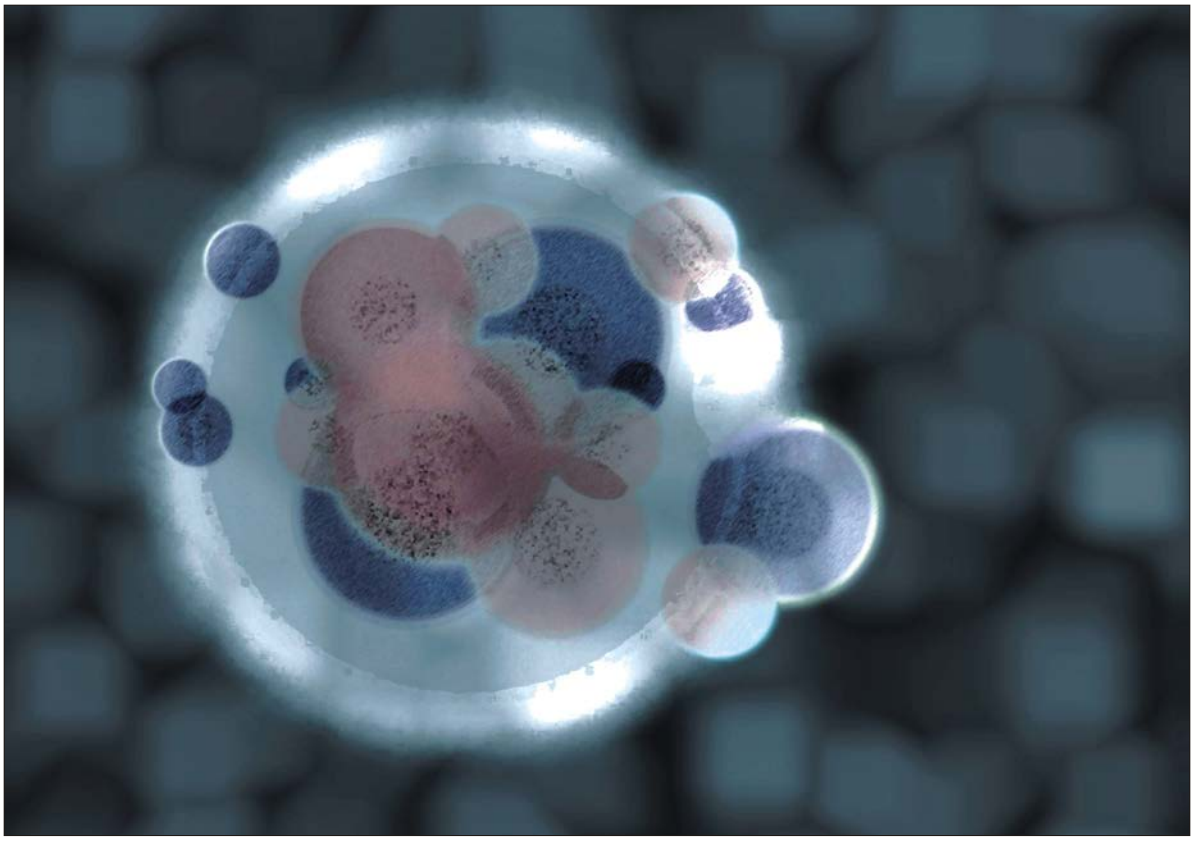

Journal of Biological Sciences

ISSN 1727-3048

science alert

ANSInet
an open access publisher
http://ansinet.com

Journal of Biological Sciences 7 (2): 421-424, 2007
ISSN 1727-3048

Effect of PGPR Inoculation on Growth and Yield of Sweetpotato

Farzana Yasmin, Radziah Othman, Kamaruzaman Sijam and Mohd Said Saad
Faculty of Agriculture, Universiti Putra Malaysia
43400 UPM Serdang, Selangor, Malaysia

