UNIVERSITI PUTRA MALAYSIA

INFLUENCE OF GLOMUS MOSSEASE AND NITROGEN FERTILIZATION ON GROWTH AND YIELD OF SWEET POTATO (IPOMOEA BATATAS L.)

YASSIN MOHAMED AHMED.

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INFLUENCE OF *Glomus mosseae* AND NITROGEN FERTILIZATION ON GROWTH AND YIELD OF SWEET POTATO (*Ipomoea batatas* L.)

By

YASSIN MOHAMED AHMED

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirement for the Degree of Master of Science

June 2005

DEDICATION

This work is dedicated To

My beloved young daughter Tasabeeh Yassin, who missed me for long time during this research,

To

The departed soul of my mother,

To

My small family members:

Tahani Yassin
Abdul khalig Yassin
Ammar Yassin
Zahra Taha

Abstract of thesis submitted to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Master of Science

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Chairperson : Associate Professor Radziah Othman, PhD

Faculty : Agriculture

Application of arbuscular mycorrhizae (AM) in sweet potato production can contribute to reduction of input of chemical fertilizers in a sustainable agriculture. Pot and field experiments were conducted to determine the effect of AM inoculum level, and AM inoculation with different rates of nitrogen, on growth and yield of sweet potato. A pot experiment was conducted under glasshouse conditions using Sepang Oren sweetpotato cultivar grown in unsterilized Bungor series soil, and inoculated with 0, 20, 40 and 80 g plant^{-1} of AM inoculum, consisting of *Glomus mosseae* UK118. The soil was amended with organic compost JITU Biofertilizer ® at rate of 20 t ha^{-1}, and inorganic fertilizer N, P, and K at the rate of 30 kg N, 60 kg P_2O_5 and 100 kg K_2O ha^{-1}, respectively. Results showed that AM inoculum level significantly ($p<0.05$) influenced the root colonization, but not the storage root yield. Application of 40 g plant^{-1} *G. mosseae* inoculum significantly increased the root infection, spore number and P concentration in shoot. Different levels of AM applied

showed no significant difference on storage root yield, starch content and nutrient concentrations.

A field experiment was conducted to assess the effect of AM inoculation and nitrogen fertilization rates on growth and yield of sweetpotato. Experimental plots were prepared in the UPM Integrated Farm and three levels of nitrogen fertilizer used were 0, 60 and 120 kg ha^{-1} in the form of urea in combination with two levels of AM inoculation. Inorganic fertilizers were applied at the rate of 60 kg P_2O_5 and 100 kg K_2O ha^{-1}. Sweetpotato was harvested at 120 days of growth. Results showed that application of nitrogen significantly ($P<0.05$) influenced the yield of sweetpotato. Storage root yield increased with increasing nitrogen fertilizer, and application of 60 kg N ha^{-1} and 120 kg N ha^{-1} showed storage roots yield increase of 54.1% and 83.6% respectively, compared to control treatment. The present study showed no significant effect of *G. mosseae* on sweetptoato yield, plant nutrient uptake and soil nutrient concentrations. However, the mycorrhizal inoculation significantly ($p<0.05$) influenced the root colonization and AM spore number in the soil. The highest root colonization of 44.36% was in AM inoculated plant with 120 kg N ha^{-1} fertilization rate. The highest spore number of 46 spore 10 g^{-1} soil was observed in AM inoculated treatment without N fertilization.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk Ijazah Master Sains

PENGARUH *Glomus mosseae* DAN BAJA NITROGEN TERHADAP PERTUMBUHAN DAN HASIL KELEDEK (*Ipomoea batatas* L.)

Oleh

YASSIN MOHAMED AHMED

June 2005

Pengerusi : Profesor Madya Radziah Othman, PhD

Fakulti : Pertanian

Aplikasi mikoriza arbuskul (MA) dalam pengeluaran ubi keledek boleh menyumbang kepada pengurangan input baja kimia dalam pertanian lestari. Eksperimen berpasu dan lapangan telah dijalankan untuk menilai kesan aras inokulum MA dan kesan inokulasi MA serta kadar berbezan baja nitrogen terhadap pertumbuhan dan hasil ubi keledek. Satu kajian berpasu telah dijalankan dalam rumah kaca menggunakan ubi keledek kultivar Sepang Oren pada tanah siri Bungor tidak steril dengan inokulasi 0, 20, 40 dan 80 g inokulum MA *Glomus mosseae* UK 118 bagi setiap pokok. Tanah dirawat dengan kompos organik Baja bio JITU® pada kadar 20 t ha^{-1} dan baja tak organik N, P, dan K masing-masing pada kadar 30 kg N, 60 kg P_2O_5 dan 100 kg K_2O ha^{-1}. Keputusan menunjutkan paras inokulum MA memberi kesan signifikan terhadap kolonisasi akar tetapi tidak pada hasil ubi keledek. Aplikasi dengan 40 g inokulum *G. mosseae* untuk setiap pokok memberi

kesan signifikan terhadap peningkatan jangkitan akar, bilangan spora dan kadar P dalam daun. Perbezaan paras inokulum MA juga menunjukkan tiada perbezaan yang signifikan ke atas hasil ubi keledek, kandungan kanji dan kandungan nutrien.

