Improving these two soil characteristics has a positive impact on nutrient efficiency, as it ensures better moisture retention and enhances the soil's ability to retain nutrients in the rhizosphere zone (Martins Neto *et al.*, 2020). Despite these agronomic advantages of BOK, it is important to mention that this alternative also has limitations that producers should consider. The first limitation is the high amount of input required per hectare and per production cycle. In this study, during the preparation of BOK, an approximate cost of $1,150.00 MXN (USD$57.50) per ton was estimated, considering the 28 $t\ ha^{-1}$ used. This represents an investment of $32,000.00 MXN (USD$1600.00). In addition to this production cost, transportation and application expenses should also be taken into account. Therefore, this technology is recommended for small-scale producers who cultivate less than one hectare. It is also recommended for livestock producers or companies that have surplus manure and other vegetal and mineral resources, allowing them to produce their own inputs for forage production.

The positive effect of a GM increases as the amount of plant biomass produced rises, particularly when there is synchronization between nutrient release into the soil and the crop's nutritional demand (Watthier *et al.*, 2023). For this study, the results indicate that in the central coastal region of Veracruz, *Crotalaria juncea* and *Canavalia ensiformis* are promising options for use under rainfed conditions. Considering the production of green forage, dry forage, ear yield, and grain yield, *Crotalaria juncea* applied alone or in combination with ENF and AMF achieved values of 29-31, 8, 11, and 4.4-4.7 $t\ ha^{-1}$; in the case of *C. ensiformis*, applied alone or in combination with ENF and AMF, the values were 28-35, 8-10, 10-12, and 4.0-4.1 $t\ ha^{-1}$, respectively. The values achieved were statistically similar to those obtained with BOK, and specifically for grain production, they were higher than those obtained with IF and unfertilized plants. The better effect of *C. juncea* and *C. ensiformis* is attributed to their greater growth capacity. In descending order, the total plant biomass supplied was 8.8-12.1, 8.8-9.3, and 8.0-9.4 t ha^{-1} with *C. juncea*, *C. ensiformis*, and *C. cajan*, respectively. The total plant biomass produced in the different areas showed no statistical differences; therefore, the varying effects promoted by the green manures are mainly attributed to the amount of biomass produced by each Fabaceae. It is important to note that the weeds mainly consisted of non-leguminous species, with prominent grasses such as *Sorghum halepense* and *Cyperus rotundus*, which are characteristic of tropical regions in Mexico (González-Elizondo *et al.*, 2018; Herrera Solano *et al.*, 2023). Since they do not belong to the Fabaceae family, the main contribution of the weeds was the provision of organic matter and nutrient recycling. Therefore, the only exogenous nutrient was nitrogen, supplied through the biomass of the Fabaceaes. Considering that the amount of nitrogen supplied to the soil depends on the amount of biomass produced (Watthier *et al.*, 2023), the nitrogen contribution was in the following descending order: *C. juncea*>*C. ensiformis*>*C. cajan*, with biomass production of 4.8-6.3, 2.1-2.4, and 0.8 t ha^{-1}, respectively. For the same geographical region, Ávila-Escobedo *et al.* (2022) report that for every ton of dry biomass produced by *C. juncea*, *C. ensiformis*, and *C. cajan*, 18.3-18.4, 24.7-26.1, and 14.9-15.1 kg of nitrogen are supplied to the soil, respectively. Therefore, for this study, it is estimated that nitrogen contributions were 88-116, 52-63, and 11.9-12.1 kg ha^{-1}, respectively.

The synchronization between nutrient release and the nutritional demand of the crop mainly depends on the C/N ratio of organic residues and climatic conditions. A lower C/N ratio results in a faster mineralization rate (Watthier *et al.*, 2022). Among the different organic residues used, the lowest C/N ratio was 12.6, corresponding to BOK. In contrast, for *C. juncea*, *C. ensiformis*, and *C. cajan*, the C/N ratios detected in the same study area were 21.6-24.3, 17.0-18.0, and 31.7-33.7, respectively, 75-89, 69-90, and 118-124 days after sowing, corresponding to the flowering stage (Ávila-Escobedo *et al.*, 2022). Considering that in this study, the green manure biomass was cut at 56 DAS, it is expected that the C/N ratio in the biomass of the three green manures was lower than that found during the flowering stage, due to reduced lignification of the plants. In the first three months following the incorporation of the plant residues, the temperature ranged between 21 and 35 °C, with an accumulated precipitation of 480 mm. Therefore, it is assumed that the environmental conditions were favorable for the mineralization of nutrients present in both the BOK and the plant residues, which helps explain the positive effects observed with these two technologies. Currently, the main limitation for the extensive use of GM technology is the availability and cost of seeds. For this study, the seed quantities used per hectare were 50 kg for *C. juncea* and 125 kg for *C. ensiformis*. The regional market price for the seeds is approximately $130.00 and $95.00 MXN (USD$6.5-4.75), representing acquisition investments of $6,500.00 and $11,875.00 MXN (USD$325-593.75), respectively. This value should be supplemented by the cost of soil preparation for the planting of these green manures. One advantage of green manures is that producers can grow their own seeds, reducing investment for subsequent cycles. When comparing GM and BOK from an economic and operational standpoint, green manures emerge as a better option for producers, as they not only require lower investment but also simplify fieldwork. The focus is on soil preparation, planting, and incorporating the green manures, with the possibility of using agricultural machinery for all tasks. Therefore, for future work, it is recommended to consider the combined application of green manures with low doses of BOK.

CONCLUSIONS

In the central coastal region of Veracruz, under rainfed conditions, bokashi applied at a dose of 28 t ha^{-1}, along with indigenous efficient microorganisms and seeds inoculated with mycorrhizal fungal spores, as well as green manures such as *Crotalaria juncea* and *Canavalia ensiformis* with biomass production of 2.1 or 6.3 t ha^{-1}, along with local weed biomass, are alternatives that can promote forage, cob, and grain yields of *Zea mays* H-520 similar to or greater than those obtained with mineral fertilization (62-00-00 kg ha^{-1} of N-P_2O_5-K_2O). Based on these results, the initial hypothesis of the research is accepted.

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