Popularization of Arbuscular Mycorrhizal (AM) Inoculum Production and Application On-farm

Sukhada Mohandas, M.J. Chandre Gowda and M. Manamohan
Department of Biotechnology
Indian Institute of Horticultural Research
Hessaraghatta, Bangalore 560 089
India

Keywords: Solarisation, starter culture, *Glomus mosseae*, plastic sheets, *Eleusine coracana*, demonstration, banana, papaya

Abstract

Beneficial effects of AM fungi as efficient scavengers of nutrients and as bio-control agents have been well established in horticultural crop production. However, the utilization of these fungi is limited by the lack of availability of inoculum in large quantity This has been a bottle neck in popularization of the fungi for large scale application. Efforts have been made at the Indian Institute of Horticultural Research, Bangalore to increase the use of this fungus in horticultural crop production at the farmers level, by introducing a system of practices. On-farm inoculum production and application methods were demonstrated in several villages close to Bangalore: Mallasandra, Tiptur, Avadesh Halli, Kesture, Srinivasapura, Veerapura, Anabe, Malur, Kithanahalli and Jettipalya. Demonstrations were carried out in three steps. First , solarisation of the soil was done by covering the soil for three weeks with plastic sheets. Starter culture of AM (*Glomus mosseae*) was applied in closely spaced rows followed by sowing of ragi *(Eleusine coracana* L.), a popular millet. Earlier studies, carried out by us, showed that ragi was a very good host for AM inoculum production. After twelve weeks, the shoots were harvested and used as the fodder. The root and the soil, dug to a depth of nine inches, were used as the inoculum. More than 3 tons of inoculum was produced in 25 square meter area. Utilisation of the inoculum in crops like banana and papaya cultivation was demonstrated to four farmers in two villages.. The farmers in all these villages were convinced about the usefulness of AM inoculum application and are training others in the production technique.

INTRODUCTION

The importance of arbuscular mycorrhizal (AM) fungi as efficient scavengers of nutrients and as bio-control agents in horticultural crop production is well known (Menge et al., 1978; Hughes et al., 1978 ; Sukhada , 1993). AM inoculum technology is limited due to difficulties in mass production and commercial distribution. Worldwide there are very few commercial companies selling AM inocula. Soil based inoculum can be produced in pots or on farm, and pot-based cultures are produced yearly by a few companies for certain target crops (Siverding, 1991). However, for fruit crops, large amounts of inoculum are required, which can be made available only using on-farm production, as soil inoculum is bulky and heavy and difficult to transport and market. Therefore it is probably better to make starter cultures available for farmers so that they can produce inoculum on their own land. An attempt was made at the Indian Institute of Horticultural Research, Bangalore to develop the inoculum production technique on farm and to demonstrate the benefit of VAM inoculation in horticultural crops such as banana and papaya.

MATERIAL AND METHODS

Demonstration of VAM Inoculum Production

Selection of farmers and villages: Farmers from 8 different villages at a radius of

Proc. XXVI IHC – Sustainability of Horticultural Systems
Eds. L. Bertschinger and J.D. Anderson
Acta Hort. 638, ISHS 2004
Publication supported by Can. Int. Dev. Agency (CIDA)

30-40 kilometers of Bangalore city who were receptive to adopting the technology were selected for demonstration of inoculum production techniques. Four farmers in two additional villages were also selected for demonstration of inoculum application to banana and papaya.

Materials Required

Polythene sheet to cover 5 x 5 m^2 land area, formaldehyde 5% solution, starter culture, certified seeds of Finger Millet (*Eleusine coracana*). Banana suckers, VAM inoculum, Papaya seeds, polybags to raise nursery.

Preparation of the Land Area for Inoculum Production

An uncultivated area near the field to be inoculated was selected, cleared of weeds and the soil was turned over several times and leveled after break-up of large soil clods. Provision was made for drainage of rain or irrigation water. Land was sterilized by solarisation or by using 5% formaldehyde drenching depending upon the preference of the farmer. Solarisation was carried out by covering the soil with a polythene sheet 150 mm thick in bright sunlight. The borders of the polythene sheet were held in place by covering them with soil. This enabled sunlight to penetrate and create a warmer temperature in the soil beneath in order to kill the pathogenic microorganisms. After three weeks the sheets were uncovered and the soil was loosened or, in the case of plots which had been treated with formaldehyde, turned over every day for up to 7-10 days till the fumes were completely expelled . A small amount of inorganic fertilizer was added at the rate of 16-16-16- mg10 kg/ha of NPK wherever the soil was very poor in nutrients. No organic manure was added. Starter cultures of AM *Glomus mosseae* obtained from a reliable source (Raukura Soil Plant Research Station, Hamilton, New Zealand), multiplied in pot culture in a glasshouse and containing a spore density of 50- 60 spores/g soil, were applied by hand in close rows at a distance of 15 cm. Ten kg of starter inoculum was used for 25 m^{-2}. Certified seeds of finger millet (*Eleusine coracana*) were sown on the inoculum in dense spacing. The plot was irrigated by hand. AM fungi multiplied on the root system of finger millet. Hygienic conditions were ensured around the field. After 12 weeks, the host plant was harvested by cutting it at ground level. Soil substrate along with the root of finger millet constituted the inoculum containing the infective propagules. Soil samples and roots were collected to assess spore count and colonization respectively in the laboratory.