Satu kajian di lapangan telah dijalankan untuk mengenalpasti kesan inokulasi MA dan kadar pembajaan N pada pertumbuhan dan hasil keledek. Plot eksperimen telah disediakan di ladang bersepadu UPM Serdang dan tiga kadar baja N telah di gunakan iaitu 0, 60 dan 120 kg ha^{-1} dalam bentuk urea dengan kombinasi dua paras inokulasi MA. Baja tak organik telah diaplikasi pada kadar 60 kg P_2O_5 dan 100 kg K_2O ha^{-1}. Ubi keledek dituai selepas 120 hari pertumbuhan. Kajian mendapati paras pembajaan N memberi kesan signifikan terhadap hasil ubi keledek. Hasil ubi keledek meningkat dengan peningkatan kadar baja N dan pemberian 60 kg dan 120 kg N ha^{-1} menunjukkan peningkatan hasil sebanyak 54.1% dan 83.6% berbanding kawalan. Kajian ini menunjukkan *G. mosseae* tidak memberi kesan signifikan terhadap hasil keledek, kadar pengambilan nutrien dalam tanaman dan kandungan nutrien dalam tanah. Walau bagaimanapun, inokulasi mikoriza memberi kesan signifikan terhadap kolonisasi akar dan bilangan spora MA dalam tanah. Mikoriza arbuskul memberi kesan ketara ($P<0.05$) terhadap kolonisasi akar dan jumlah spora dalam tanah. Peratusan kolonisasi tertinggi 44.36% didapati pada rawatan 120 kg N ha^{-1} dengan MA. Bilangan spora tertinggi 46 spora 10 g^{-1} tanah didapati dalam rawatan mikoriza tanpa pembajaan N.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF ABBREVIATIONS

AM	: Arbuscular Mycorrhiza.
AMF	: Arbuscular Mycorrhiza Fungi.
ANOVA	: Analysis of Variance.
Ca	: Calcium.
CIP	: International Potato Center.
CRD	: Completely Randomized Design.
DOA	: Department of Agriculture.
ECM	: Ectomycorrhiza.
K	: Potassium.
LSD	: Least Significant Difference.
MAFF	: Ministry of Agriculture, Food and Fisheries.
Mg	: Magnesium.
MOP	: Muriate of Potash.
N	: Nitrogen.
P	: Phosphorus.
PGPR	: Plant Growth Promoting Rhizobacteria.
PSB	: Phosphate Solubilizing Bacteria.
R/S	: Root to shoot.
RCBD	: Randomized Complete Block Design.
TSP	: Triple Super Phosphate.
VAM	: Vesicular Arbuscular Mycorrhiza.
Zn	: Zinc.

CHAPTER I

INTRODUCTION

Sweetpotato *Ipomoea batatas (L.)* is ranked the fifth among the world most important food crops, with more than 133 million tones of annual production (CIP, 2005). Sweetpotato is currently grown in more than 100 countries. Most of the producing nations are situated in the tropical developing world. The increasing recognition of potential of sweetpotato has resulted intensified research to enhance its production and consumption as food for the world (Woolfe, 1992). In Malaysia sweetpotato is the second most important root crop ranked after cassava. At present utilization possibilities are somewhat limited mainly to home use and modest snack industry (Tan and Mooi, 1997). It has the potential of being transformed from minor food crop into a commercial crop. Sweetpotato is one of the cash crops with total area of 1,413.7 hectares and total production of 15,946.5 metric tones; most producing states are Johor, Perak and Kelantan (DOA, 2005).

Main problems of sweetpotato production in Malaysia are the yield decline of sweetpotato cultivars (Mooi and Tan, 2001) lack of good soil, low market price of sweetpotato yield, small hectareage and lack of mechanization of production operations (Saad, 1994). It is essential to increase sweetpotato production as a potential food, but the use of high chemical fertilizers to increase the production lead to environmental problems and contamination in land and water resources and finally deterioration of the product quality. Therefore, due to the public concern, there is increasing interest in the application of biofertilizers in agriculture. A biofertilizer such as mycorrhizal fungi can keep the balance between the high production of important crops, natural resources and environment.

