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Effect of Arbuscular Mycorrhizal Fungi and Balanced Phosphate Fertilization on Two Fibre Yielding Plants, *Corchorus capsularis* L. (Jute) and *Gossypium arboretum* L. (Cotton)

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ABSTRACT

Different levels of phosphate and arbuscular mycorrhizal fungal (*Glomus fasciculatum*) inoculation were carried on two fibre yielding plants. *Corchorus capsularis* L. (jute) plants grew much taller than non mycorrhizal plants in 3.0 mg Rp/kg, Sp/kg super phosphate with AM fungus *Glomus fasciculatum* inoculation significantly increased plant height, root length, and reduced per cent root colonization and spore number. 3.5 mg/kg treatment of Rp with mycorrhizal inoculation on *Gossypium arboretum* L. (cotton) influenced the plant growth, biomass production and P-uptake in mycorrhizal plants over the non-mycorrhizal plants. The suitable level of rock phosphate and super phosphate treatment with *Glomus fasciculatum* inoculation has been recommended on these two fibre yielding plants.

INTRODUCTION

The importance of soil as a reservoir of plant nutrients responsible for growth is well known. Soil also provides the matrix for the biological processes involved in nutrient cycling. Among the biological processes involved in the rhizoplane, the unique role of symbiotic bacteria and the mycorrhizal fungi, which ensure fixation and mobilization and availability of nitrogen and phosphorus to plants, has been well recognized. Therefore, proper fertilizer application is essential to increase plant production in infertile soils. Most of the Indian tropical soils require phosphorus for growing crop plants. It has been well documented that AM fungi are associated with most of the terrestrial plants. They play a vital role in uptake and translocation of limited nutrients mainly by diffusion of P thereby promoting plant growth (Anonymous 2005). It has also been observed that external hyphae of AM fungi can extend as much as 5-8 cm away from roots and absorb nutrients from a large soil volume (Udaiyan et al. 1997).

Thus, absorption of phosphate ions could be possible through some beneficial microsymbioants that are associated with rhizospheric zones in numerous plants. It is also known this fungi that have been associated symbiotically with almost all plants including fibre yielding plants (Allen 1991). Rhodes & Gerdmann (1978) studied the influence of phosphorus and sulphur, and their nutrition uptake by arbuscular mycorrhiza infected onion. Smith (1982) reported the inflow of phosphate into mycorrhizal and non mycorrhizal plants of *Trifolium subterranean.* Jalali & Thereja (1985) worked on the plant growth response to arbuscular mycorrhizal inoculation in soils along with rock phosphate. Jones (2000) demonstrated the effect of long term organic or inorganic fertilization of subterranean clover with mycorrhiza mediated phosphorus uptake. Since most of the mycotropical plants depend on AM colonization, when they grow under low external P conditions, their yield can be enhanced either by inoculation of more efficient fungal strains in agronomic practices (Sndeepkumar et al. 2009). Only limited reports are available on the phosphate fertilizer application on fibre yielding plants to know their effect with mycorrhizal inoculation.

The present investigation deals with the effect of four different levels of single super phosphate and rock phosphate on two fibre yielding plants with and without inoculation of arbuscular mycorrhizal fungi (*Glomus fasciculatum*).

MATERIALS AND METHODS

The seeds of experimental plants *Corchorus capsularis* L. and *Gossypium arboretum* L. were sown in 15 cm × 15 cm earthen pots containing 4 kg of sterile sandy loam plus sand (3 parts garden soil and 1 part of pure sand). The triplicate sets of pots were maintained with proper controls. Four different levels of super phosphate and super phosphate at the rate of 0.5mg/kg, 1.5 mg/kg and 4.5 mg/kg rock phosphate and super phosphate were provided with 10 g of AM (*Glomus fasciculatum*) mixed inoculum. The inoculation consisted of freshly infected chopped root pieces, spore, sporocaps, mycelia and rhizospheric soil collected from the host *Saghum suanese.* The inoculation was placed to each seedling in the vicinity of the root system.