Abstract: A field study was conducted to determine the effects of different local strains of PGPR and nitrogen fertilizer on growth and yield of sweetpotato. Four PGPR strains (*Klebsiella* sp. UPM SP9, *Erwinia* sp. UPM SP10, *Azospirillum brasilense* SP7 and *Bacillus sphaericus* UPMB 10) and a non-ninoculated control and three levels of nitrogen fertilizer (0, 33 and 100 kg N ha^{-1}) were used. Plants were grown for 110 days and plant biomass, storage root yield, nutrient concentrations of both storage root and plants parts were determined. Plants inoculated with the PGPR together with 1/3 of the normal rate (33 kg N ha^{-1}) gave the highest storage root dry weight compared to non-inoculated control plants. Inoculation also increased the concentrations of N, P and K in shoots and storage root. The experiment indicated that PGPR could be used as bioenhancer and biofertilizer for sweetpotato production at reduced rates of N fertilization.

Key words: Sweetpotato, PGPR, nitrogen fertilizer, growth, yield

INTRODUCTION

Sweetpotato is one of the most important root crop in Malaysia. It has potential carbohydrate source for man and feed stuff for livestock. It also serves as snack food and dessert preparations (Tan, 2000). Sweetpotato form a subsistence or cash crop and can be greater industrial application, i.e., transforming its use into raw materials for processing other products especially for food industries. For high production of root yield, fertilization is important. However, the high inorganic fertilizer input contributes significant effect to the production cost and environment pollution (Blamey, 1996). Therefore, due to the public concern of uncontrolled used of chemical fertilizers, there is increasing interest in the use of biofertilizer for sustainable agriculture. The use of biofertilizer such as Plant Growth-Promoting Rhizobacteria (PGPR) can reduce the application of inorganic fertilizers and environment pollution. Application of PGPR has been known to positively influence growth and yield of several field crops (Okon and Labandera-Gonzales Carlos, 1994). Earlier reports have shown that PGPR can improve the growth of sweetpotato (Radziah and Zulkifli, 2003; Saad *et al*., 1999). Several species of rhizobacteria inhabiting the rhizosphere that could be utilized for sweetpotato production. These bacteria enhance plant growth through mechanisms like asymbiotic nitrogen fixation and the production of phytohormones, such as Indole-3-Acetic Acid (IAA), that contribute substantial amounts of nitrogen to plant nutrition, promote growth and enhance the uptake of minerals (Kumar *et al*., 2002; Glick *et al*., 1999). However, there is insufficient study of these bacteria as biofertilizer for sweetpotato production. Therefore the following studies aimed to assess the effect of different local strains of PGPR and nitrogen fertilizer on growth and yield of sweetpotato under field condition.

MATERIALS AND METHODS

Sepang Oren sweetpotato variety cuttings were inoculated with four PGPR strains (*Klebsiella* sp. UPM SP9, *Erwinia* sp. UPM SP10, *Azospirillum brasilense* SP7 and *Bacillus sphaericus* UPMB 10) and non-inoculated control. All bacteria isolated locally except *Azospirillum brasilense* SP7 which was originally obtained from Empresa Brasileira de Pesquisa Agropecuaria (EMBRAPA), Brazil. Three levels of nitrogen fertilizer (0, 33 and 100 kg N ha^{-1}) were given to each bacterial treatment. All plants received 80 kg P_2O_5 ha^{-1} and 120 kg K_2O ha^{-1} in the forms of Triple Super Phosphate (TSP) and Muriate of Potash (MOP), respectively and organic compost was applied at the rate of 20 t ha^{-1} one week before planting. Plants were grown on sandy clay soil at the University Putra Malaysia experimental plot in a randomized complete block design with four replications. Two day old cultures of the rhizobacterial isolates were inoculated with respective treatments at planting and one month after planting for maximum colonization.

