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The Effect of Local Mycorrhiza Isolated and Fertilization on *Zea Mays* Plant Productivity under Greenhouse Condition

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Abstract

Vesicular Arbuscular mycorrhizal (VAM) fungi play an important role in plant nutrition and plant productivity. The experiment was conducted to examine the effect of indigenous strains of mycorrhizal Fungi and fertilization on maize plant under greenhouse conditions. Soil and root samples of three crop plants (Alfalfa, sugar cane and date palm) were collected from the rhizosphere from depth 0-30cm of two different sites of Sudan(Northern State and Khartoum State). The (VAM) spores were isolated by wet sieving and decanting method. Root dry weights, plant height, root colonization, tissue phosphorus, nitrogen and potassium were significantly affected by the VAM. At P treatment root dry weight was increased by 14.3% compared to the control. Compared with the control treatment, the MD400 treatment increased maize plant height, shoot dry weight, N (%), P (%), and K (%) by 10.1%, and 37.9%, 120%, 150%, and 100% respectively. The MS400 increased, root colonization by 70% relative to control treatment. While color rating increased by N treatment by 53.8%.

Keywords: *Indigenous mycorrhiza, fertilization, zea mays*

Introduction

Maize (*Zea mays* L.), also known as Indian corn and simply as corn, is an important crop worldwide, cultivated above an area of 197.2 million hectares with a production of 1134.8 million tons during 2017, (FAOSTAT, 2019). Not only because it is the third cereal after wheat and rice and more important than either as a forage crop, but also because of its numerous uses and because of the shortage of its supply compared with the increasing demand and (Babiker, 1999). In Sudan, maize is considered a minor crop and it is normally grown in Kordofan, Darfur and Southern States in small irrigated areas in the Northern states, with an average production of about 0.697 ton/ha (Gomez and Gomez, 1984). During the last decades, the increased costs of fertilizers coupled with the progressively increasing use of chemical fertilizers are adding to the cost of crop cultivation(Ghorchiani et al., 2018). Also, chemical fertilizers are harmful when they persist in the soil and enter the food chain. Instead, an approach is adopted to introduce into the soil potential microorganism, a practice known as inoculation. The inoculants were also known as biofertilizers (Abdel-Fattah and Asrar, 2012). Several microorganisms and their association with crop plants are being exploited in the production of biofertilizers. The microorganisms, which are potential biofertilizers, are symbiotic and non-symbiotic nitrogen fixing microorganisms, phosphorous solubilizing microorganisms, silicate bacteria and mycorrhizal fungi (Faye et al., 2013). The potential uses of biofertilizers in agriculture play an important role in providing an economically viable level for achieving the ultimate goal to enhance economical crops productivity. (Elhassan et al., 2010). Investigations in Sudan showed that plant inoculated with mycorrhizal fungi enhance nodule formation and dry matter (Mahdi et al., 2004). Also (Ahmed and Elsheikh, 1998). Mycorrhizal inoculation significantly increased nodule number, nodule dry weight, flower set, pod production and seed yield compared to non-mycorrhizal plants under both watering regimes. Other studies by (Ahmed and Elsheikh, 1998). However, work on maize improvement in Sudan is limited and only three cultivars have been released. These are var.113, a selection from local material; Giza 2 and Mogtamaa 45.

The objectives of this study was to test indigenous mycorrhizal fungi isolated from Sudanese soils associated with the most crops of economic importance and to test the efficiency of the isolates in improving the yield of *Zea mays* plant.

Materials and methods:

Soil samples collection:

Soil and root samples of three crop plants (Alfalfa, sugar cane and date palm) were collected from the rhizosphere from depth 0-30cm of two different sites of Sudan. Northern State and Khartoum State. Five replications were made for each collection site. Soil samples with roots of respective plant species were collected and placed in plastic bags and kept refrigerated at 4^0C until used.

Isolation of VAM spores:

The Vesicular Arbuscular Mycorrhizae (VAM) spores were isolated by wet sieving and decanting method (Gerdemann and Nicolson, 1963). Fifty grams of representative soil sample were drawn from each site and suspended in 1000 ml of tap water and stirred thoroughly. The suspension was allowed to stand for 15 minutes and then passed through a series of sieves of 1 mm size, 500µm, 250µm, 125µm, 53 µm and 45 µm arranged in descending order of their mesh size. The spores on the six sieves were transferred to a 250 ml conical flask.

