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Effects of mycorrhiza, organo-mineral and NKP fertilizer on the performance and post harvest quality of sweetcorn

Etukudo O.O[1,3]*, Babatola L. A.[1], Ojo O. D.[2] and Fagbola O.[1]

[1]Department of Agronomy, University of Ibadan, Ibadan, Oyo State, Nigeria.
[2]National Horticultural Research Institute, Ibadan, Oyo State, Nigeria.
[3]Kabba College of Agriculture, Division of Agricultural Colleges, Ahmadu Bello University, Kabba, Kogi State, Nigeria.

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A field experiment was carried out to assess the effects of vesicular arbuscular mycorrhiza (VAM), Organo-mineral fertilizer (OMF) and NPK (15:15:15), on the performance and post-harvest quality of sweet corn. The experiment was laid out in a split plot design with mycorrhiza as main plot and fertilizer combinations as treatments. VAM inocula were applied at a rate of 888.88 kg ha^{-1}, OMF at 2000 kg ha^{-1} and NPK (15:15:15) at 400kg ha^{-1}. Storability of the sweet corn was evaluated at open shelf (25-27°C), normal refrigeration (40°C) and deep freezing conditions (0°C). Results showed that there were significant differences ($p < 0.05$) between mycorrhiza and non mycorrhiza. Across mycorrhiza treatment, the highest yields of free corn ears were obtained with the complementary use of OMF and NPK (15:15:15). Fertilizer application had significant effect on the storage life of sweet corn, however, sweet corn stored by freezing at 0°C had the best storage properties in terms of firmness, weight loss and disease incidence.

Key words: Vesicular arbuscular mycorrhiza; sweetcorn yield; Organo-mineral fertilizer

INTRODUCTION

Sweet corn (*Zea Mays*, L.) is gradually becoming an important vegetable crop in Nigeria, since it forms a useful ingredient in the preparation of salad and other food both at home and in hotels (Akintoye and Olaniyan, 2012). It is one of the few vegetables that originated in North America. Canned sweetcorn in salads is popular in Europe. Sweet corn powder can be use as thickening agents for soup and noodles. It has a lower calorie and higher protein concentration compared to the field corn; it is also a good source of dietary fiber.

In Nigeria, sweetcorn production and utilizations have not been a viable option to farmers despite the numerous benefits and economic importance. This is due to the decline in soil fertility, which prevents optimum yield, and the short shelf life of sweet corn. Akintoye and Olaniyan (2012) noted sweet corn as a heavy feeder requiring high amount of macro nutrients. With management practices such as continuous cropping and reduced fallow periods, tropical soils can hardly support cropping without supplementations (CIMMYT 1989/90).

*Corresponding author. E-mail:lolaetukudo@gmail.com.

Although there are environmental criticisms towards the use of inorganic fertilizer (Stone et al., 1995; Dormaar and Chang, 1995; Akintoye and Olaniyan, 2012), its use is still a must (Hera, 1996), since the land is limited and the demand for higher production is pressing. Despite the global campaign towards organic fertilizers, it must be realized that their cost and other constraints frequently deter farmers from using them in recommended quantities and in balanced proportions. Hence, a judicious combination of mineral fertilizers with organic sources of plant nutrient is being promoted. In the same vein, through biological based technology, crop production can be economical and sustainable with emphases on enhanced production, through increased resource productivity on farms with limited resources in which mycorrhiza comes to play.

Food storage at all levels of production is essential since no producer will increase his production if he has no way of storing the excesses. A huge economic loss to farmers results from post-harvest produce wastages as a result of lack or insufficient storage facility. There has been a consensus by authors regarding deteriorations and post-harvest loss of fruits and vegetables in all countries (Cappellini and Ceponis, 1984; Harvey, 1978), thus, the aim of good storage facility is to reduce this waste to the barest minimum. Brecht (2004) stated that storing sweet corn at 30°C for 24 h reduced the sugar content by 60%. Although there is limited information on the post-harvest quality of sweetcorn in Nigeria, several storage techniques such as perforated package (Riad and Brecht, 2002), shrink-wrapping (Aharoni et al., 1996), modified atmosphere (Morales-Castro et al., 1994) and controlled freezing-point (Shao and Li, 2011) have been critically investigated elsewhere.

