Plant Growth-Promoting Rhizobacteria For Yield Improvement Of High Value Vegetable Crops Grown On Soilless Culture System Under Protected Environment

Halimi Mohd Saud & Mohd Razi Ismail

Faculty of Agriculture
Universiti Putra Malaysia
43400 UPM, Serdang, Selangor
Malaysia

Telephone Number of Corresponding Author: 03-89466967
E-mail of Corresponding Author: halimi@agri.upm.edu.my

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Introduction

In recent years, a substantial amount of reports have been published extolling the benefits of using Plant Growth-Promoting Rhizobacteria (PGPR) as biofetilizer for many different crops. Plants received positive growth benefits from the association with PGPR through various mechanisms which include enhancement of nutrient uptake, increasing root biomass, supplying nitrogenous compounds by fixing dinitrogen from the air, disease suppression, as antagonists for plant pathogens and solubilization of immobilized soil phosphorous (Doberiener et al., 1987). The PGPR that have been studied includes the genera Azospirillum, Azotobacter, Clostridium, Bacillus, Enterobacter, Klebsiella, Pseudomonas and Serratia (Belandreau, 1983). Many of these PGPR will increased plant growth and vigour and have been reported locally to benefit oil palm (Amir et al., 2000), bananas (Mia et al., 2001) and pineapples (Halimi et al, 2002).

In Malaysia, the demand for vegetables is increasing annually and it is estimated that the amount required for consumption increased to 600,000 tonnes in the year 2000. Most of the vegetable crops supplied to the market are planted conventionally in Cameron Highlands and other highland areas and in the lowlands using high amount of chemical fertilizers, frequently under protected environment or rain shelter. The amount of chemical fertilizers used is also increasing to produce higher crop yield thus intensifying the problems of environmental pollution from excessive use of chemicals. Many consumers keenly felt the problems of soil and ground water pollution from the excessive use of chemical fertilizers and pesticides. Hence there is a growing demand for vegetables grown organically which can fetch a premium price. PGPR inoculants can be a viable alternative to using chemical fertilizers and thus this study was carried out to determine the benefits of using PGPR for high value vegetable crops that include tomatoes (*Lycopersicon temulentum*), sweet pepper (*Capsicum annum*) and Japanese cucumber (*Cucumis sativus*).

Materials and Methods

PGPR inoculants: Three species of PGPR inoculants were used i.e. *Azospirillum brasiliensis* Sp7, *Bacillus sphaericus* UPMB10 and *Agrobacterium rhizogenes* UPMB 1001. Sp7 and UPMB10 was grown in Okon media using a shaker incubator for 48 hours at 25°C until it reached a cell density of 1×10^7 c.f.u. mL^{-1}, whereas UPMB1001 was grown in nutrient broth under similar conditions to obtain the same cell density prior to use as inoculant. Estimation of cell density was made using standard curve and readings using spectrophotometer.

Tomatoes, Japanese cucumber and Sweet pepper. Tomatoes and Japanese cucumber were grown from seeds and transferred to polybags containing soilless culture media. The treatments used in the experiment were single inoculants of Sp7, UPMB10 and UPMR 1001 and a mixed inoculant of all three bacteria. Additional experiment included the used of different chemical fertilizer concentration of 1.5, 3.0 and 6.0 mS cm^{-1} for tomatoes. For sweet pepper, similar inoculation treatments were given as for tomatoes and Japanese cucumber except that an extra treatment was use to include mycorrhiza and fertilizer concentration was used only at 3.0 mS cm^{-1}. For control, plants were not treated with any bacterial or mycorrhizal inoculants but given the standard chemical fertilizer based on Cooper's nutrient solution. Five replicate plants were used for each treatment.

Cultivation media and growth of plants. All plants were grown in polybags containing three kg of a 3:1 peat:coir dust admixture. The plants were placed as rows inside the glasshouse which was well-ventilated. Watering and fertilization was done via drip irrigation/fertigation with each polybag receiving 15 minutes of watering and the time increased as the plants mature. Plants were harvested when the fruits matured and data were taken based on plant weight, height, root biomass and fruit yield. Other physiological characteristics such as stomata conductance and chlorophyll content were also recorded.

