RESPONSE OF MULBERRY TO CO-INOCULATION WITH AZOTOBACTER CHROOCOCCUM AND BACILLUS MEGATERIUM

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ABSTRACT

Field experiment was conducted to study the response of M-5 Mulberry (Morus alba L.) to co-inoculation with the diazotrophic Azotobacter chroococcum isolate RFB and the P solubilizing Bacillus megaterium at graded levels of N and P (75 and 100 per cent). Significant increase in leaf yield, N and P uptake was recorded in co-inoculated plants as compared to the uninoculated and individually inoculated plants. In presence of full dose of N and P (300:120 kg/ha/yr.), the combined inoculation recorded 11.43% higher leaf yield, 20.15 and 15.60 per cent increase in N and P uptake. Plants receiving 75 per cent N and P in presence of the above organisms recorded 2.4 per cent increase in leaf yield, 10.35 and 8.16 per cent more uptake of N and P respectively. The total chlorophyll content increased by 10.32 per cent in co-inoculated plants and 6.8 per cent in those receiving B. megaterium as individual inoculant. The population of B. megaterium and A. chroococcum increased by 1.97 and 2.34 folds respectively in the rhizosphere when inoculated together as compared to their individual inoculations. The results revealed a synergistic interaction between the two inoculants, which could save 25 per cent of N and P fertilizers with significant increase in leaf yield and nutrient uptake.

INTRODUCTION

The beneficial effects of nitrogen fixing and phosphate solubilizing microorganisms have been well documented (Kundu and Gaur, 1984; Gaur and Alagawadi, 1989; Somani, 1987; Somani et al., 1990; Tilak, 1991). Inoculation of soil with these micro-organisms is known to change the rhizosphere populations, consequently influencing plant growth (Dey, 1988; Saxena and Tilak, 1994). A few studies on the synergistic effects of PSMs and nitrogen fixers have revealed increased growth and yield in potatoes (Shinkina, 1961), tomatoes (Smith et al., 1961), Lavender (Ocampo et al., 1975), cotton (Kundu and Gaur, 1980, Patil et al., 1991) and wheat (Kundu and Gaur, 1982). Mulberry (Morus alba L.) is the sole food plant of silkworm (Bombbyx mori L.) and the cost of leaf production accounts for more than 50 per cent of the total cost of cocoon production. Nitrogen (N) and Phosphorus (P) are the major nutrients required by mulberry in high quantities for better leaf yield and quality, which among other factors determine the healthy growth of silkworms and cocoon yield. However, the cost is hindering their use especially by the poor and subsistence farmers. Supplementing these chemical fertilizers with microbial inoculants can save a part of the fertilizers still meeting the requirement of the plant. Individual inoculations of mulberry with Azotobacter, Azospirillum and phosphate solubilizing micro-organisms increase leaf yield (Dayakar Yadav and Nagendra Kumar, 1993; Nagendra Kumar and Sukumar, 1995; Das et al., 1992). However, studies on their combined inoculations with reference to mulberry are negligible (Subramanian, 1995). The present study embodies the results of a field experiment on combined influence of A. chroococcum and B. megaterium on leaf yield, N and P uptake in mulberry.

MATERIAL AND METHODS

The studies were conducted on five-year-old mulberry plants of the variety M-5 of
Morus alba L. grown in micro plots measuring 4.88 x 4.88 m during 2000-2002. The soil was analysed for pH, OC, EC and available P (P2O5) just before imposing the treatments by following Jackson (1973). Bacillus megaterium, a phosphate solubilizing bacterium and Azotobacter chroococcum isolate RFB, an efficient nitrogen fixing strain isolated from mulberry rhizosphere were used as lignite based inocula. They were applied at the rate of 25 and 20 kg/ha/year respectively in two equal split doses mixed with farmyard manure. The uninoculated control plots received the recommended dose of NPK fertilizers at 300:120:120 kg/ha/year while the inoculated plots were provided with 75 and 100 per cent of N and P and full dose of potassium. All the treatments received 20 tons of farmyard manure/ha/year in two equal split doses. The data on the leaf and stem yield were recorded on 55th day of growth on whole plot basis excluding the border rows. Leaf samples from five randomly selected plants of each replicate were analysed for N and P contents following Jackson (1973). The population of B. megaterium and A. chroococcum in the rhizosphere soils was enumerated on Pikovskayas and Jensen’s agar media respectively by serial dilution method.

RESULTS AND DISCUSSION

The experimental soil had a pH of 7.3, EC 0.8, OC 0.63 and available P of 32.5 kg/ha. Ten harvests were made. The data on leaf yield, N and P uptake are presented in the Table 1. Maximum leaf yield (31,824 kg/ha/year) was recorded in plots receiving both the inoculants (T9) in presence of full dose of NPK as compared to the uninoculated control (T1) and other treatments. The increase in the leaf yield was 11.43 per cent over the control. The other uninoculated treatments (T2-T4) recorded significantly lower leaf yield than the control and other inoculated treatments receiving graded levels of N and P. The plants inoculated individually with A. chroococcum (T6) in presence of 75 per cent N and full dose of P, and T8 receiving B. megaterium with 75 per cent P and full dose of N were on par with T1. However, the treatments receiving combined inoculation (T10) in presence of reduced N and P recorded significantly higher leaf yield (2.40%) over T1 but not over T9 receiving combined inoculation with full dose of fertilizers.