Consequently, this study was designed to evaluate the effects of mycorrhiza, organo-mineral fertilizer (OMF) and inorganic fertilizer on the performance and storability of sweetcorn under an open shelf, normal and freezer conditions.

MATERIALS AND METHODS

Pre-cropping soil sampling

Before ploughing, soil sampling was done at the depth of 15 cm and 30 cm which was assumed to be the active rooting zone for corn. Sampling was done based on the history of the land. Composite samples were taken from the plots. These were bulked and air-dried in the shade for 7 days after which the samples were grounded and thoroughly mixed. They were then sieved using 2 mm and 0.5 mm sieves. These prepared samples were analyzed for physical and chemical properties at the analytical laboratory of the International Institute for Tropical Agriculture (IITA), Ibadan, Nigeria.

Experimental design

A field experiment was conducted in the National Horticultural Research Institute (NIHORT), Ibadan Nigeria (7° 54^1 N; 7° 30^1 E), to determine the effects of mycorrhiza, pacesetter OMF (Grade A) and golden fertilizer NPK (15:15:15) on the performance and storability of sweet corn. The vesicular arbuscular mycorrhiza (VAM) was obtained from IITA, Ibadan. The variety of sweet corn used was T21035 (*Zea mays* L.) The corn was sourced from the NIHORT, Ibadan. The experiment was laid out on split plot design with a 2 x 2 x 2 factorial arrangement. Mycorrhiza inoculation formed the main plot treatment, the application of OMF and NPK (15:15:15) were sub-plot treatments with three replicates. Plot size measured 3 m x 2 m (6 m^2) and separated by 2 m alleyways between the main plots and 1 m alleyways between the sub-plots. The experimental plot was harrowed twice before planting. Plant spacing of 75 cm x 30 cm was used to give a plant population of 44, 444 plants ha^{-1}. 20 g of VAM fungal inocula were placed few centimeters below the sweet corn seedling root in each VAM fungus treatment, making up an application rate of 888.88 kg ha^{-1}. OMF at the rate of 2000 kg ha^{-1} and NPK (15:15:15) at the rate of 400 kg ha^{-1} were applied simultaneously in each fertilizer treatment. Fertilizer application was done in two splits, at 14 and 42 days after planting (DAP). Weeding was done manually at 20 and 35 DAP, subsequent weed emergences were hand pulled to ensure a weed free field.

Growth and yield assessment

Measurements on plant height, stem girth, number of leaves and leaf area were taken weekly. Leaf area was calculated according to the model given by Saxena and Singh (1965) as:

$0.75 \times \text{Length} \times \text{Width}$

Harvesting of sweet corn was done at 98 DAP when the cobs were still green.

Storage experiment

Harvested sweetcorn was stored under three storage conditions viz: ambient condition (25-27°C, RH 83%), refrigeration (4°C, RH 87%) and deep freezing (0°C, 90%). Data were collected on storage weight loss.

Loss in fresh weight (%) = Difference in weight/ Initial weight × 100

Firmness and decay or mould growth were subjectively scored. Firmness was determined by hand-feel and rated on a scale, where 1= firm, 2=moderately firm, 3=moderately soft and 4= soft. Mould growth on cobs with grains were observed and rated as 1= intact, 2= slight attack, 3= high incidence, 4=unmarketable.

Data analysis

Analysis of variance procedures were performed for all data to test treatments effects on the various parameters measured. Significant means ($p < 0.05$) were separated using Duncan's Multiple Range test (Duncan, 1955). Data were analyzed using Statistical Analysis System software, version 8.0 (SAS, 1999).