Mycorrhiza*e* are symbiotic associations between the roots of most plant species and soil fungi. Bi-directional movement of nutrients characterizes this symbiosis where carbon flows to the fungus and inorganic nutrients move to the plant thereby providing a critical linkage between plant root and soil. Mycorrhizal associations between fungus and plant root are ubiquitous in the natural environment (Smith and Read, 1997). The arbuscular mycorrhizal association is the most ancient and most common and probably aided the first land plants (Simon et al., 1993).

Mycorrhiza may give an advantage to the plant group with a tendency to efficiently exploit a given soil volume by accessing nutrients outside of the roots' nutrient depletion zone (Campbell et al., 1991). Arbuscular-mycorrhizal fungi (AMF) form symbiotic associations with most of the tropical crop plants. This fungi can improve plant growth under conditions of low fertility, confer resistance and/or tolerance of some pathogens, improve the water balance of plants and contribute to the formation of soil structure (Harikumar and Potty, 2002).

Tropical crops, such as cassava, sweetpotato and cowpea are often heavily colonized by arbuscular mycorrhiza AM fungi under natural conditions. Environmental conditions affect the formation of AM or influence the extent of root colonization.

The natural inoculum concentration of AM fungi in the soil also determines the extent of root infection (Sieverding, 1991). The quantity of mycorrhizae formed by species of AM fungi in field soils will depend on both the amount of infective hyphae and their relative competitive ability (Abbott and Robson, 1984). The length of root colonized by AM fungi at early stages of root growth is related to inoculum density (Abbott and Robson, 1984; Wilson, 1984; Giovannetti and Avio, 1986). The difference in competitive ability to form mycorrhizae may be based on antagonism (Hepper et al., 1988). Depletion of nutrients within roots (Wilson and Trinick, 1983) and carbon demand (Pearson et al., 1993).

Nitrogen is one of the most limiting elements for the plant production in tropical soils. It is the most frequently applied fertilizer in the tropics and often the only fertilizer element added to the soil. The most common nitrogen fertilizer source is urea. In the soil, urea is converted to ammonium. Ammonium fertilizer sources were reported to inhibit mycorrhizal growth more than nitrate sources (Chambers et al., 1980). However, the effects of nitrogen application on vesicular arbuscular mycorrhiza (VAM) are not consistent. They vary from one soil site to another and may depend on the availability of P (Sieverding, 1991). The uptake of many ions by plants, including NO_3^- seems to be controlled by specific demand driven mechanisms (Imsande and Touraine, 1994).

High application rates of inorganic fertilizers especially nitrogen cause pollution of water and land resources, soil acidification and increased production cost. Many studies were conducted on the AM application in agriculture, but most of the studies were on other crops. Currently there are insufficient studies on the AM application on root crops in general and specifically on sweetpotato as one of the world's potential food crops.

In view of the benefits of AM on plant growth the following studies were conducted to determine the effect of arbuscular mycorrhizal fungi (*Glomus mosseae*) inoculum density on growth and yield of sweetpotato under glasshouse condition, and to assess the effect of AM inoculation and nitrogen fertilization rate on growth and yield of sweetpotato under field conditions.

CHAPTER II

LITERATURE REVIEW

Sweetpotato

Sweetpotato *Ipomoea batatas (L.)* is ranked the fifth among the world most important food crops, with more than 133 million tonnes of annual production (CIP, 2005). It is an ancient food plant of tropical America and Pacific Islands, and several varieties of sweetpotato are now extensively cultivated in many parts of the world (Winaro, 1982). Sweetpotato is the second most important root crop in Malaysia ranked after cassava (*Manihota esculent* Crantz) grown mainly as a cash crop or subsistence crop, in small farm or home garden for the fresh food market or home consumption. Sweetpotato production in Malaysia is 15,946.5 metric ton in an area of 1,413.7 hectare, with average yield of 11 t ha^{-1} (DOA, 2005). Some sweetpotato varieties planted in Malaysia are UPMSS5 and Ubi Biru (Saad, 1994), Serdang1, Empat Bulan, Large While, Bukit Naga (Anon, 1990), Gendut, Telong, Jalomas, Kuala Bikam and Susu Lembu (Tan, 2000).

Sweetpotato is a major crop that feeds millions of people in developing world. It is especially popular among farmers with limited resources, and produces more biomass and nutrients per hectare than any other food crop in the world (Prakash, 1994). Sweetpotato is adaptable to a broad range of agro-ecological conditions and fits in low input agriculture. It is in many ways an ideal crop for farmers as it grows on low nitrogen soils, tolerates drought well, crowds out weeds, suffers relatively from few pests, and is highly productive even under adverse farming conditions. Sweetpotato is grown in more than 100 countries as a valuable source