At 110 days of growth plant were harvested, the fresh weight of the above ground biomass, storage roots fresh weight, storage roots yield and nutrient contents of both storage root and plants parts were determined. The plant

Corresponding Author: Farzana Yasmin, Faculty of Agriculture,
Universiti Putra Malaysia 43400 UPM Serdang, Selangor, Malaysia

parts and storage root slices were then dried in the oven at 70°C till a constant weight reached and the dry weights measured. Dried shoot and storage root samples were ground using mechanical grinder with 0.5 mm sieve and digested by concentrated sulphuric acid (H_2SO_4) and hydrogen peroxide (H_2O_2) using Block Digestion following the Kjeldhal method (Bremner, 1996). N, P and K were determined using an Autoanalyzer (AA), while Ca and Mg were analysed by Atomic Absorption Spectrophotometer (AAS). Data were analyzed by analysis of variance using of the Statistical Analysis System (SAS, version 6.12, 1989). Mean separation showed by Tukeys Studentized Range test (p = 0.05).

RESULTS AND DISCUSSION

Plant growth: Results showed that there was a significant response of PGPR inoculation, N fertilization and interaction of both factors on shoot and storage root dry weight. PGPR inoculation improved the growth parameters compared to the non-inoculated control plants (Table 1). Inoculated plants with N fertilizer produced significantly ($p<0.05$) higher growth parameters when compared with plants non-inoculated without N fertilizer. *Klebsiella* inoculation with 33 kg N ha^{-1} produced the highest plant growth. The inoculation process also enhanced plant growth of the sweetpotato which could be related to enhancement of root growth and higher nutrient uptake. Nitrogen fertilizer is one of the main factor that affects the shoot and root growth of the sweetpotato (O' Sullivan, 1997). Previous studies showed that the use of nitrogen in combinations with PGPR produced significantly higher plant growth than those from fertilization alone under field condition (Chela *et al*., 1993).

Storage root yield: PGPR inoculation and Nitrogen fertilization rate significantly ($p<0.05$) increased the storage root yield (Table 2). In general, PGPR inoculation improved the storage root weight compared to non-inoculated control, with *Klebsiella* inoculation producing the highest root yield. Application of 33 kg N ha^{-1} generally increased yield compared to 0 kg N ha^{-1} fertilizer rate and non-inoculated treatments. Yield was reduced when applied with 100 kg N ha^{-1}. Control plant without N fertilizer produced the lowest storage root yield 8.98 t ha^{-1}. Highest yield was observed in plants inoculated with *Klebsiella* and applied with 33 kg N ha^{-1} and storage root yield 19.68 t ha^{-1}. Saad *et al*. (1999) found that, inoculated sweetpotato with PGPR+1/3N_i, produced higher root yield and plant growth of sweetpotato plants than non-inoculated plants given normal rate of N fertilizer. The beneficial effect could probably be due to production of plant-growth promoting substances such as IAA and other metabolic activities by the bacteria. Plant growth promoting substances

Table 1: Effect of rhizobacterial inoculation and N fertilization rate on dry weights of Shoot and storage root

Treatments			
Bacterial isolates	N fertilizer	Shoot dry weight (g $plant^{-1}$)	Storage root dry weight (g $plant^{-1}$)
Control	0 kg N ha^{-1}	182.59^{k}	63.89^{f}
	33 kg N ha^{-1}	350.19^{fg}	114.08^{c}
	100 kg N ha^{-1}	317.78^{g}	79.44^{de}
Klebsiella sp.	0 kg N ha^{-1}	325.37^{gh}	88.52^{d}
	33 kg N ha^{-1}	543.15^{a}	141.11^{a}
	100 kg N ha^{-1}	497.18^{b}	131.66^{ab}
Erwinia sp.	0 kg N ha^{-1}	292.78^{hi}	79.63^{de}
	33 kg N ha^{-1}	477.07^{bc}	122.22^{bc}
	100 kg N ha^{-1}	390.18^{ef}	114.63^{c}
Azospirillum sp.	0 kg N ha^{-1}	234.52^{j}	69.44^{ef}
	33 kg N ha^{-1}	442.04^{cd}	119.07^{bc}
	100 kg N ha^{-1}	342.89^{g}	88.89^{d}
Bacillus sp.	0 kg N ha^{-1}	265.59^{ij}	74.63^{ef}
	33 kg N ha^{-1}	427.93^{de}	117.96^{c}
	100 kg N ha^{-1}	335.70^{gh}	88.89^{d}
Significance due to PGPR		*	*
N Fert.		*	*
PGPR * N Fert		*	*

