Nativa, Sinop, v. 11, n. 4, p. 500-504, 2023.
Pesquisas Agrárias e Ambientais
DOI: https://doi.org/10.31413/nativa.v11i4.16654
ISSN: 2318-7670

Analysis of soil planted to sweet corn applied with mycorrhizal inoculants and varied fertilizer rates

Gleven Jay Valde LARAÑO [1]*, Carolina Danio AMPER [2]

[1]College of Agriculture, Forestry and Environmental Sciences, Mindanao State University at Naawan, Misamis Oriental, Philippines.
[2]Department of Plant Pathology, College of Agriculture, Central Mindanao University, Musuan, Bukidnon, Philippines.
*E-mail: glevenjay.larano@msunaaawan.edu.ph

Submitted on: 11/15/2023; Accepted on: 12/17/2023; Published on: 12/29/2023.

ABSTRACT: Mycorrhizae, a group of beneficial soil microorganisms that establish symbiotic associations with plant roots, have gained considerable attention in scientific research. A research was conducted from December 2021 to March 2022 in Calao-calao, Don Carlos, Bukidnon sought to investigate the effects of mycorrhizae inoculants and varying fertilizer rates on the performance of sweet corn. It aimed to quantify the concentration of NPK (nitrogen, phosphorus and potassium) on soil planted with sweet corn. The experiment followed a split plot arranged in a randomized complete block design (RCBD) with fertilizer rates as the main plot and mycorrhizal inoculants as the subplot. The entire area was divided into three blocks, each further divided into three main plots measuring 5.25 meters (m) by 16 m. MykoRich was applied at a rate of two capsules per hill, while MykoVam was applied at the rate of 10 g per hill. Both inoculants were applied for their respective hills during planting. For soil analysis, the initial assessment was done before planting and after harvest to determine the total N, extractable P, and exchangeable K. The findings of the study indicate that the presence of mycorrhizae significantly increases the levels of nitrogen ($p<0.05$) and phosphorus ($p<0.001$) in the soil. Furthermore, when mycorrhizal inoculants are combined with 75% fertilizer rates, there is an observed elevation in the availability of potassium ($p<0.05$) in the soil. Finally, a 75% Fertilizer Rate combined with either Mykorich or MykoVam increases the available potassium concentration. Thus, it is recommended to apply MykoVam or MykoRich to increase the available N and P concentration and to apply MykoRich or MykoVAm when fertilizer rates are reduced to 75% to increase the available potassium concentration in the soil.

Keywords: fertilization combination; mycorrhizae; fertilizer rates.

Análise de solo plantado com milho doce aplicado com inoculantes micorrízicos e doses variadas de fertilizantes

RESUMO: As micorrizas, um grupo de microrganismos benéficos do solo que estabelecem associações simbióticas com raízes de plantas, têm ganhado considerável atenção na pesquisa científica. Uma pesquisa foi realizada de dezembro de 2021 a março de 2022 em Calao-calao, Don Carlos, Bukidnon e procurou investigar os efeitos dos inoculantes de micorrizas e das diferentes taxas de fertilizantes no desempenho do milho doce. Objetivou-se quantificar a concentração de NPK (nitrogênio, fósforo e potássio) em solo plantado com milho doce. O experimento seguiu uma parcela subdividida, disposta em delineamento de blocos completos casualizados (RCBD), com doses de fertilizantes como parcela principal e inoculantes micorrízicos como subparcela. Toda a área foi dividida em três blocos, cada um dividido em três parcelas principais medindo 5,25 metros (m) por 16 m. MykoRich foi aplicado na proporção de duas cápsulas por linha, enquanto MykoVam foi aplicado na proporção de 10 g por linha. Ambos os inoculantes foram aplicados nas respectivas covas durante o plantio. Para análise do solo, a avaliação inicial foi feita antes do plantio e após a colheita para determinação do N total, P extraível e K trocável. Os achados do estudo indicam que a presença de micorrizas aumenta significativamente os teores de nitrogênio ($p<0,05$) e fósforo ($p<0,001$) no solo. Além disso, quando os inoculantes micorrízicos são combinados com doses de fertilizante de 75%, observa-se uma elevação na disponibilidade de potássio ($p<0,05$) no solo. Finalmente, uma taxa de fertilizante de 75% combinada com Mykorich ou MykoVam aumenta a concentração de potássio disponível. Assim, recomenda-se aplicar MykoVam ou MykoRich para aumentar a concentração disponível de N e P e aplicar MykoRich ou MykoVAm quando as taxas de fertilizantes forem reduzidas a 75% para aumentar a concentração de potássio disponível no solo.

