J Indian bot Soc Vol 76 (1997) 21-24

A PACKAGE OF MICROBIAL INOCULANTS FOR LINSEED

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(Accepted May, 1997)

A package of triple inoculants consisting of a highly efficient vesicular arbuscular mycorrhizal fungus *(Glomus aggregatum)*, a potential phosphate solubilizing fungus *(Aspergillus niger)* and an appropriate nitrogen fixer (*Azotobacter chroococcum*, SCSA 6) identified on the basis of preliminary screening was evaluated for its efficacy. Compared to single and double inoculations, the triple inoculation proved to be more beneficial to the crop.

Key Words : Package, microbial inoculants, linseed.

Presently, the use of synthetic fertilizers is being discouraged and they are being replaced by biofertilizers or microbial inoculants. Symbiotic and non-symbiotic nitrogen fixers, phosphate solubilizing microbes (PSM) and vesicular - arbuscular mycorrhizal fungi (VAMF) are being tried as microbial inoculants to the crops for offering them a better nutrition (Mosse, 1973; Gaur, 1985; Kehri and Chandra, 1994ab). Synergistic effect of nitrogen fixers and VAMF or PSM used as microbial inoculants in combination has been reported by a number of workers. However, very few attempts have been made to investigate the response of the crops to triple inoculations with a nitrogen fixer, a PSM and a VAMF. On the basis of preliminary screening *Glomus aggregatum* and *G. fasciculatum* (VAMF), *Aspergillus niger* (PSF) and *Azotobacter chroococcum* (SCSA 6) were identified as effective microbial inoculants for linseed, an important oilseed crop of India (Kehri, 1993). In the present study, a comparative efficacy of these inoculants as single, double and triple inoculations in improving the performance of linseed was investigated under greenhouse conditions and the findings are reported in the present communication.

MATERIALS AND METHODS

Response of linseed (cvs. *Shubhra* and *Garima*) to the microbial inoculants was tested in the following combinations :

1. Control (No treatment)
2. + *Azotobacter* (*A. chroococcum* SCSA 6)
3. + PSM *(Aspergillus niger)*
4. + VAMF *(Glomus aggregatum)*
5. + *Azotobacter* and VAMF
7. + PSM and VAMF
8. + *Azotobacter*, PSM and VAMF

Linseed (cvs. *Shubhra* and *Garima)* was raised in earthen pots (30 x 30 cm) filled with 8 kg of unsterilized field soil (sandy clay loam, pH 6.5, organic matter, 0.75). In single inoculation series, inocula of *Azotobacter* or PSM were provided to the crop through the seeds by treating them with culture suspensions of the inoculants (10^8 cells or conidia/ml) while VAMF through soil inoculation (Menge *et al.*, 1977). In dual inoculation series involving *Azotobacter* and PSM, the crop was raised from seeds treated with a mixture of an equal amount of culture suspensions of the two inoculants. On the other hand, in dual inoculation series involving *Azotobacter* and PSM or VAMF, the crop was raised from *Azotobacter*/PSM treated seeds in soil supplimented with inoculum of VAMF. In triple inoculation series involving *Azotobacter*, PSM and VAMF, the crop was raised from seeds treated with *Azotobacter* and PSM in soil supplimented with inoculum of VAMF. Five pots filled with the soil were left as such for collecting samples of non-rhizosphere soil.

The plants were uprooted at seedling, vegetative, flowering and fruiting stages of growth and the samples of roots and rhizosphere soils were collected. Samples of non-rhizosphere soil were also collected at the same time. The population of *Azotobacter* and PSM in the rhizosphere/non-rhizosphere soil was determined by the dilution plate and count method of Timonin (1940) employing Jensen's medium and Pikovaskyas medium respectively. The mycorrhizal

