Enhancing yield of onion (*Allium cepa* L.) through mycorrhizal inoculant in *Meloidogyne graminicola*-infested soil

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Abstract

Mychorrhizal inoculants containing vesicular arbuscular mycorrhizal (VAM) fungi were evaluated in *M. graminicola*-infested soil, and their effects on growth and yield of onion were determined under greenhouse conditions. The study showed that the mixture of *Glomus mosseae*, *G. fasciculatum* and Mykovam applied at sowing was the best inoculant for onion. Mycorrhizal inoculation improved the growth of Yellow Granex and Red Creole onions in the presence or absence of *M. graminicola* in NPK-deficient soil. With complete NPK fertilization, inoculation enhanced the bulb development of Yellow Granex and Red Creole. In nematode-free soil, bulb weight of Yellow Granex increased by 54% and Red Creole by 23% while bulb diameter increased by 24% and 13%, respectively, compared with the untreated control. In *M. graminicola*-infested soil, yield of Red Creole was seriously affected but Yellow Granex showed tolerance to root-knot infection with increase in bulb weight by 262% and bulb diameter by 96.4% over the control. Field studies showed no differences in onion yield between inoculated and non-inoculated plants because of the presence of indigenous mycorrhizae in the field. Similarly, there was no difference in yield of inoculated plants that were given 120-240-120 kg NPK ha^{-1} and 60-120-60-kg NPK ha^{-1}. This indicates that half of the recommended fertilizer rate was sufficient for mycorrhizal onion plants thereby reducing the fertilizer inputs in the field.

Media summary

Mycorrhizal inoculant containing *Glomus mosseae*, *G. fasciculatum* and *Gigaspora margarita* will enhance onion yield and reduce fertilizer inputs even in *M. graminicola*-infested soil.

Key words

Onion, Yellow Granex, Red Creole. Mycorrhizae, *Meloidogyne graminicola.*

Introduction

The rice root-knot nematode, *Meloidogyne graminicola*, is an important nematode parasite of rice in rainfed and upland rice ecosystems. It is highly adapted to flooded conditions and could infect a number of crops such as onion upon conversion of field into upland ecosystem (Gergon 2000). Onion in the Philippines is a high value crop with high demand in both local and export markets. It is mainly grown in 8,000 ha over 12,000 ha in total area in Central part of Luzon during summer months after the rice crop, exposing onion to *M. graminicola*-infection. The nematode can reduce the bulb diameter and weight of Yellow Granex from 20% to 95% depending on the nematode population density at the start of the cropping period (Gergon et al. 2002).

Vesicular-arbuscular mycorrhizal fungi (VAMF) have been reported to reduce nematode reproduction in the roots (Thomas et al. 1989). Their interactions, however, have varied results depending on host cultivar, VAMF and nematode species, inoculum densities, and soil fertility (Siddiqui and Mahmood 1996). This study was conducted to identify the best species of VAMF that will enhance growth and onion yield, assess the influence of VAMF on Yellow Granex and Red Creole onions in *M. graminicola* infested soil, and determine the effects of VAMF applied at seeding and transplanting at two fertilizer levels on yield of Yellow Granex and Red Creole onions under field conditions.

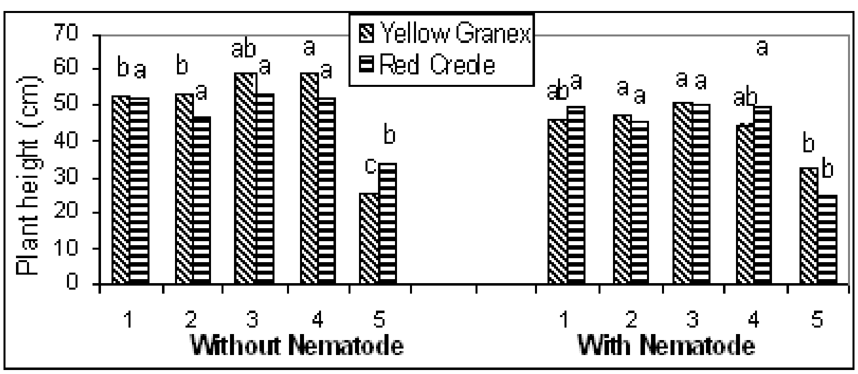
Methods

Three VAM species- *Glomus mosseae*, *G. fasciculatum* and *Gigaspora margarita* which was the main species in commercially inoculant, Mykovam, and the mixture of the three species were inoculated on onion seeds sown in sterile soil. The inoculated and uninoculated 45-day old seedlings were transplanted in pots filled with nematode-free soil and soil infested with *M. graminicola*. In the first experiment, mycorrhizal plants were planted in P-deficient soil without added N and K fertilizers. In the second experiment, the plants were fertilized with 10 bags of 14-14-14 kg NPK/ha. The potted plants were arranged in RCBD in the greenhouse. Data were analyzed statistically.

In the field trial, VAM contained in finely cut corn roots were used as inoculant. The VAM was broadcast on the surface of the seedbeds and lightly covered with soil. Onion seeds were distributed evenly on top of treated and untreated seedbeds. After 45days, the seedlings were pulled and divided accordingly in preparation for transplanting. Some seedlings from untreated beds were given VAM prior to transplanting. The rest of the seedlings without VAM served as the control. The treatments were laid out in a split plot design with two fertilizer levels: recommended rate (RR) of 120-240-120 kg NPK^{-1} with N applied in two splits at 2 and 4 weeks after transplanting and half of the RR as the main plots. Timing of VAM application at seeding and transplanting were the sub-plots. Yield data were taken at harvest and analyzed statistically.