The parameters such as plant height, dry weight of root and shoots, root/shoot ratio, per cent of colonization, spore number and P content (Jackson 1973) in shoots were determined. Percentage of mycorrhizal colonization in roots was determined after cleaning the roots in 10 % KOH and stained in 0.5% tryphan blue in lactophenol (Phillips & Hayman 1970). Mycorrhizal spores were recovered by wet sieving and decanting technique.

RESULTS AND DISCUSSION

Different levels of rock phosphate and super phosphate were given to experimental plants of jute and cotton as given in Tables 1 and 2. The AM fungus (*Glomus fasciculatum*) inoculated plants grew much taller than non-mycorrhizal plants with P fertilizer application in both the experimental plants. The maximum plant height (67 cm) was observed in *Corchorus capsularis* when treated with 3.5 mg Sp/kg of soil. *Gossypium arboretum* showed a higher growth (54 cm) after treatment with 3 mg Sp/kg of soil with AM fungal inoculation. The application of super phosphate level (3.0 mg Sp/kg soil) influenced the plant height and biomass production with *Glomus fasciculatum* inoculated plants of *Gossypium arboretum*. These plants showed decreased per cent colonization and spore number when treated with Sp and AM fungus. Root shoot ratio was drastically decreased in all the inoculated plants over non-mycorrhizal plants. The P fertilization experiments on *Gossypium arboretum* indicated that mycorrhizal inoculation alone aids the effective utilization of rock phosphate than super phosphate. This is because of changing into available from by mycorrhizal *Glomus fasciculatum* which was taken up by the plants for their better growth.

Arbuscular mycorrhizal fungi produced an increase in absorbing root surface area due to gross changes in morphology of the feeder roots (Hayman & Mosse 1972, Manjunath & Bhagyaraj 1984). The data obtained in the present study indicates that the mycorrhizal colonization of the host i.e., fibre yielding plants were able to utilize soluble phosphates quickly. The super phosphate treatment was more efficient in *Corchorus capsularis*. The trend of lower per cent mycorrhizal colonization with increasing fertilizer (Sp) agrees with the result of previous workers (Sylvia & Schenck 1983, Siverding & Hower 1985). On the other hand arbuscular mycorrhizal fungi are known to occur in soils with very high P contents and, thus, among the species of mycorrhizal fungi, there may be different responses to low or high P conditions or P fertilization treatment (Jones 2000).

Table 1: Effect of different P levels on AM (*Glomus fasciculatum*) inoculated *Corchorus capsularis* for 90 days.