Palavras-chave: combinação de fertilização; micorrizas; taxas de fertilizantes.

1. INTRODUCTION

Corn, like rice, is an important food in the Philippines. It is one of the Philippines' primary crops. Each year, corn is subject to various diseases (GALLO et al., 2020), but some of them can be controlled using fertilizer; while these fertilizers assist the corn plants in warding off diseases, they

can also harm the environment (UR REHMAN et al., 2021). Therefore, there's a need to reduce this potentially harmful fertilizer use without negatively affecting the corn's growth. A type of soil microbe known as mycorrhizae, could serve as a solution. These microbes form partnerships with the roots of the plants, including corn, and they help each other out. The mycorrhizae increase the ability of the plants to take in essential nutrients from the soil, promoting better growth. In return, the plants give the mycorrhizae the nutrients they need to grow (BONFANTE and GENRE, 2010).

Numerous studies have shown that mycorrhizae can enhance crop growth (Artursson et al., 2011; Nadeem et al., 2014; Nanjundappa et al., 2019). They help plants obtain important nutrients like phosphorus (P) and nitrogen (N), which means less chemical fertilizer is necessary (He et al., 2009). These fungi can also improve the plant's ability to absorb nitrogen, phosphorus and potassium (Larano et al., 2023), zinc, copper, and nitrate (CAVAGNARO, 2005). Furthermore, they boost the plant's ability to handle stress, such as drought or soil diseases (Miransari, 2010; Elsen et al., 2008). They can even strengthen the plant's defenses, not just in the roots, but also in the stems and leaves (HAO et al., 2012; DE LA NOVAL et al., 2007).

However, more information is needed on effectively using mycorrhizae alongside varying amounts of fertilizer. A study is being conducted to examine how much Nitrogen, Phosphorus, and Potassium (NPK) are in the soil when growing hybrid sweet corn with mycorrhizae and varied fertilizer rates.

2. MATERIALS AND METHODS

2.1. Time and Place of the Study

The study occurred in P-8, Calao-calao, Don Carlos, Bukidnon, from December 2021 to March 2022. For microscopic examination and soil analysis, samples were forwarded to the Department of Plant Pathology and Soil and Plant Analysis Laboratory, respectively. These service laboratories are in the College of Agriculture at Central Mindanao University, Musuan, Bukidnon.

2.2. Experimental Design and Treatments

The experiment followed a split plot arranged in a randomized complete block design (RCBD) with fertilizer rates as the main plot and mycorrhizal inoculants as the subplot. Each treatment combination was replicated three times. The following were the main plots, subplots, and treatment combinations:

Main Plot – Fertilizer Rates
- A1 – 100% Fertilizer Rate
- A2 – 75% Fertilizer Rate
- A3 – 50% Fertilizer Rate

Subplot – Mycorrhizal Inoculants
- B1 – No Mycorrhiza
- B2 – MykoVam
- B3 – MykoRich

Treatment Combinations
- A1B1- 100% Fertilizer Rate x No Mycorrhiza
- A1B2 - 100% Fertilizer Rate x MykoVam
- A1B3 - 100% Fertilizer Rate x MykoRich
- A2B1 - 75% Fertilizer Rate x No Mycorrhiza
- A2B2 - 75% Fertilizer Rate x MykoVam
- A2B3 - 75% Fertilizer Rate x MykoRich
- A3B1 - 50% Fertilizer Rate x No Mycorrhiza
- A3B2 - 50% Fertilizer Rate x MykoVam
- A3B3 - 50% Fertilizer Rate x MykoRich

