mixed cropping of chickpea and mustard for heavy soil of Tal land in Bihar for achieving maximum land-use efficiency.

Maintenance of Seed Purity in Nonnodulating Lines of Chickpea

O.P. Rupela, Onkar Singh, C. Sivaramakrishna, and **T.P. Rao** (ICRISAT Center)

During the course of our experimentation over the last 5 years with nonnodulating (Nod^-) lines of chickpea, we noticed occasional presence of nodulated (Nod^+) plants in the plots of Nod^- genotypes. In a low-N soil (<15 mg available-N kg^{-1} soil in top 60-cm profile), such plants were readily noticed due to their better growth. Generally 1% or less plants were found to be Nod^+ in the plots of Nod^- lines, which is unlikely to be due to genetic reversion of the trait. In an independent study, we noticed this level of contamination of desi-type seeds in the routine handling of a Nod^- kabuli line. This observation alerted us to the possibility of an increase in the proportion of Nod^+ contaminants because of their better growth, in Nod^- populations, if care is not taken to rogue out these plants. The following two methods have been employed by us to keep the Nod^- lines free of contaminants.

1. On fields with low available-N. When Nod^- lines were grown on low-N soils (but not limiting in other nutrients), the plants grew very poorly and any plant growing well was found to be Nod^+. Such plants could be easily rouged out.

2. On fields with moderate to high available-N. Nod^- plants cannot be easily differentiated from Nod^+ plants when grown on fields with >20 mg available-N kg^{-1} soil in the top 60-cm profile. To identify Nod^- plants in such fields, the plants were carefully removed from the soil at physiological maturity and their roots observed for nodulation. Seeds of the Nod^- plants were retained for further use.

Rouging is a must for the crop grown for seed multiplication for the next year. For any genetic study on nonnodulation, the plants used for crossing must be examined for nodulation at physiological maturity (Rupela, in press). Alternatively, selfed seeds of the plants used in the crosses may be separately harvested and tested for nodulation. We have supplied seeds of Nod^- lines to several researchers and recommend that they critically examine this material before further use as there could be obvious implications for genetic studies.

These suggestions do not imply that all Nod^+ plants in the Nod^- population are contaminants. At present we do not know the reason(s) for the Nod^- trait in our material. One possible reason could be the absence of a specific *Rhizobium* strain required by these lines. If so, most plants of a given Nod^- line should nodulate where adequate population of such a strain is present. We would appreciate receiving nodules and seeds of these plants from such locations. Nodules can be dried on calcium chloride vials as described by Somasegaran and Hoben (1985, P. 272) that can be mailed along with seeds of the same Nod^+ plant(s) to establish whether the Nod^- line(s) required a specific *Rhizobium* strain.

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A Method for Application of Chickpea Rhizobia over Large Areas

R.P.S. Pundir (ICRISAT Center)

Chickpea germplasm evaluations at ICRISAT Center during the 1987/88 postrainy season were planned for a Vertisol field (BS 10) where chickpea had not been grown for at least 17 years. Most probable number estimation (Toomsan et al. 1984) of chickpea rhizobia in the field prior to sowing of chickpea revealed very low *Rhizobium* numbers (<10 rhizobial cells g^{-1} of soil). Responses of chickpea to *Rhizobium* inoculation are to be expected when counts are <100 cells g^{-1} soil (Rupela and Saxena 1987). Several methods of *Rhizobium* application are recommended for chickpea, such as the liquid suspension method where peat inoculum suspended in water is applied on seeds at sowing time (Islam and Afandi 1980; Rupela et al. 1984), but they are not easy to apply over large areas. We therefore adopted the following procedure:

- To cover the 2.0 ha field, with 1 kg of peat culture containing 10^9 to 10^{10} cells g^{-1} peat of chickpea *Rhizobium* strain IC 59 was used.
- The peat culture was thoroughly mixed with about 200 kg of coarse river sand wetted with 20 L of jaggery suspension (jaggery and water in 1:20 ratio).
- In August 1987, when the field was optimally wet and suitable for harrowing, the culture coated sand was manually broadcast and the field immediately harrowed.

The chickpea plots were sown on dry soils in the 4th week of October 1987 and the field subsequently irrigated to ensure good establishment of chickpea seedlings. At 40 days after sowing, 30 random plant samples were checked for nodulation, which was noted as very good according to the scale of Rupela (1990). The procedure was repeated in another Vertisol field in 1988, and again good nodulation and growth of chickpea was achieved.

Although, for our purpose, the *Rhizobium* inoculation method described appeared to be feasible, economical, and effective, it needs to be experimentally evaluated against a noninoculated control and other possible inoculation procedures for large areas. Inoculation and mixing of rhizobia into wet soil well before sowing of chickpea may have allowed better establishment and multiplication of inoculant rhizobia than if they had been applied at sowing. This effect has also been recorded earlier (Rupela and Sudarshana, in press). This apparently successful inoculation method may be further evaluated and tried for other legume crops.

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Effect of *Glomus versiforme* Inoculation on the Yield of Chickpea at Varying N Levels

K.V.B.R. Tilak and **A. Dwivedi** (Microbiology Division, Indian Agricultural Research Institute, New Delhi 110 012, India)

Legumes have a high phosphorus requirement for nodulation, N_2 fixation, and optimal growth, and are largely dependent on mycorrhiza for the supply of phosphorus in P-deficient soils (Mosse et al. 1981; Subba Rao et al. 1982). The inhibition of vesicular-arbuscular mycorrhizal fungi (VAM) infection by high levels of phosphatic fertilizers, however, is well established (Graham et al. 1981). Hitherto available reports (Azcon et al. 1982; Bevege 1971) on the effect of various N levels on VAM colonization are feeble and contradictory. The present studies deal with the determination of effect of various N levels on nitrogen fixation and grain yield of chickpea due to VAM inoculation.

A field experiment was conducted in microplots (1.5 m × 1.25 m) separated from each other by 0.3-m wide paths. To each plot, phosphorus was added at the rate of 50 kg P_2O_5 ha^{-1} as single super phosphate. The seeds were coated with carrier based (charcoal:soil; 3:1) culture of *Rhizobium* strain C1 in all the treatments. There were four treatments, one carried no nitrogen and to remaining three, nitrogen was added at the rate of 25, 50, and 100 kg N ha^{-1} in the form of urea. Four microplots carrying different levels of N were inoculated with sand + soil (1:1) -based inoculum of *Glomus versiforme*. Two hundred and fifty grams of inoculum (125-150 spores 100 g^{-1}) carrying infected root segments of *Cenchrus ciliaris*, was spread uniformly on the microplots. For each treatment, four replicate plots were maintained.

The statistical analysis of results revealed that all the five parameters studied, i.e., percentage of VAM coloni-