Received February, 1996

Fig. 1 A

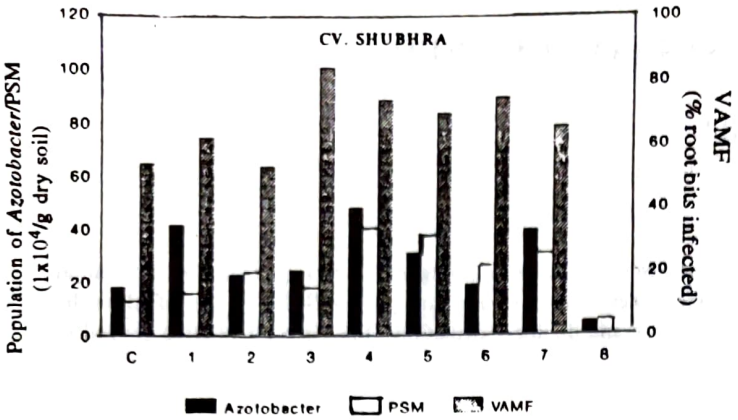


Fig. 1 B

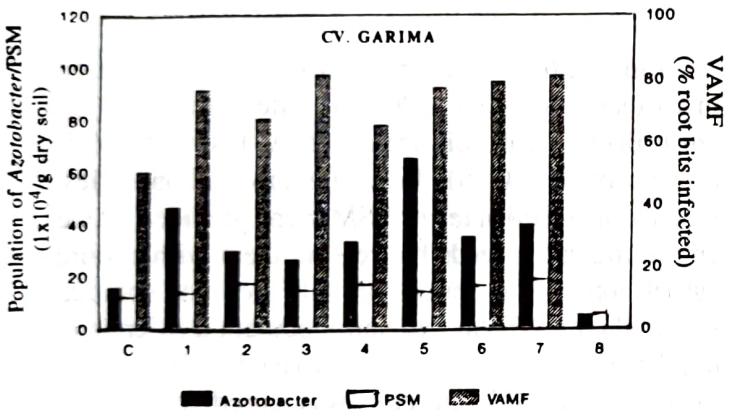


Figure 1. Population of *Azotobacter* and PSM in the rhizosphere and mycorrhizal intensity in the roots of linseed cvs. *Shubhra* (A) and *Garima* (B) as affected by integrated treatments with selected *Azotobacter*, PSM and VAMF. C: Control, 1: *Azotobacter*, 2: PSM, 3: VAMF, 4: *Azotobacter* + PSM, 5: *Azotobacter* + VAMF, 6: PSM + VAMF, 7: *Azotobacter* + PSM + VAMF, 8: Non-rhizosphere soil.

Fig. 2 A

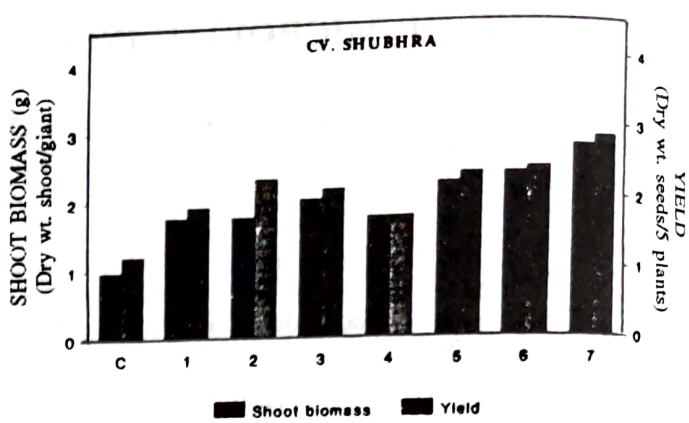


Fig. 2 B

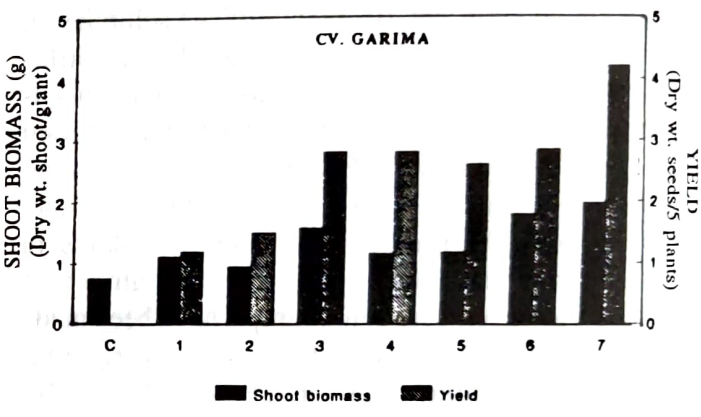


Figure 2. Shoot biomass and yield in linseed cvs. *Shubhra* (A) and *Garima* (B) as affected by integrated treatments with selected *Azotobacter*, PSM and VAMF. C : Control, 1: *Azotobacter*, 2: PSM, 3: VAMF, 4: *Azotobacter* + PSM, 5: *Azotobacter* + VAMF, 6: PSM + VAMF, 7: *Azotobacter* + PSM + VAMF.

intensity in the roots was determined following method outlined by Phillips and Hayman (1977).