2.3. Land Preparation

The experimental area, spanning 1352 m2, underwent clearing, plowing, and harrowing processes to ensure thorough soil pulverization. Treatment rows were established through the use of stakes. The entire area was divided into three blocks, each further divided into three main plots measuring 5.25 meters (m) by 16 m. Three subplots were designated within each main plot, measuring 5.25 m by 5 m. A spacing of 1 m was maintained between the main plots, while 0.5 m separated the subplots. Each plot consisted of seven rows, including three rows for data collection and four border rows.

2.4. Fertilizer Application

After analyzing the soil, the fertilizers were administered according to the recommended rate determined by SPAL. Based on the recommendation, the following materials were used: urea (46-0-0) applied at the rate of 143.67 kg/ha, diammonium phosphate (18-46-0) applied at the rate of 21.74 kg/ha, and muriate of potash applied at the rate of 16.67 kg/ha. The application was carried out in two stages: basal application during planting, where 100% urea and 50% diammonium phosphate were used, and side dressing during hilling-up, where 50% diammonium phosphate and 100% muriate of potash were applied.

2.5. Planting and Hilling-up

Macho F1 hybrid sweet corn seeds were directly planted with a row spacing of 0.75 m and a plant spacing of 0.25 m. additionally, seeds were sown in seed trays to replace missing hills and maintain a population density of 53,333 plants per hectare. This replanting was carried out seven days after planting (DAP). Hilling up, on the other hand, was performed at 30 DAP.

2.6. Application of Mycorrhizal Inoculants

MykoRich was applied at a rate of two capsules per hill, while MykoVam was applied at the rate of 10 g per hill. Both inoculants were applied for their respective hills during planting. These two inoculants were purchased from the University of the Philippines Los Baños, Laguna.

2.7. Soil Analysis after Harvest

After harvest, soil samples were randomly collected from the experimental area using the zigzag method. The samples were taken at a depth of 15 cm and subsequently submitted to the City Soils for analysis. The soil samples were analyzed to determine various properties, including total nitrogen, extractable phosphorus, and exchangeable potassium.

2.8. Data Gathered

For soil analysis, the initial assessment was done before planting and after harvest to determine the total N, extractable P, and exchangeable K.

2.9. Data Analysis

The data obtained from the experiment were analyzed using Analysis of Variance (ANOVA). Significant differences between the means of different treatments were further examined using Tukey's Honestly Significant Difference (HSD) test at a significance level of 5%.

3. RESULTS

Table 1 summarizes the analysis of soil planted to sweet corn applied with mycorrhizal inoculants and varied fertilizer rates at harvest. The initial analysis showed that soil had a total N of 0.23%, extractable P of 36.86 ppm, and exchangeable K of 330 ppm.

There was no significant difference in the total nitrogen (%N) on sweet corn applied with varied fertilizer rates, as the same values of %N with 0.18% were observed in all fertilizer rates. However, mycorrhizal inoculants affect the %N on sweet corn across fertilizer rates. MykoVam (B2) had the highest %N with 0.187%, comparable to MykoRich (B3) with 0.186%, while no mycorrhiza had the lowest %N with 0.179%. The treatment combination did not affect the %N as the values range from 0.18% (A1B1 - 100% Fertilizer Rate x No Mycorrhiza, A2B1 - 75% Fertilizer Rate x No Mycorrhiza, A2B2 - 75% Fertilizer Rate x MykoVam, A3B1 - 50% Fertilizer Rate x No Mycorrhiza, A3B3 - 50% Fertilizer Rate x MykoRich) to 0.19% (A1B2 - 100% Fertilizer Rate x MykoVam, A1B3 - 100% Fertilizer Rate x MykoRich, A2B3 - 75% Fertilizer Rate x MykoRich, A3B2 - 50% Fertilizer Rate x MykoVam).