Duration	Treatment	Plant (cm)	Dry wt. of shoot (g)	Dry wt. of Root (g)	Root/ Shoot ratio	% AM Coloniza- -tion	Spore Nos./ 50g soil	Shoot P (%)	Root P (%)
	NM	12.2±1.3	0.98±0.0	0.74±0.0	0.83±0.0	-	-	0.12	0.07
	M+RP_0	17.2±4.6	0.90±1.0	0.78±2.0	0.53±0.0	45.3±0.0	54.4±2.6	0.19	0.13
	M+RP_1	13.5±2.6	1.80±1.0	0.91±0.0	0.53±0.0	53.2±2.1	57.9±2.9	0.18	0.09
	M+RP_2	22.5±2.3	1.36±1.0	0.98±0.0	0.62±0.0	62.3±3.1	64.7±3.2	0.25	0.15
30 days	M+RP_3	32.3±2.3	1.83±1.0	1.98±1.0	0.59±0.0	60.3±3.0	54.6±1.9	0.19	0.13
	M+SP_0	27.3±1.1	1.00±1.0	0.91±0.0	0.67±0.0	38.9±1.2	42.1±1.3	0.23	0.04
	M+SP_1	32.3±2.1	1.90±1.0	0.98±0.0	0.44±0.0	44.1±2.1	53.2±2.1	0.26	0.12
	M+SP_2	31.1±2.0	1.34±0.0	0.80±0.0	0.73±0.0	40.2±2.3	44.9±3.1	0.27	0.07
	M+SP_3	28.5±1.0	1.90±0.0	0.83±0.0	0.37±0.0	37.7±14.0	49.5±1.2	0.31	0.08
	NM	14.3±1.1	1.20±0.0	0.81±0.0	0.85±0.0	-	-	0.11	0.06
	M+RP_0	15.2±1.1	1.10±0.0	1.00±0.0	0.53±0.0	49.2±1.0	51.5±2.2	0.17	0.09
	M+RP_1	19.3±2.1	1.90±0.0	2.06±0.0	0.61±0.0	55.8±2.2	57.3±2.2	0.21	0.09
	M+RP_2	32.1±2.2	2.00±1.0	1.31±0.0	0.42±0.0	57.2±2.1	64.2±2.1	0.24	0.10
60 days	M+RP_3	38.5±3.2	1.98±1.0	0.98±0.0	0.53±0.0	58.9±3.1	60.0±1.1	0.21	0.08
	M+SP_0	29.5±4.1	1.11±0.0	1.21±0.0	0.32±0.0	35.7±0.0	42.7±0.0	0.21	0.07
	M+SP_1	33.4±1.1	1.48±1.0	1.31±0.0	0.39±0.0	38.3±1.1	49.9±1.1	0.28	0.08
	M+SP_2	30.0±1.0	1.23±1.0	0.82±0.0	0.62±0.0	38.2±2.1	42.4±2.1	0.24	0.06
	M+SP_3	29.5±2.0	1.81±0.0	0.98±0.0	0.35±0.0	07.5±1.1	46.8±3.1	0.24	0.09
	NM	15.6±1.0	1.13±0.0	0.83±1.0	0.75±0.0	-	-	0.12	0.07
	M+RP_0	10.9±2.1	1.12±0.0	0.75±0.0	0.46±0.0	47.7±1.0	53.7±3.6	0.25	0.12
	M+RP_1	22.1±1.0	1.97±1.0	0.86±1.0	0.57±1.0	52.2±1.0	56.5±3.2	0.32	0.13
	M+RP_2	34.5±3.2	2.78±1.0	1.35±0.0	0.41±0.0	60.0±2.1	68.0±3.1	0.39	0.19
90 days	M+RP_3	48.7±2.3	3.21±2.1	1.10±0.0	0.49±0.0	55.9±0.0	62.7±2.1	0.36	0.14
	M+SP_0	27.3±4.1	1.28±1.1	1.12±0.0	0.41±0.0	32.6±1.1	43.3±2.0	0.32	0.11
	M+SP_1	33.5±2.1	4.92±1.0	1.46±0.0	0.32±1.0	36.7±1.0	46.8±2.1	0.34	0.12
	M+SP_2	32.2±1.0	1.90±0.0	0.98±0.0	0.56±0.0	35.3±0.0	42.3±1.1	0.26	0.10
	M+SP_3	31.1±1.1	3.55±0.0	1.28±0.0	0.39±1.0	32.6±1.0	44.2±2.1	0.34	0.08

NM = Non mycorrhizal; M+RP_0 = AM+0.5 mg rock phosphate/kg of soil; M+RP_1 = AM+1.5 mg rock phosphate/kg of soil; M+RP_2 = AM+3.0 mg RP/kg of soil; M+RP_3 = AM+3.5 mg RP/kg of soil; M+SP_0 = AM+0.5 mg super phosphate/kg of soil; M+SP_1 = AM+1.5 mg super phosphate/kg of soil; M+SP_2 = AM+3.0 mg SP/kg of soil, M+SP_3 = AM+3.5 mg SP/kg of soil

Studies on *Gossypium arboretum* treated with 3.5 mg Rp/kg soil has the beneficial response with mycorrhizal inoculation. The plants grew much better than non-mycorrhizal plants. This could be easily explainable that low solubility of P source (rock phosphate) is more effective than the plants treated with super phosphate. Plant roots may increase the rate of dissolution of rock phosphate by lowering the *Glomus fasciculatum* with 3.5 mg/kg soil. Rock phosphate was most effective on *Gossypium arboretum* in promoting plant growth. These finding are consistent with the earlier results (Jalai & Thereja 1985, Lakshman 1992, 1996).