RESULTS AND DISCUSSION

Field experiment

The soil was found to be sandy loamy on textural triangle and slightly acidic (pH 6.0) (Table 1). Total N value of

Table 1. Pre-planting soil physico-chemical properties

Properties	Soil
pH (H_2O)	6.60
Total N (%)	1.08
Bray-1- P	4.93
Organic C (%)	1.80
Exchangeable cation (cmol/kg)	
K	0.11
Mg	1.50
Ca	2.00
Na	0.43
Exchangeable acidity (cmol kg^{-1})	
CEC	0.60
Mn	27.69
Fe	9.66
Cu	0.80
Zn	2.80
Particle size analysis (g kg^{-1})	
Sand	810
Silt	120
Clay	70

Table 2. Effects of mycorrhiza on the number of leaves, plant height, leaf area and stem girth of sweetcorn.

Parameter	Mycorrhiza effect	2 WAP	4 WAP	6 WAP	8 WAP
Number of leaves	Mycorrhiza	5.25[a]	5.92[a]	8.75[a]	10.75[a]
	Non-mycorrhiza	4.92[a]	5.08[a]	6.83[a]	7.50[b]
Plant height (cm)	Mycorrhiza	10.33[a]	43.08[a]	136.55[a]	167.00[a]
	Non-mycorrhiza	9.93[a]	36.50[b]	109.74[a]	133.11[b]
Leaf area (cm^2)	Mycorrhiza	36.43[a]	207.10[a]	422.68[a]	497.24[a]
	Non-mycorrhiza	32.13[a]	171.59[b]	306.78[b]	409.76[b]
Stem girth (cm)	Mycorrhiza	2.24[a]	3.75[a]	5.50[a]	7.65[a]
	Non-mycorrhiza	1.78[b]	3.23[b]	4.92[a]	5.93[b]

[ab]Means followed by the different superscripts along same column are significantly different at 5% level of probability.

1.08%, was less than the critical level of 1.15% (Enwezor et al., 1989) and the phosphorus level was found to be lower than 10-16 mg kg^{-1} critical level reported by Adeoye and Agboola (1985). The 0.11 cmol kg^{-1} obtained in this study for potassium was less than the critical level of 0.18-0.20 cmol kg^{-1} (Agboola and Obigbesan, 1975). This result suggests that the soil used for the study was very low in major nutrient elements and would respond favourably to fertilizer application.

The effect of mycorrhiza on the growth parameter is presented in Tables 2 and 3. At 2 WAP, there was significant effect of mycorrhiza inoculation only on stem girth ($p<0.05$). Leaf area and stem girth were significantly different between the inoculated and non-inoculated plants at 4, 6 and 8 WAP with mycorrhiza inoculated sweetcorn having the highest significant means throughout. Although mycorrhiza inoculation significantly affected all growth parameters, the time of expression varies. As the

Table 3. Interactive effects of mycorrhiza and fertilizer on stem girth of sweetcorn.

Mycorrhiza	Fertilizer	2 WAP	4 WAP	6 WAP	8 WAP
Mycorrhiza	NPK	2.18^{b}	3.93^{a}	5.47^{ab}	7.67^{ab}
	OMF	2.08^{b}	3.67^{b}	5.20^{bc}	7.87^{a}
	NPK+OMF	2.72^{a}	4.17^{a}	5.47^{ab}	7.67^{ab}
	Control	1.96^{bc}	3.23^{c}	5.87^{a}	7.40^{b}
Non-mycorrhiza	NPK	1.72^{cd}	3.42^{bc}	4.90^{bc}	6.00^{cd}
	OMF	1.76^{cd}	3.20^{c}	4.93^{bc}	5.80^{cd}
	NPK+OMF	2.09^{b}	3.33^{c}	5.13^{bc}	6.20^{c}
	Control	1.55^{d}	2.93^{d}	4.70^{d}	5.53^{d}

[abcd]Means followed by the different superscripts along same column are significantly different at 5% level of probability.