Table 1. Analysis of soil planted to sweet corn applied with mycorrhizal inoculants and varied fertilizer rates at harvest.
Tabela 1. Análise do solo plantado com milho doce aplicado com inoculantes micorrízicos e taxas variadas de fertilizantes na colheita.

Parameters	% N	Extr. P (ppm)	Exch. K (ppm)
Initial Soil Analysis	0.23	36.86	330
Treatment			
Main Plot (Fertilizer Rates)			
A1 – 100% Fertilizer Rate	0.18	16.26	288.67
A2 – 75% Fertilizer Rate	0.18	16.40	334.33
A3 – 50% Fertilizer Rate	0.18	13.98	326.33
F-test	ns	ns	ns
Subplot (Mycorrhizal Inoculants)			
B1 – No Mycorrhiza	0.179^{b}	14.17^{b}	301.67
B2 – MykoVam	0.187^{a}	17.67^{a}	330.67
B3 – MykoRich	0.186^{ab}	14.80^{b}	317.00
Ftest	*	**	ns
A x B (Fertilizer Rates x Mycorrhizal Inoculants)			
A1B1	0.18	14.44	264.00^{c}
A1B2	0.19	18.19	324.00^{abc}
A1B3	0.19	16.16	278.00^{bc}
A2B1	0.18	14.19	301.00^{abc}
A2B2	0.18	19.40	348.00^{a}
A2B3	0.19	15.59	354.00^{a}
A3B1	0.18	13.87	340.00^{ab}
A3B2	0.19	15.42	320.00^{abc}
A3B3	0.18	12.64	319.00^{abc}
Ftest	ns	ns	*
CV a (%)	6.37	24.88	17.74
CV b (%)	3.14	11.78	7.21

This means a column with the same letter is not significantly different at the 5% level based on Tukey's HSD test. ** - highly significant; * - significant; ns - non-significant.

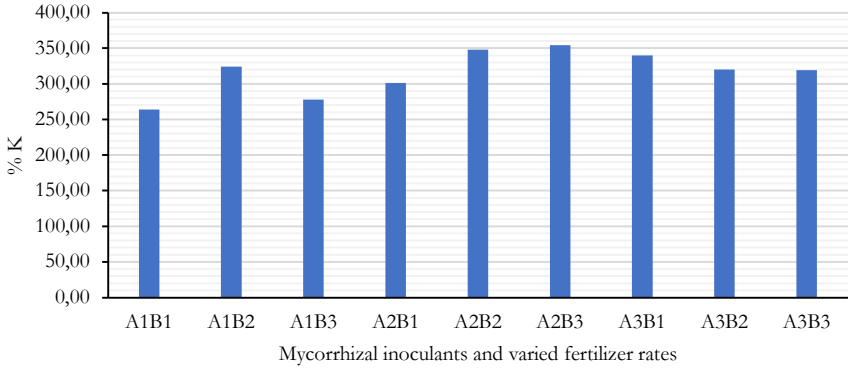

Figure 1. Concentration of exchangeable potassium in the soil planted to sweet corn applied with mycorrhizal inoculants and varied fertilizer rates at harvest (A1B1 - 100% Fertilizer Rate x No Mycorrhiza; A1B2 – 100% Fertilizer Rate x MykoVam; A1B3 – 100% Fertilizer Rate x MykoRich; A2B1 – 75% Fertilizer Rate x No Mycorrhiza; A2B2 – 75% Fertilizer Rate x MykoVam; A2B3 – 75% Fertilizer Rate x MykoRich; A3B1 – 50% Fertilizer Rate x No Mycorrhiza; A3B2 – 50% Fertilizer Rate x MykoVam; A3B3 – 50% Fertilizer Rate x MykoRich)
Figura 1. Concentração de potássio trocável no solo plantado com milho doce aplicado com inoculantes micorrízicos e doses variadas de fertilizantes na colheita (A1B1 - Taxa de Fertilizante 100% x Sem Micorrizas; A1B2 – Taxa de Fertilizante 100% x MykoVam; A1B3 – Taxa de Fertilizante 100% x MykoRich; A2B1 – Taxa de fertilizante de 75% x Sem micorriza; A2B2 – Taxa de fertilizante de 75% x MykoVam; A2B3 – Taxa de fertilizante de 75% x MykoRich; A3B1 – Taxa de fertilizante de 50% x Sem micorriza; A3B2 – Taxa de fertilizante de 50% x MykoVam; A3B3 – Taxa de fertilizante de 50% x MykoRich).