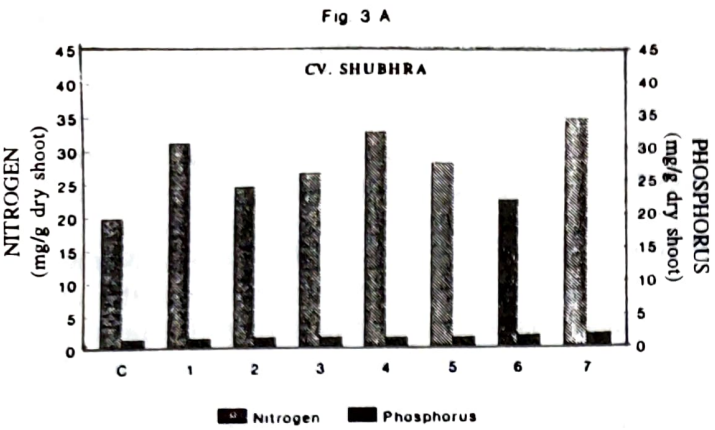
Data on biomass of shoots as well as yield was collected after harvest. The total nitrogen (Jackson, 1973) and phosphorus (Murphy and Relay, 1962) content in shoots was also determined. All the data were analysed statistically by the method of analysis of variance (Panse and Sukhatme, 1985) and critical difference (C.D.) was calculated at 5% level of significance.

RESULTS AND DISCUSSION

When used separately the *Azotobacter* inoculant caused an appreciable increase in the population of *Azotobacter* in the rhizosphere. The PSM inoculant caused a similar increase in the population of PSM while VAMF inoculant caused the same effect in the mycorrhizal intensity in the roots (Fig. 1A, B).

When used together, the *Azotobacter* and PSM inoculants caused an appreciable increase in the population of both *Azotobacter* as well as PSM in the rhizosphere. At the same time, they could improve also the mycorrhizal intensity in the roots. When *Azotobacter* and VAMF inoculants were used in combination they caused an appreciable increase in the population of *Azotobacter* and mycorrhizal intensity. At the same time, they caused a similar increase in the population of PSM. Combination of PSM and VAMF inoculants improved the population of PSM and mycorrhizal intensity significantly but caused no effect on the population of *Azotobacter*.

When all the three microbial inoculants were



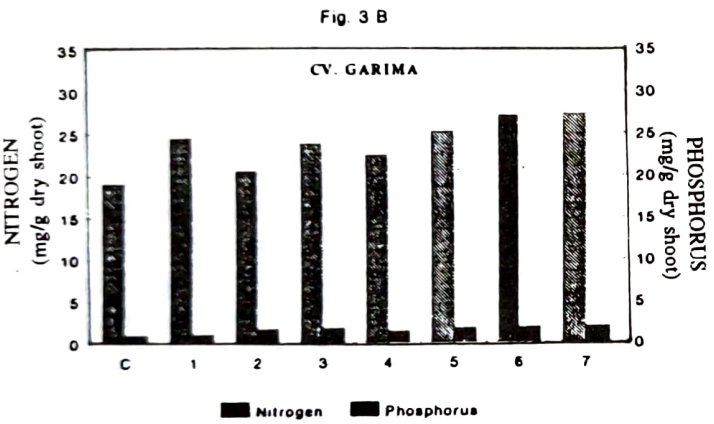


Figure 3. Nitrogen and Phosphorus content in the shoots of linseed cvs. *Shubhra* (A) and *Garima* (B) as affected by integrated treatments. C: Control, 1: *Azotobacter*, 2: PSM, 3: VAMF, 4: *Azotobacter* + PSM, 5: *Azotobacter* + VAMF, 6: PSM + VAMF, 7: *Azotobacter* + PSM + VAMF.

used together, an appreciable increase in the population of *Azotobacter* and PSM as well as in mycorrhizal intensity was recorded.

All the three microbial inoculants improved the shoot biomass, nitrogen and phosphorus uptake as well as yield when used separately (Fig. 2A, B and 3A, B). Similar improvement was recorded when they were used in combination of two as dual inoculation. However, maximum improvement in all the parameters was recorded when all the three were used together as triple inoculation. Possibly, the superiority of triple inoculation was due to uninhibited supply and improved uptake of both the important nutrients *viz.* nitrogen and phosphorus to the crop, a situation which was not available to it when it was offered single or double inoculations.

It has been indicated that the increased performance of crops due to dual inoculation of *Azotobacter* and PSM may not be solely due to better availability of nitrogen and phosphorus but also due to release of growth promoting substances by *Azotobacter* (Barea and Brown, 1974; Barea *et al.*, 1976). Phosphate solubilizing microorganisms have been shown to produce a variety of plant growth hormones and vitamins (Azcon *et al.*, 1978; Baya *et al.*, 1981). It has been suggested that the hormones and vitamins produced by PSM may also contribute to mycorrhizal development when PSM and VAM are used as components of dual inoculations.

Very few attempts have been made to study the effect of triple inoculations involving a nitrogen fixer, a phosphorus solubilizer and VAM on the growth and yield of crops. The beneficial effect in this experiment was attributed to improved nitrogen and phosphorus availability and uptake to the crop. They open up a new approach to ensure better nutrition and productivity in linseed through microbial inoculants. The package of triple inoculants may be safely transferred to the farmers after requisite field trials.

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