Table 4. Interactive effects of mycorrhiza and fertilizer on yield of sweetcorn.

Mycorrhiza	Fertilizer	Yield (kgha^{-1})
Mycorrhiza	NPK	3339.20^{b}
	OMF	2858.20^{c}
	NPK+OMF	3514.96^{a}
	Control	2781.37^{c}
Non-mycorrhiza	NPK	1842.27^{e}
	OMF	1144.43^{f}
	NPK+OMF	2418.63^{d}
	Control	971.43^{g}

[abcdefg]Means followed by the same letter in each column are not significant different by Duncan's multiple range test at 5% level of probability.

mycorrhiza effects manifestation started as early as 2 WAP on the stem girth, number of leaves did not increase significantly until 8WAP. The reason for this variation is not far from the difference in the physiological requirements of different plant parts. The reliability of VAM to enhance the P uptake of the crop has been reported to vary with length of fallow, tillage practices, soil nutrient status, fertilizer and host crop (Thompson, 1994). This was confirmed in the present study as leaf area showed appreciable increase with mycorrhiza and fertilizer treatment combinations over the plant without mycorrhiza and fertilizer. The interactive effect of mycorrhiza and fertilizer combinations on the yield of sweet corn is presented in Table 4.

Irrespective of the type of fertilizer used, sweet corn with mycorrhiza generally had more yield than their counterparts with no mycorrhiza. The significant increase in sweet corn yield for mycorrhiza-inoculated plants underscores the positive effects of VAM in plant nutrition. The reliant of plant nutrition, especially phosphorus uptake, on VAM have been documented (Howler et al., 1987; Osonubi et al., 1991; Atayese et al., 1993; Fagbola et al., 1998). Tas (2014) also reported a higher yield for sweet corn inoculated with mycorrhiza. With mycorrhiza inoculation, combination of NPK with OMF gave the highest significant yield. This result is in variance with the report of Akintoye and Olaniyan (2012) who obtained higher yield from plot with NPK relative to organic fertilizer and organo-mineral fertilizer, similar report was also documented by Paul and Beauchamp (1993). However, the better yield under the complementary use of OMF and NPK has been reported by several authors (Titiloye, 1982; Akpomudjere and Omueti, 1991; Sodunke, 1997).

Storage experiment

The three storage methods showed significant differences ($P < 0.05$) for the three post harvest indices (Table 5). While storage in deep freezer was best across the three indices used, storage under ambient condition was the worst. The result showed that loss in quality of sweet corn was greatly slowed down by storage under cold freezer conditions. Better storability of sweet corn in deep freezer than in the normal refrigerator and open

Table 5. Effect of storages methods on percentage disease incidence, percentage weight loss, and firmness of sweetcorn.

Storage method	Disease	Weight loss (%)	Firmness (1-4)
Ambient	3.50[a]	35.46[a]	2.2. 2.66[a]
Normal	2.00[b]	21.78[b]	2.45[a]
Deep freezing	1.10[c]	2.54[c]	1.10[b]

[abc]Means followed by the same letter in each column are not significant different by Duncan's multiple range test at 5% level of probability.

shelf as indicated by firmness, percentage weight loss and percentage disease incidence agrees with the report of Willis et al. (1981). The authors reported that temperature and humidity were the most important factors in the shelf life of fruit and vegetables. Also, the observed reduction in spoilage of sweetcorn due to refrigeration was in line with the report of Babatola and Olaniyi (1998).

Conclusions

Mycorrihiza inoculation and the complementary use of organo-mineral and inorganic fertilizer are very essential for enhancing soil nutrient status and increasing crop yield. Storage of sweetcorn is very important for prospects in its production, as corn stored in deep freezer was better than those in the normal refrigerator and open shelf in terms of firmness, percentage weight loss and disease incidence.

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