Plant inoculation with AM fungi (*Glomus fasciculatum*) and treated with different levels of super phosphate and rock phosphate grown in green house conditions showed enhanced nutrients in shoot when compared with non inoculated plants. These finding are supported by others who reported similar results (Abbott & Robson 1991, Koide & Li 1990). Many rhizospheric soils contain organic acids with low calcium. It could be desirable to practice AM inoculation technique to young nursery plants with different levels of rock phosphate and indigenous mycorrhizal fungi. It many be

Table 2: Effect of different P levels of AM (*Glomus fasciculatum*) inoculated *Gossypium arboretum* for 90 days.

Duration	Treatment	Plant (cm)	Dry wt. of shoot (g)	Dry wt. of Root (g)	Root/ Shoot ratio	% AM Colonization	Spore Nos./ 50g soil	Shoot P (%)	Root P (%)
	NM	13.5±0.0	0.97±0.0	0.72±0.0	0.77±0.0	-	-	0.11	0.06
	$M+RP_0$	14.5±1.1	1.80±0.0	0.65±0.0	0.46±0.0	32.5±2.2	46.6±1.0	0.12	0.05
	$M+RP_1$	17.4±2.0	1.90±1.0	0.95±0.0	0.52±0.0	39.5±5.2	51.2±1.0	0.13	0.07
	$M+RP_2$	22.7±1.0	1.10±1.0	0.96±1.0	0.59±1.0	42.8±2.0	43.7±3.0	0.30	0.12
30 days	$M+RP_3$	19.5±2.0	1.85±1.0	1.88±0.0	0.55±0.0	44.4±3.1	53.5±1.0	0.15	0.13
	$M+SP_0$	20.6±1.0	0.90±0.0	0.94±1.2	0.46±0.0	28.2±1.1	45.1±0.0	0.18	0.14
	$M+SP_1$	24.5±2.1	1.20±1.0	0.94±1.0	0.52±0.0	34.1±1.1	52.4±1.0	0.28	0.16
	$M+SP_2$	28.5±2.0	1.84±0.0	0.82±0.0	0.61±0.0	38.2±1.2	46.2±3.1	0.25	0.16
	$M+SP_3$	37.2±1.0	1.81±0.0	0.89±1.0	0.57±0.0	32.7±2.0	41.2±1.0	0.29	0.18
	NM	14.6±1.1	0.98±0.0	0.79±1.0	0.75±0.0	-	-	0.24	0.06
	$M+RP_0$	19.9±1.0	0.10±0.0	1.00±0.0	0.53±0.0	49.2±1.0	51.5±2.2	0.17	0.09
	$M+RP_1$	20.5±1.0	0.88±0.0	0.81±0.0	0.55±0.0	52.1±1.0	51.6±1.0	0.25	0.12
	$M+RP_2$	22.1±0.0	0.90±0.0	0.91±1.0	0.56±0.0	37.5±0.0	54.1±1.1	0.26	0.14
60 days	$M+RP_3$	24.7±1.0	1.96±1.0	0.99±1.0	0.53±0.0	43.9±2.0	55.0±1.0	0.21	0.12
	$M+SP_0$	22.3±1.1	0.91±0.0	0.99±1.1	0.51±1.0	32.7±1.0	38.7±2.0	0.25	0.14
	$M+SP_1$	27.4±2.0	1.88±1.0	1.21±0.0	0.59±0.0	35.3±1.0	41.4±3.0	0.32	0.17
	$M+SP_2$	30.7±2.0	1.93±1.0	1.22±1.0	0.58±0.0	33.2±1.1	42.0±1.0	0.23	0.13
	$M+SP_3$	43.0±1.0	1.81±0.0	1.18±0.0	0.55±0.0	29.5±2.1	42.8±3.0	0.24	0.15
	NM	17.6±1.0	1.11±0.0	0.84±0.0	0.75±0.0	-	-	0.25	0.11
	$M+RP_0$	22.9±0.0	1.00±0.0	1.05±0.0	0.56±0.0	38.7±3.1	54.1±3.0	0.19	0.12
	$M+RP_1$	24.5±2.0	2.57±0.0	1.36±0.0	0.57±1.0	40.1±2.0	54.1±1.0	0.29	0.14
	$M+RP_2$	29.2±1.0	1.19±0.0	1.15±0.0	0.56±0.0	46.2±3.1	55.0±1.1	0.22	0.15
90 days	$M+RP_3$	28.1±2.3	1.91±0.0	1.1 0±0.0	0.59±0.0	45.9±3.0	55.7±10	0.32	0.14
	$M+SP_0$	25.3±2.1	1.98±0.0	1.36±0.0	0.30±0.0	38.6±2.0	44.3±2.0	0.33	0.14
	$M+SP_1$	30.5±2.0	1.92±0.0	1.46±0.0	0.36±1.0	32.7±1.0	43.8±3.0	0.36	0.18
	$M+SP_2$	36.2±1.0	1.19±0.0	1.22±0.0	0.56±0.0	33.1±1.0	40.3±1.0	0.26	0.15
	$M+SP_3$	39.3±2.1	3.25±0.0	1.38±0.0	0.36±0.0	28.6±2.0	39.6±1.0	0.34	0.18