Inoculation of VAM spores:

Trap culture:

For propagation of the isolated spores, an experiment was conducted at the College of Agricultural Studies, Sudan University of science and technology. Sudan grass was planted in sandy soil washed by hydrochloric acid. Eighty seeds were surface sterilized by H_2O_2 (30%) for 15 minutes. The inoculums which had been isolated from plants and trees (Date palm, alfalfa, sugarcane) was used at the rate of 3000 spores for each and inoculated pots. A nutrient solution (Ashiton,40%) was added to the soil every week. Five replications were made or each treatment. The experiment duration was three months.

Greenhouse experiment:

The study was conducted in a greenhouse, at Sudan University of science and technology, college of agricultural studies. (LAT: 15º 40'N, LONG: 32º 32'E, and ALT.: 380 M). The temperature was adjusted at 20 °C during the night and 25 °C during the day. Relative humidity was maintained constantly at 55 %. Seeds of zea maize (Hidiba1) variety were, obtained from The Agricultural Research Corporation (Wad Medani Station), were surface sterilized by H_2O_2 (30%) for 15 minutes and washed three times by sterile water. The sterilized seeds were then transferred to petri dishes and incubated at 30 ^{o}C for two days using an incubator model (LIB030M). Eight seeds were aseptically added per pot. The plants were grown in black plastic bags (20cm diameters, five-kilogram capacity) filled with 4kg of sterilized soil. Drainage holes were made in the bottom of the bags using a sterile needle. The pots were irrigated immediately with sterile tap water. For sterilization, the top soil was sieved using a 2- mm mesh sieve and then steam sterilized at 121^o C and 15bar/inch^2 pressure, for 2 hours using the autoclave to eliminate native arbuscular mycorrhizal fungi propagules as well as other microorganisms. Seeds were placed at 5-cm depth from the soil surface for all treatments. For the AMF treatments, 200g and 400g of the appropriate AMF inoculum was placed in the soil over which the seeds were planted as described by (Azcón et al., 1991). For the fertilizers treatments, urea and superphosphate were used at the recommended dose (Abdelgadir et al., 2010). Control without fertilization with either nitrogen or phosphorus were included.

Soils were maintained at moisture holding capacity by periodically adding water. Pots were randomized in the greenhouse by repositioning once a week. The duration of experiment was three months.

At harvest, plants colors were rated and plant height measures were taken. Also, root dry weight, top dry weight and root colonization were done. Each treatment was replicated three times in a completely randomize design. The program used in statistical analysis is (SAS) statistical analysis system software version 9.0. (Yuan, 2010)

Results

Table (1): Chemical and physical properties of the soil used in the study of greenhouse experiment:

Soil property	value
ECe (dS/m)	1.4
pH(Paste)	7.7
Na (Meq/l)	12
K(Meq/l)	0.3
Ca+Mg (Meq/l)	7.5
CO_3 (Meq/l)	0.0
HCO_3 (Meq/l)	3.4
Cl (Meq/l)	0.08
SO_4 (Meq/l)	16.4
P (ppm)	2.7
N (%)	0.04
O.C (%)	0.7
C/N	17
Sand%	11
Silt%	34
Clay%	54
Texture class	Clay soil
SAR	6

Table 1 shows the chemical and physical properties of the soils used in the experiment. The other measured plant traits were tabulated in tables 2 and 3.

Table (2) the effect of isolate indigenous mycorrhiza fungi and chemical fertilizers on maize plant high, shoot dry weight, root dry weight, root colonization and color rating

Treatments	Plant height (cm)	Top dry weight gm/plant	Root dry weight gm/plant	Root colonization %	Color rating
MS200	82.3^{e}	1.26^{de}	0.6^{cd}	65.0^{a}	2.3^{b}
MD200	83.6^{de}	1.26^{de}	0.76^{ab}	69.0^{a}	2.6^{b}
MA200	82.0^{e}	1.13^{df}	0.6^{cd}	61.0^{a}	2.6^{b}
MS400	83.6^{de}	1.3^{bc}	0.5^{d}	70.0^{a}	2.3^{b}
MD400	95.0^{a}	1.6^{a}	0.76^{ab}	56.0^{a}	3.0^{b}
MA400	90.3^{b}	1.4^{b}	0.6^{cd}	68.0^{a}	2.3^{b}
P	87.0^{c}	1.2^{de}	0.8^{a}	0.0^{b}	3.0^{b}
N	89.0^{bc}	1.0^{f}	0.7^{bc}	0.0^{b}	4.0^{a}
Ck	86.3^{cd}	1.16^{de}	0.7^{bc}	0.0^{b}	2.6^{b}
LSD	2.8	0.1	0.1	30.0	0.8
CV	1.9	5.6	11.0	26.0	16.9

Means with the same letter within the same column are not significantly different at $P \leq 0.05$.