The N and P uptake recorded significant increase in plants combinedly inoculated in presence of full dose of fertilizers, respectively 20.15 and 13.51 per cent more as compared to T1. This was followed by plants inoculated singly with R. megaterium in presence of full dose of fertilizers which harvested 350 and 35.64 kg of N and P, an increase of 7.14 and 10.21 per cent respectively over T1. The results obtained with individual inoculations of A. chroococcum (T5) in presence of full dose of fertilizers were on par with control. On the other hand, those receiving B. megaterium either with full or 75 per cent P (T7 and T8) yielded significantly higher amounts of P (35.64 and 32.80 kg) as compared to T1 which further increased when both the organisms were used together. Although the deficiency of P in soil is met by addition of phosphatic fertilizers, the efficiency of utilization is very low due to its fixation into insoluble phosphates. This problem could be overcome to a great extent by utilizing P solubilizing micro-organisms as observed in the present study, where significant differences were recorded between B. megaterium inoculated and uninoculated plants. The population of B. megaterium and A. chroococcum increased by 1.97 and 2.34 times respectively when inoculated together (Table 2). Similar observations have been made by Ocampa et al. (1975) with respect to the population of Azotobacter and phosphobacteria in the rhizosphere, which
Table 1. Effect of combined inoculation of *A. chroococcum* and *B. megaterium* on leaf yield, N and P uptake in mulberry (average data of two years)

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Leaf yield kg/ha/yr leaf yield</th>
<th>% Increase in N uptake kg/ha/yr</th>
<th>P Uptake kg/ha/yr</th>
<th>% Increase in uptake of N and P</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 NPK (control)</td>
<td>21,100</td>
<td>236.00</td>
<td>23.00</td>
<td>-</td>
</tr>
<tr>
<td>T1 N and P 100%</td>
<td>28,560</td>
<td>325.00</td>
<td>32.00</td>
<td>-</td>
</tr>
<tr>
<td>T2 N 75 and P 100%</td>
<td>27,845</td>
<td>320.00</td>
<td>31.70</td>
<td>-</td>
</tr>
<tr>
<td>T3 N 100 and P 75%</td>
<td>27,510</td>
<td>312.00</td>
<td>31.30</td>
<td>-</td>
</tr>
<tr>
<td>T4 N 75 and P 75%</td>
<td>26,715</td>
<td>305.00</td>
<td>30.70</td>
<td>-</td>
</tr>
<tr>
<td>T5 Ac + N and P 100%</td>
<td>28,450</td>
<td>325.00</td>
<td>31.90</td>
<td>-</td>
</tr>
<tr>
<td>T6 Ac + N 75 and P 100%</td>
<td>28,530</td>
<td>327.00</td>
<td>31.10</td>
<td>-</td>
</tr>
<tr>
<td>T7 Bm + N and P 100%</td>
<td>30,845</td>
<td>350.00</td>
<td>35.64</td>
<td>+7.14 +10.21</td>
</tr>
<tr>
<td>T8 Bm + N 100 and P 75%</td>
<td>29,274</td>
<td>329.00</td>
<td>32.80</td>
<td>+1.23 +1.24</td>
</tr>
<tr>
<td>T9 Bm + Ac + N and P 100%</td>
<td>31,824</td>
<td>390.00</td>
<td>37.00</td>
<td>+20.15 +13.51</td>
</tr>
<tr>
<td>T10 Bm + Ac + N and P 75%</td>
<td>29,245</td>
<td>358.00</td>
<td>35.00</td>
<td>+10.35 +8.16</td>
</tr>
<tr>
<td>CD @ 5%</td>
<td>650</td>
<td>7.4</td>
<td>0.95</td>
<td>-</td>
</tr>
</tbody>
</table>

were always more when inoculated together than their single inoculation. The synergistic influences of nitrogen fixers and P solubilizers on growth and yield of crop plants are well documented. While nitrogen fixers benefit mulberry by providing atmospheric nitrogen phosphate solubilizers render insoluble forms of P available for absorption by the plant. Thus inoculation of crop plants with either groups of organisms benefit the plants with that particular nutrient, while their combined inoculation supply both the nutrients, provided their interaction is synergistic as observed in the present study.

The increased values of the parameters recorded in the present study clearly indicate the synergism between the two organisms in the rhizosphere. From the above studies it can be concluded that a possibility exists to save 25 per cent of N and P fertilizers in presence of *B. megaterium* and *A. chroococcum* with a substantial increase in leaf yield which enables the farmers to produced more cocoons per unit area of mulberry garden and earn more profit.

**REFERENCES**