Demonstration of AM Application Trials in Banana and Papaya Production Systems
Banana

Application of AM in banana and papaya crop production was demonstrated in three farmers' fields. Pits, 1m x 1m, were dug at a distance of 2 meters between plants and rows. Each pit was filled with 2 kg of neem cake at the bottom followed by 10 kg of farm yard manure, and the 250 g of AM inoculum prepared in the above manner containing 50 spores/g soil was placed on the top most layer. Banana suckers were placed on the inocula at the commonly used planting density of 2500 plants/ha and covered. The recommended basal dose of super phosphate was not applied. The recommended doses of nitrogen and potash were applied, i.e 110 g of urea and 100 g of muriate of potash per plant, four times at an interval of 60 days. Plants were irrigated normally. Uninoculated plants were separated from inoculated plants by four rows of plants grown according to the normal practice of the farmer. In total, 50 plants were maintained as treatment and as control. After two months of growth, roots were examined for colonization by the fungus. The time taken for flowers to emerge, plant height and girth were noted. The total yields of inoculated and control plants were recorded

Papaya

Papaya seedlings were raised in polybags containing 500 g of a sterilized Alfisol of pH 6.0 and with 0.72 % organic carbon. AM inoculum was mixed with the farm yard

manure, soil, sand mixture at the rate of 50 g per poly bag containing root and spores of AM fungi (*G .mosseae).* Seeds of papaya (*Carica papaya* cv Solo) were sown in each bag. In control bags, not inoculated with AM, other operations were similar. After 45 days the plants had been colonized by the fungus and were ready for transplantation in the field.

Field Planting

Pits 0.6m x 0.6m x 0.6 m were dug in the field at an inter row and inter plant distance of 2m. Pits were filled with neem cake, and farm yard manure as described for banana. 250g of AM inoculum was again added to the pits by hand in the top layer. Poly bags containing 40day old seedlings of papaya were carefully removed from the bags without causing any damage to the seedlings and placed in the pits. There were separate irrigation channels for treatment and control plots. In total, 50 plants were kept under observation in each case in three replications. Fertilizer dosages were given two months after transplanting at the rate of 250g nitrogen, 175 g (75% of the recommended dose) and 150 K per plant, banded at a radius of 0.5 m from the plant. Plant growth in terms of stem girth, plant height and flower initiation was evaluated. The total yield of the crop was recorded.

RESULTS

On-farm Inoculum Production

At all sites, host plants were well-colonized by the fungus and spore counts were good. The results obtained are for the villages (by name) Avadeshahalli, Anabe and Mallasandra. When the soil was pre-fumigated with formaldehyde, a very rich inoculum with a spore count of 40-70 spores /g soil was obtained, and in solarised soil, 50-60 spores/g soil were observed (Table 1). In an area of 25-m^2 about 4 tons of inoculum were obtained (Table 1). For soil solarised with a plastic sheet, a few spores of other AM fungal species were also present. Finger millet, having a fibrous root system, is a good host for AM colonization. The root pieces showed different stages of arbuscule and vesicle formation and bunches of spores hanging on to the hyphae .

Banana

Plants treated with AM fungi showed a marked increase in plant height and girth compared to uninoculated plants. (Table 2) Inoculated plants flowered a fortnight earlier than the uninoculated plants and were also ready for harvest earlier. The bunch weight of the plants treated with the fungus increased on an average by 2 kgs. The application of basal dose of fertilizers could probably be reduced in this cultivation system.

Papaya

Plants treated with papaya crop were 70-80% colonized with the fungus within 45 days. After transplanting in the field, the plants established very well compared to uninoculated plants. The plant height and stem girth increased by 10% in all the inoculated plants (Table 3).