4. DISCUSSION

According to the published research by Qiu et al. (2021), they discovered that the presence of AMF greatly reduced soil N and P losses, with soil NO_3-N losses being significantly reduced by 32%, total P losses by 21%, available P losses by 16%, and N_2O losses by 10%. However, identifying the AMF inoculum, plant type, and soil biotic and abiotic variables all impacted the mitigating effects of AMF on soil N and P loss. The mitigating benefits of AMF generally increased with rising AMF root colonization rate, microbial variety of inoculants, soil organic carbon (SOC) content, experimental duration, and lowering soil sand contents and soil N and P availability. Present findings were documented in another study by O'callaghan et al. (2022).

There was no significant difference in sweet corn applied with varied fertilizer rates for the extractable phosphorus. The values range from 13.98 ppm (A3 - 50% Fertilizer Rate) to 16.40 ppm (A2 - 75% Fertilizer Rate). Mycorrhizal inoculants, on the other hand, affect the extractable P on sweet corn across varied fertilizer rates. MykoVam (B2) had the highest extractable P with 17.67 ppm, while MykoRich (B3) and No Mycorrhiza (B1) had the lowest and comparable extractable P with 14.80 ppm and 14.17 ppm, respectively. The treatment combination did not affect the extractable P as the values ranged from 12.64 ppm (A3B3 - 50% Fertilizer Rate x MykoRich) to 19.40 (A2B2 - 75% Fertilizer Rate x MykoVam).

There was no significant variation in exchangeable potassium on sweet corn applied with varied fertilizer rates, as the values ranged from 288.67 ppm (A1 - 100% Fertilizer Rate) to 334.33 ppm (A2 - 75% Fertilizer Rate). Similarly, mycorrhizal inoculants did not affect the exchangeable K on sweet corn across varied fertilizer rates. The exchangeable K ranges from 301.67 ppm (B1 - No Mycorrhiza) to 330.67 ppm (B2 - MykoVam). However, a significant difference was observed in the treatment combinations. 75% Fertilizer Rate x MykoRich (A2B3) and 75% Fertilizer Rate x MykoVam (A2B2) had the highest and comparable exchangeable K with 354.00 and 348.00 ppm, respectively. On the other hand, 100% Fertilizer Rate x No mycorrhiza (A1B1) had the lowest exchangeable K with 264.00 ppm.

5. CONCLUSION

Based on the observations above, the following conclusions are reached: soil planted with sweet corn mycorrhized with MykoVam and MykoRich increases the nitrogen concentration in the soil. Similarly, MykoVam also increases the extractable phosphorus. Finally, a 75% Fertilizer Rate combined with either Mykorich or MykoVam increases the available potassium concentration. Thus, it is recommended to apply MykoVam or MykoRich to increase the available N and P concentration and to apply MykoRich or MykoVAm when fertilizer rates are reduced to 75% to increase the available potassium concentration in the soil.

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Acknowledgments: The authors thank the Department of Science and Technology – Science and Technology Regional Alliance of Universities for National Development (DOST–STRAND) for providing financial support, which has been instrumental in the successful execution of the research.

Authors' contribution: Both authors were involved in all stages of the article and have read and agreed to the published version of the manuscript.

Financing: *Not applicable.*

Review by institutional committee: *Not applicable.*

Ethics Committee: *Not applicable.*

Data availability: Study data can be obtained by request to the corresponding author or the second author, via e-mail. It is not available on the website as the research project is still under development.

Conflicts of Interest: The authors declare no conflict of interest. Supporting entities had no role in the study's design; in the collection, analysis, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.