MS200: Indigenous mycorrhiza isolate from Sugar cane (200g/pot), MD200: Indigenous mycorrhiza isolate from Date palm (200g/pot), MA200: Indigenous mycorrhiza isolate from Alflfa (200g/pot), MS400: Indigenous mycorrhiza isolate from sugar cane (400g/pot), MD400: Indigenous mycorrhiza isolate from Date

palm (200g/pot), MA400: Indigenous mycorrhiza isolate from Alfalfa(400g/pot), P: Recommended dose of superphosphate, N: Recommended dose of urea and C: Control w/o inoculation w/o fertilization.

Table (3) the effect of isolate indigenous mycorrhiza fungi and chemical fertilizers on plant content of total nitrogen, phosphorus and potassium.

Treatments	N%	P%	K%
MS200	1.2^{d}	0.0001^{e}	0.005^{bc}
MD200	2.1^{b}	0.0003^{bcd}	0.009^{ab}
MA200	1.5^{c}	0.0002^{ed}	0.009^{ab}
MS400	1.3^{cd}	0.0001^{e}	0.006^{abc}
MD400	3.3^{a}	0.0005^{a}	0.01^{a}
MA400	2.0^{b}	0.0004^{b}	0.006^{abc}
P	1.5^{c}	0.0003^{bc}	0.005^{bc}
N	3.3^{a}	0.0002^{cd}	0.003^{c}
Ck	1.5^{c}	0.0002^{cd}	0.005^{bc}
LSD	0.2	0.1	0.1
CV	7.6	25.2	36.6

Means with the same letter within the same column are not significantly different at P≤ 0.05.

MS200: Indigenous mycorrhiza isolate from Sugar cane (200g/pot), MD200: Indigenous mycorrhiza isolate from Date palm (200g/pot), MA200: Indigenous mycorrhiza isolate from Alflfa (200g/pot), MS400: Indigenous mycorrhiza isolate from sugar cane (400g/pot), MD400: Indigenous mycorrhiza isolate from Date palm (200g/pot), MA400: Indigenous mycorrhiza isolate from Alfalfa(400g/pot), P: Recommended dose of superphosphate, N: Recommended dose of urea and C: Control w/o inoculation w/o fertilization.

Discussions

Plant height:

The statistical analysis showed highly significant differences between treatments at

(P≤ 0.05), the highest was recorded at the MD400 treatment (95cm/plant), followed by MA400 (90cm), urea (89cm/plant), superphosphate (87cm), control (86.3cm), MD200 (83.6cm), MS400 (83.6cm), MS200 (82.3cm), MA200 (82.0cm), this results agree with (Elhassan *et al.*, 2010). As shown in table (2)

Top dry weight:

The statistical analysis showed that performance of the mycorrhiza inoculum tested concerning top dry weight is highly significant differences between treatments (at P≤ 0.05) (table???). The MD400 record high value top dry weight (1.6g/plant) followed by other treatments this results agree with (Mahadi, 2004). Also, results showed that was no significant differences between superphosphate and control. As shown in table (2).

Root dry weight:

The statistical analysis showed highly significant differences between treatments (at P≤ 0.05). The treatment of superphosphate record high value (0.8g/plant) followed by other treatments. These results typically with (Ahmed, 1998). also, there were no significant differences between MD400, MD200 and MA200, MA200 and MS200. As shown in table (2).

Root colonization:

The statistical analysis showed that no significant differences between plant infected by mycorrhiza indigenous isolated from some economical crops (at P≤ 0.05). As shown in table (2).

Color rating:

The statistical analysis showed that significant differences between urea fertilizer treatment and other treatments (at P≤ 0.05) also no significant differences between other treatments accept urea treatments. As shown in table (2).

The effects of mycorrhizal colonization and fertilization on total nitrogen (N) uptake by maize:

The statistical analysis revealed highly significant differences between all treatments (at P≤ 0.05). Both treatments MD400 and urea fertilizers record high percentage absorption of total nitrogen percentage per plant (3.3). It has been well documented that mycorrhizal colonization can have significant impacts on nitrogen uptake by the host plant. Followed by urea, these results agree with(Sharma et al., 2020). As shown in table (3).

The effects of mycorrhizal colonization and fertilization on phosphorus (P) uptake by maize:

The statistical analysis revealed highly significant differences between all treatments (at P≤ 0.05). The shoot phosphorus content was significantly increased by VA mycorrhiza. The best values were observed in the MD400 (at P≤ 0.05) followed by MA400 and superphosphate fertilizer. These results agree with (Wahid et al., 2016). As shown in table (3).