DISCUSSION

The technology of VAM inoculum production was easily demonstrated in different villages around Bangalore. The transportation of the soil based inoculum is cumbersome, but interested farmers were able to move it 100 to 200 kg units. The demonstration of an on-farm production technique makes it possible for a farmer to have his own inoculum and keep multiplying it year after year in large quantity. In on-farm production, when the inoculum is dug out up to a depth of 25 cm a large pit is created, which could be filled up with fresh soil and the whole process of inoculum production repeated. To avoid the formation of pits, the inoculum could be produced on raised beds with the soil transported freshly from an outside source and the field not disturbed. Finger millet is a good host for

production of the inoculum in this part of the world where the crop forms part of the staple diet. The crop can be left to complete its cropping period of 5 months and then harvested so that the farmer reaps the benefit of both inoculum and crop production.

The benefit of AM inoculation in papaya and banana production system was reported previously by our laboratory (Sukhada, 1988; Sukhada, 1994). AM fungal inoculation in banana removes the need for a basal dose of phosphate and also provides the plants with other nutrients like K, Zn and Cu. In papaya, inoculum could be added in the nursery itself and then colonized plants could be transferred to field. Various methods of placement of AM inoculum in field have been discussed by Sieverding (1993). For each crop there is a need to standardize the inoculum placement. The demonstration of inoculation to banana and papaya crop in farmers field in the current study was successful and most of the farmers have spread the message of its effectiveness around. More and more farmers are becoming convinced of the importance of restoring soil health and are resorting to organic farming. The amount of AM starter cultures sold to farmers has increased many times since these demonstrations and coverage in local news papers.

ACKNOWLEDGEMENT

The technical assistance of Mr. Ravi Kumar and Mr. Venkateshiah is gratefully acknowledged.

Literature Cited

Hughes, M., Martin, L.W. and Breen, P.J. 1978. Mycorrhizal influence on the nutrition of strawberries. J.Amer Soc.Hort Sci. 103 (3): 179-81.

Menge, J.A., Labanaus, C.K., Johnson, E.L.V. and Plant, R.G. 1978. Partial substitution of mycorrhizal fungi for phosphorus fertilization in green house citrus. Soil Sci.Soc. Am.J. 142: 922-936.

Sieverding, E. 1991. Vesicular-arbuscular mycorrhiza Management: Technical Cooperation, Federal Republic of Germany.

Sukhada Mohandas. 1988. Response of papaya (*Carica papaya* cv.Coorg Honey Dew) to VAM inoculation. In mycorrhiza for green asia, (Eds). Mahadevan et al P.260-261 .

Sukhada Mohandas, 1993. VA mycorrhiza in vegetable production. In Advances in Horticulture. Vegetable crops: 6 (1993) Eds. K.L. Chadha and G. Kallo. Malhotra Publishing House, New Delhi, India.

Sukhada Mohandas, 1994. VA mycorrhizal fungi in banana cultivation: Mycorrhiza, biofertilisers of the future. Eds. A. Adholeya and S. Singh. TERI, New Delhi.

Tables

Table 1. Arbuscular mycorrhizal fungi production in Village Avadesha Halli with starter culture of *Glomus mosseae.*

Treatment	Number of spores of Glomus g^{-1} soil 3 months after planting *	% Colonisation in roots of finger millet 3 months after planting*
Soil fumigated with formaldehyde Avadeshhalli village Mallasandra village	 70* 40*	 70 50
Soil where only solarisastion was done Avadeshhalli village Anabe village Mallasandra village	 60 * 60 * 50*	 50 50 40
Untreated soil Avadeshhalli village Anabe village Mallasandra village	 20 15 5	 10 15 5

* Average of 20 sample counts. Significantly different from untreated control at 5% level.

Table 2. Response of banana to inoculation with AM in Doddakadathur (D) and Anabe (A) villages 30 km from Bangalore city.

Treatment	Stem girth (cm) D A	Plant height (cm) D A	Initiation of flowering (weeks) D A	Saving in fertilizers % D A	Yield kg/plant D A
Glomus mosseae inoculated	25 25	136 115	32 32	25 25	46 40
Uninoculated control	18 30	93 80	30 30	0 0	42 38
CD at 5%	2.5 3.5	17.8 11.5	5.8 2.5	- -	4.8 3.5

Table 3. Response of papaya to inoculation with VAM in Mallasandra (M) and Jettipalya (J) village 25 km from Bangalore city.

Treatment	Stem girth (cm) M J	Plant height (cm) M J	Initiation of flowering (days after planting) M J	Saving in fertilizer P % M J	Yield k kg/plant M J
Glomus mosseae inoculated	25 28	48 50	24 23	25 25	86 110
Uninoculated control	23 25	44 46	26 20	0 0	76 90
CD at 5%	3.5 2.6	4.6 3.5	3.5 2.5	- -	17 12