*Significant ($p<0.05$), Means in column followed with same letter(s) are not significantly different ($p>0.05$)

Table 2: Effect of rhizobacterial inoculation and N fertilization on total storage root weight and yield

Treatments			
Bacterial isolates	N fertilizer	Total storage root weight (kg $plot^{-1}$)	Sweetpotato yield (t ha^{-1})
Control	0 kg N ha^{-1}	5.75^{f}	8.98^{f}
	33 kg N ha^{-1}	10.17^{c}	15.89^{c}
	100 kg N ha^{-1}	7.24^{de}	11.32^{de}
Klebsiella sp.	0 kg N ha^{-1}	7.91^{d}	12.36^{d}
	33 kg N ha^{-1}	12.59^{a}	19.68^{a}
	100 kg N ha^{-1}	11.81^{ab}	18.46^{ab}
Erwinia sp.	0 kg N ha^{-1}	7.13^{de}	11.14^{de}
	33 kg N ha^{-1}	10.94^{bc}	17.09^{bc}
	100 kg N ha^{-1}	10.26^{c}	16.03^{c}
Azospirillum sp.	0 kg N ha^{-1}	6.25^{ef}	9.77^{ef}
	33 kg N ha^{-1}	10.70^{bc}	16.72^{bc}
	100 kg N ha^{-1}	7.99^{d}	12.49^{d}
Bacillus sp.	0 kg N ha^{-1}	6.64^{ef}	10.38^{ef}
	33 kg N ha^{-1}	10.53^{c}	16.46^{c}
	100 kg N ha^{-1}	7.97^{d}	12.45^{d}
Significance due to PGPR		*	*
N Fert.		*	*
PGPR * N Fert		*	*

*Significant ($p<0.05$), Means in column followed with same letter(s) are not significantly different ($p>0.05$)

IAA play an important role in root elongation and shoot growth. This suggests that IAA may be partly responsible for increases in yield (Gadagi *et al*., 2004).

Nutrient concentration in shoots and storage root: There was a significant effect of PGPR and nitrogen fertilizer on N, P, K, Ca and Mg concentration in plant tissue and storage root except the storage root Ca concentration.

Table 3: The effect of rhizobacterial inoculation and N fertilization on sweetpotato shoot nutrient concentration

Treatments		Nutrient concentration (%)				
Bacterial isolates	N fertilizer	N	P	K	Ca	Mg
Control	0 kg N ha^{-1}	1.00^{f}	0.31^{f}	2.12^{g}	0.36^{de}	0.16^{e}
	33 kg N ha^{-1}	1.85^{ab}	0.39^{abcdef}	3.01^{de}	0.50^{abc}	0.25^{bcde}
	100 kg N ha^{-1}	1.58^{cde}	0.35^{def}	2.77^{ef}	0.44^{cd}	0.16^{e}
Klebsiella sp.	0 kg N ha^{-1}	1.64^{bcde}	0.33^{ef}	2.80^{ef}	0.42^{cde}	0.19^{e}
	33 kg N ha^{-1}	1.82^{abc}	0.49^{a}	3.55^{ab}	0.48^{abc}	0.37^{a}
	100 kg N ha^{-1}	1.74^{abcd}	0.44^{abcd}	3.26^{bcd}	0.51^{abc}	0.30^{abcd}
Erwinia sp.	0 kg N ha^{-1}	1.52d^{e}	0.38^{cdef}	2.95^{def}	0.32^{e}	0.20^{e}
	33 kg N ha^{-1}	1.77^{abcd}	0.46^{abc}	3.54^{ab}	0.59^{a}	0.36^{a}
	100 kg N ha^{-1}	1.65^{bcde}	0.38^{cdef}	3.22^{bcd}	0.58^{ab}	0.33^{abc}
Azospirillum sp.	0 kg N ha^{-1}	1.45^{e}	0.39^{bcdef}	2.93^{def}	0.48^{bc}	0.20^{e}
	33 kg N ha^{-1}	1.90^{ab}	0.48^{ab}	3.78^{a}	0.57^{ab}	0.34^{a}
	100 kg N ha^{-1}	1.65^{bcde}	0.36^{def}	3.12^{de}	0.44^{cd}	0.24^{cde}
Bacillus sp.	0 kg N ha^{-1}	1.58^{def}	0.35^{def}	2.56^{f}	0.41^{cde}	0.22^{de}
	33 kg N ha^{-1}	1.97^{a}	0.47^{abc}	3.44^{abc}	0.55^{ab}	0.30^{abcd}
	100 kg N ha^{-1}	1.66b^{cde}	0.41^{abcde}	3.02^{de}	0.47^{bc}	0.35^{a}
Significance due to PGPR		*	*	*	*	*
N Fert.		*	*	*	*	*
PGPR * N Fert		*	*	NS	*	*