The effects of mycorrhizal colonization and fertilization on potassium (K) uptake by maize:

MD400 inoculum was highly significant (at P≤ 0.05) over the other treatments tested in this study, It had an average mean of 0.01%. these results agree with (El-Mesbahi et al., 2012). Although there was no significant difference among MD200 and MA200, also no significant difference between MS400 and MA400. As shown in table (3).

Conclusions:

We conclude that the mycorrhiza isolated from date palm enhanced growth of *Zea Maize* plants in the greenhouse experiment. In the greenhouse experiment, nitrogen fertilizer was superior in color rating. Potassium and phosphorus tissue content increased by indigenous mycorrhiza mixture.

References

i. *Abdel-Fattah, G.M., Asrar, A.-W.A., 2012. Arbuscular mycorrhizal fungal application to improve growth and tolerance of wheat (Triticum aestivum L.) plants grown in saline soil. Acta Physiol. Plant. 34, 267–277.*
ii. *Abdelgadir, E.M., Fadul, E.M., Fageer, E.A., Ali, E.A., 2010. Response of wheat to nitrogen fertilizer at reclaimed high terrace salt-affected soils in Sudan. J. Agric. Soc. Sci. 6, 43–47.*
iii. *Ahmed, A.E., Elsheikh, E.A.E., 1998. Effects of Biological and Chemical Fertilizers on Growth and Symbiotic Properties of Faba Bean (Vida/aha L.) Under Salt Stress. Univ. Khartoum J. Agric. Sci. 6, 150–164.*
iv. *Azcón, R., Rubio, R., Barea, J.M., 1991. Selective interactions between different species of mycorrhizal fungi and Rhizobium meliloti strains, and their effects on growth, N2-fixation (15N) and nutrition of Medicago sativa L. New Phytol. 117, 399–404.*
v. *Babiker, E.A., 1999. Effect of sowing date and plant density on growth and yield of irrigated maize (Zea mays L.) at Rahad (Sudan).*
vi. *El-Mesbahi, M.N., Azcón, R., Ruiz-Lozano, J.M., Aroca, R., 2012. Plant potassium content modifies the effects of arbuscular mycorrhizal symbiosis on root hydraulic properties in maize plants. Mycorrhiza 22, 555–564. https://doi.org/10.1007/s00572-012-0433-3*
vii. *Elhassan, G.A., Abdelgani, M.E., Osman, A.G., Mohamed, S.S., Abdelgadir, B.S., 2010. Potential production and application of biofertilizers in Sudan. Pakistan J. Nutr. 9, 926–934.*
viii. *FAOSTAT, F.A.O., 2019. Disponível em: http://www. fao. org/faostat/en/# home. Acesso em 30.*
ix. *Faye, A., Dalpé, Y., Ndung'u-Magiroi, K., Jefwa, J., Ndoye, I., Diouf, M., Lesueur, D., 2013. Evaluation of commercial arbuscular mycorrhizal inoculants. Can. J. Plant Sci. 93, 1201–1208.*

x. *Gerdemann, J.W., Nicolson, T.H., 1963. Spores of mycorrhizal Endogone species extracted from soil by wet sieving and decanting. Trans. Br. Mycol. Soc. 46, 235–244.*

xi. *Ghorchiani, M., Etesami, H., Alikhani, H.A., 2018. Improvement of growth and yield of maize under water stress by co-inoculating an arbuscular mycorrhizal fungus and a plant growth promoting rhizobacterium together with phosphate fertilizers. Agric. Ecosyst. Environ. 258, 59–70.*

xii. *Gomez, K.A., Gomez, A.A., 1984. Statistical procedures for agricultural research. John Wiley & Sons.*

xiii. *Mahdi, A.A., Nur Eldaim, A.B., Arbab, A.A., 2004. Influence of mycorrhizal inoculation, form of phosphate fertilization and atwering regime on nodulation and yield of soybean. Univ. Khartoum J. Agric. Sci.*

xiv. *Sharma, S., Gosal, S.K., Choudhary, R., Singh, R., Adholeya, A., 2020. Optical sensing and arbuscular mycorrhizal fungi for improving fertilizer nitrogen and phosphorus use efficiencies in maize. J. Soil Sci. Plant Nutr. 1–12.*

xv. *Wahid, F., Sharif, M., Steinkellner, S., Khan, M.A., Marwat, K.B., Khan, S.A., 2016. Inoculation of arbuscular mycorrhizal fungi and phosphate solubilizing bacteria in the presence of rock phosphate improves phosphorus uptake and growth of maize. Pak. J. Bot 48, 739–747.*

xvi. *Yuan, Y.C., 2010. Multiple imputation for missing data: Concepts and new development (Version 9.0). SAS Inst. Inc, Rockville, MD 49, 12.*