NM = Non mycorrhizal; $M+RP_0$ = AM+0.5 mg rock phosphate/kg of soil; $M+RP_1$ = AM+1.5 mg rock phosphate/kg of soil; $M+RP_2$ = AM+3.0 mg RP/kg of soil; $M+RP_3$ = AM+3.5 mg RP/kg of soil; $M+SP_0$ = AM+0.5 mg super phosphate/kg of soil; $M+SP_1$ = AM+1.5 mg super phosphate/kg of soil; $M+SP_2$ = AM+3.0 mg SP/kg of soil, $M+SP_3$ = AM+3.5 mg SP/kg of soil

concluded that mycorrhizal plants absorb P only from the soluble phosphorus pools in soils and that they are unable to utilize source of P to non-mycorrhizal roots or non-mycorrhizal plants.

In tropical countries like India, there is problem of nitrogen deficiency and phosphorus nonavailability and these problems are accentuated particularly in degraded or stressed areas. Plantation of seedlings of fibre species with established AMF infection at necessary stage enables to utilize these lands successfully. Use of mycorrhizal biofertilizers would reduce dependence on chemical fertilizers, which would be a step towards reducing pollution. Over and above these benefits, mycorrhizal biofertilizers are renewable resources, unlike chemical fertilizers, which are based on the use of depletable resources.

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ENVIRONMENTAL NEWS

Reprocessing Plastic Waste

The Department of Chemicals and Petrochemicals (DCP) decided to constitute plastic waste reprocessing fund for promoting plastic waste processing through chemical process in the country. The proposed fund will be mainly utilised in reprocessing post-consumer plastic waste in a systematic manner. The rationale behind the scheme is the perceived need to create awareness about the recyclable properties of plastics and eliminate littering of plastics, while promoting used plastics. In line with this thinking, a charge is proposed to he levied on the manufacture and import of polymers in the country. The rate is envisaged at 0.5% of the ex-factory price of the Cost Insurance Freight (CIF) value of the imported polymers. The proceeds of this cess will go to the proposed fund. The DCP expects the cess amount to be the in range of Rs 150-200 crore per annum. The scheme will initially be operational for a period of three years, and, will be tentatively reviewed in 2011- 12. The DCP is of the view that the proposed scheme, apart from its core function, would also promote collection of plastic wastes, along with storage and segregation in an integrated manner.

DCP, November 3, 2009

Energy Guzzlers

The government has finalized a blueprint to reduce energy consumption in the nine most energy intensive industrial sectors of the country. The plan mooted under the national Action Plan on Climate Change will soon regulate the energy guzzled by railways, aluminum, cement, pulp and paper, fertilizers and steel industries besides also covering power generation plants.

The plan will cover roughly 750 large industrial installations. Only those plants that consume more than specified levels of energy annually will be targeted. Industrial plants will be expected to attain targets assigned to them within a 3-year period. The target for each plant would be based on the average specific energy consumption.

Indian Building Congress, August 2009