NS: Non Significance and *: Significant difference at ($p<0.05$). Means in column followed with same letter(s) are not significantly different ($p>0.05$)

Table 4: Effect of rhizobacterial inoculation and N fertilization on nutrient concentration of storage root

Treatments		Nutrient concentration (%)				
Bacterial isolates	N fertilizer	N	P	K	Ca	Mg
Control	0 kg N ha^{-1}	0.17^{f}	0.10^{f}	0.98	0.49	0.18^{g}
	33 kg N ha^{-1}	0.27^{cde}	0.16^{cde}	1.21	0.54	0.23^{efg}
	100 kg N ha^{-1}	0.25^{cde}	0.14^{de}	1.21	0.51	0.20^{fg}
Klebsiella sp.	0 kg N ha^{-1}	0.26^{cde}	0.15^{de}	1.21	0.48	0.26^{cde}
	33 kg N ha^{-1}	0.36^{a}	0.22^{a}	1.65	0.54	0.29^{bcd}
	100 kg N ha^{-1}	0.34^{ab}	0.21^{ab}	1.49	0.50	0.30^{abc}
Erwinia sp.	0 kg N ha^{-1}	0.24^{de}	0.13^{ef}	1.26	0.52	0.27^{cde}
	33 kg N ha^{-1}	0.36^{a}	0.18^{bcd}	1.59	0.52	0.33^{ab}
	100 kg N ha^{-1}	0.27^{cde}	0.17^{cd}	1.38	0.52	0.23^{efg}
Azospirillum sp.	0 kg N ha^{-1}	0.22^{ef}	0.15^{de}	1.24	0.49	0.23^{ef}
	33 kg N ha^{-1}	0.37^{a}	0.17^{cd}	1.52	0.51	0.22^{efg}
	100 kg N ha^{-1}	0.30^{bc}	0.16^{cde}	1.34	0.52	0.30^{abc}
Bacillus sp.	0 kg N ha^{-1}	0.26^{cde}	0.14^{de}	1.21	0.51	0.24^{def}
	33 kg N ha^{-1}	0.34^{ab}	0.19^{abc}	1.60	0.48	0.34^{a}
	100 kg N ha^{-1}	0.29^{bcd}	0.16^{cde}	1.39	0.51	0.30a
Significance due to PGPR		*	*	*	NS	*
N Fert.		*	*	*	NS	*
PGPR * N Fert		*	*	NS	NS	*

*Significant ($p<0.05$). Means in column followed with same letter(s) are not significantly different ($p>0.05$)

Sweetpotato shoot nutrient concentration decreased at 100 kg N ha^{-1}. Plants inoculated with PGPR and 33 kg N ha^{-1} showed higher N concentration compared to the control plants without N fertilizer (Table 3). P, K, Ca and Mg concentration showed higher with PGPR and N application of 33 kg N ha^{-1} compared to the 100 kg N ha^{-1}. The results showed that storage root N, P, K and Mg concentration increased with application of 33 kg N ha^{-1} fertilizer compared to the control. However, there is no interaction effect of PGPR inoculation and N fertilization on K and Ca concentration of storage root (Table 4). Sarig *et al.* (1988) found that growth promoting effects of PGPR inoculation are mainly derived from morphological and physiological changes of plant and enhancement of nutrient concentration in inoculated plant.