Results and Discussion

The study showed some interactions between inorganic fertilizer concentration and and PGPR on the growth and yield of tomatoes. The highest plant dry weight was obtained when UPMB10 and Sp7 was used with 3.0 and 1.5 mS cm^{-1} of fertilizer respectively. The highest root dry weight was obtained with Sp7 and 3.0 mS cm^{-1} fertilizer and UPMB10 with 6.0 mS cm^{-1} of fertilizer. The results showed that the presence of Sp7 and UPMB10 can promote the growth and yield of tomatoes. The best fresh fruit yield (51.0 g $plant^{-1}$) was obtained with Sp7 and 3.0 mS cm^{-1} fertilizer concentration. Similarly, fruit yield in Japanese cucumber also showed a positive trend in terms of number and fruit weight when PGPR was used. Stomata conductance increased in Japanese cucumber whilst photosynthetic activity and chlorophyll content in sweet pepper showed a significant increase over control. However the results on fruit yield for sweet pepper could not be properly documented due to a heavy infestation of insects resulting in uneven and premature fruit setting. The leaves were severely attacked and showed viral-like infections. Viral infection via insect vectors was suspected. From these studies we can confirm the beneficial effects of selected microbial inoculants, which has also been reported for other plants such as oil palm, bananas and soybean. This study was quite simplistic in its approach since the main objective was to determine if any of the PGPR could benefit and showed positive response of vegetables grown under protected environment using soilless culture media. The use of soilless culture media means that plants are naturally deprived of the indigenous microbial flora that is present when conventional soil media is used. Hence inoculation with PGPR will alleviate any detrimental effects of depriving vegetable crops of the natural microbial flora. The use of PGPR is also a means of providing alternative fertilizer source since cultivation of vegetable crops under similar environment is dependent on expensive inorganic fertilizer input. The use of PGPR inoculant can also be part of an organic farming technology for producing organically grown vegetables.

Conclusions

PGPR inoculants could enhance the growth of selected high value vegetable crops grown on soilless culture media under protected environment agriculture. PGPR can be a potential biofertilizer to replace or supplement the use of expensive inorganic fertilizer.

Benefits from the study

The study has shown that several PGPR isolates can be used as biofertilizers of vegetable crops grown in soilless culture under protected environment. Besides promoting growth, the biofertilzers can reduced the use of chemical fertilizers and has the potential for used in the cultivation of organically grown high value vegetable crops.

Patent(s), if applicable:

Nil

Stage of Commercialization, if applicable:

Nil

Project Publications in Refereed Journals:

Nil

Project Publications in Conference Proceedings

1. Halimi Mohd Saud, Raffidah Zakaria and Mohd Razi Ismail (2000). Growth Responses of Tomatoes (*Lycopersicon esculentum* Mill.) Under Protected Environment to Rhizobacterial Inoculation. Transactions of the Malaysian Society of Plant Physiology Vol. 9. p 235-239

2. Halimi Mohd Saud, Raffidah Zakaria and Mohd Razi Ismail (2000). Growth Performance of Tomatoes In Soilless Culture System to PGPR Inoculation. Malaysian Science and Technology Congress 2000 (Symp. A) & Asia Pacific Symposium on Food Science & Nutrition 2000, Kota Kinabalu, Sabah. p 141

3. Ho Mei Kheng, Halimi Mohd Saud and Mohd Razi Ismail (2002). Physiological Responses of Sweet Pepper (*Capsicum annum*) Grown in Soilless Culture to Rhizobacterial and Mycorrhizal Inoculation. Programme and Abstract: Workshop on Environmental Stress Impact on Tropical Crops. p 21

Graduate Research

Name of Graduate	Research Topic	Field of Expertise	Degree Awarded	Graduation Year
Khor Sock Khun	Identification of a Plant Growth Promoting Rhizobacteria, *Bacillus sphaericus* (UPMB10) using PCR-based DNA Fingerprinting Technique	Molecular identification using DNA fingerprinting	Master of Science	2002

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