CONCLUSION

Application of local bacterial isolates at reduced N fertilization rate improved the storage root yield of Sepang Oren sweetpotato. The increase in yield could be due to the beneficial effects of the applied PGPR which stimulated root growth and enhanced nutrient uptake. There were differences in the performance of the bacterial species on growth and yield under field conditions. In

general, inoculation of sweetpotato with beneficial bacteria has the potential to increase the yield of sweetpotato and improve the healthier plant growth.

REFERENCES

Blamey, F.P.C., 1996. Corrrection of Nutrient Disorders of Sweet Potato and Taro: Fertilizers and Soil Amendments. In: Craswell, E.T., C.J. Asher and J.N. O'sullivan (Eds.), Mineral nutrient disorders of root crops in the south pacific, Australian Centre for International Agriculture Research. Canberra., pp: 91-95.

Bremner, J.M., 1996. Nitrogen-Total. In: Methods of soil analysis. Part 3. Chemical Methods, Spark, D.L., A.L. Page, P.A. Helmke, R.H. Loeppert, P.N. Sultanpour, M.A. Tabatabai, C.T. Johnsto and M.E. Sumner (Eds.), Am. Soc. Agron. Inc., Madison, Wisconsin, USA., pp: 1085-1121.

Chela, G.S., M.S. Tiwana, I.S. Thind, K.P. Puri and K. Kur, 1993. Effect of bacterial cultures and nitrogen fertility on the yield and quality of maize fodder (*Zea mays* L.). Ann. Biol., 9: 83-86.

Gadagi, R.S., P.U. Krishnraj, J.H. Kulkarni and T.M. Sa, 2004. The effect of combined *Azospirillum* inoculation and nitrogen fertilizer on plant growth promotion and yield response of the blanket flower *Gaillardia pulchella*. Sci. Hortic., 100: 323-332.

Glick, B.R., C.L. Patten, G.Holguin and D.M. Penrose, 1999. Biochemical and genetic mechanisms used by plant growth promoting bacteria. Imperial College Press. London, UK.

Kumar, N.R., V.T. Arsu and P. Gunasekaran, 2002. Genotyping of antifungal compounds producing plant growth-promoting rhizobacteria, *P. fluorescens*. Curr. Sci., 82: 1463-1466.

O'Sullivan, J.N., C.J. Asher and F.P.C. Blamey, 1997. Nutrient disorders of sweetpotato. ACIAR Monograph No. 48, Canberra.

Okon, Y. and A. Labandera-Gonzales Carlos, 1994. Agronomic application of *Azospirillum*: An evaluation of 20 years worldwide Field inoculation. Soil Biol. Biochem., 26: 1591-1601.

Radziah, O. and. H.S. Zulkifli, 2003. Utilization of Rhizobacteria for Increased Growth of Sweetpotato. In Investing Innovation, Vol.1: Agriculture, Food and Forestry, Zaharah, A.R. *et al*. (Ed.), University Putra Malaysia Press, Serdang, Malaysia, pp: 255-258.

Saad, M.S., A.S.A. Shabuddin, A.G. Yunus, and Z.H. Shamsuddin, 1999. Effects of *Azospirillum* inoculation on sweetpotato grown on sandy tin-tailing soil. Commun. Soil Sci. Plant Anal., 30(11-12): 1583-1592.

Sarig, S., A. Blum and Y. Okon, 1988. Improvement Of the water status and yield of field-grown grain sorghum (*S. bicolor*) by inoculation with *A. brasilense*. J. Agric. Sci., 110: 271-277.

SAS Version 6.12. 1989. SAS/ STAT. Guide to Personal Computers. SAS Institute Inc., Cary, North Carolina.

Tan, S.L., 2000. Problems related to yield performance decline in sweet potato in Malaysia. Paper presented in International Workshop on Sweet Potato Cultivar decline study September 8-9, 2000. Miyakopnojopand Miyazaki, Japan.