Results

In P-deficient soil, plant height and top weights of both Yellow Granex and Red Creole onions were significantly reduced by *M. graminicola*. Application of VAM fungi caused significant increase in plant height and top weights of both varieties in nematode-free soil. In *M. graminicola*-infested soil, all treatments significantly improved the fresh top weights of both onions as well as the plant height of Red Creole. Only *G. fasciculatum* and *Gigaspora margarita* significantly increased the height of Yellow Granex (Figure 1).



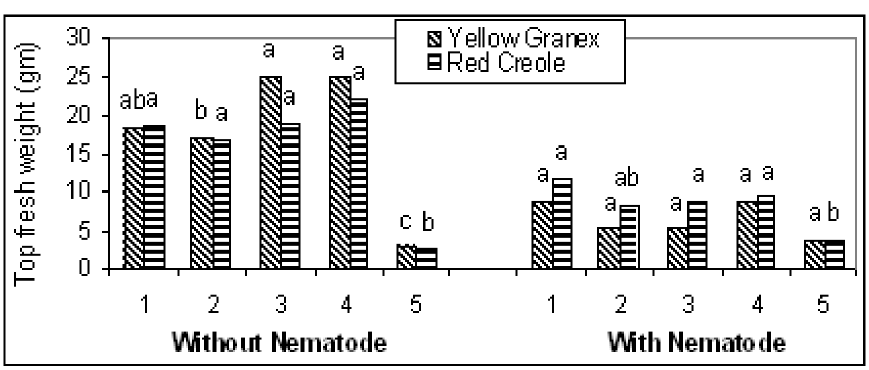


Figure 1. Effect of VAMF on growth of Yellow Granex and Red Creole onions in P-deficient soil. (Treatment 1- *Glomus mosseae*, 2-*G. fasciculatum*, 3-*Gigaspora margarita*, 4-Mixture of 1,2,and 3, and 5 - uninoculated control).

Mykovam-treated Yellow Granex also had the highest P-content in the leaves whether the plants were grown in *M. graminicola*-infested soil or nematode-free soil. All VAM fungi colonized the roots of both Yellow Granex and Red Creole. At harvest, however, roots of both onions were heavily galled indicating severe infection by *M. graminicola* with gall index rating of 5. The results show that VAM fungi did not prevent *M. graminicola* –infection but enhanced the tolerance of Yellow Granex and Red Creole to root-knot disease.

In fertilized soil, with or without *M. graminicola*, the plant height, top and root weights of mycorrhizal plants of both varieties and the uninoculated control plants did not differ significantly. Apparent differences in plant height, however, were observed during the bulb development stage of the crop. The P content of mycorrhizal plants was significantly higher than the uninoculated plants, which indicate that VAM fungi enhanced P uptake of onions in fertilized soil. Microscopic examination of the roots showed that all VAMF colonized the roots of Yellow Granex and Red Creole. Likewise, all plants grown in infested soil were severely infected by *M. graminicola*.

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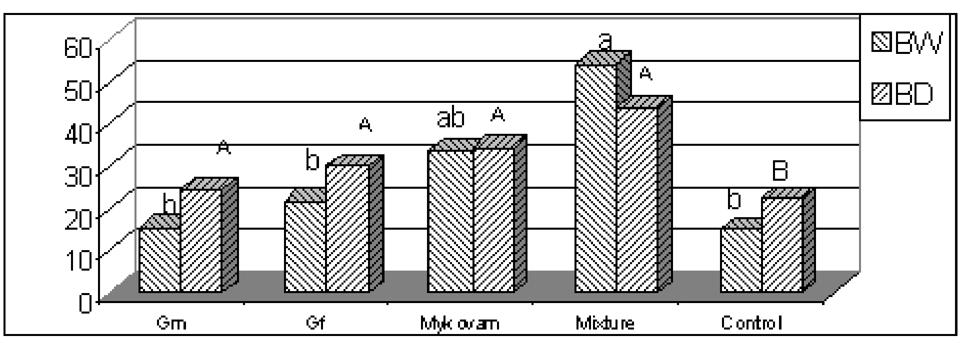
In nematode-free fertilized soil, inoculation of a mixture of three VAMF increased the bulb weight and diameter of Yellow Granex by 54 and 24%, respectively (Figure 2). In infested soil, the same treatment further caused a significant increase of 262% in bulb weight and 96.4% in diameter. Bulb weight and diameter of Red Creole also increased by 23% and 13%, respectively, but only with *G. mosseae* treatment and where *M. graminicola* was not present (Figure 3). This increase in onion yield can be attributed to more available P for onion, which basically requires high P inputs, and increased tolerance to *M. graminicola* infection.



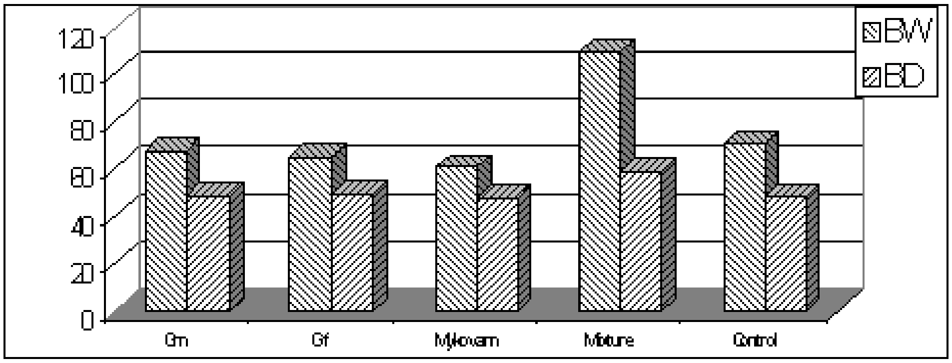
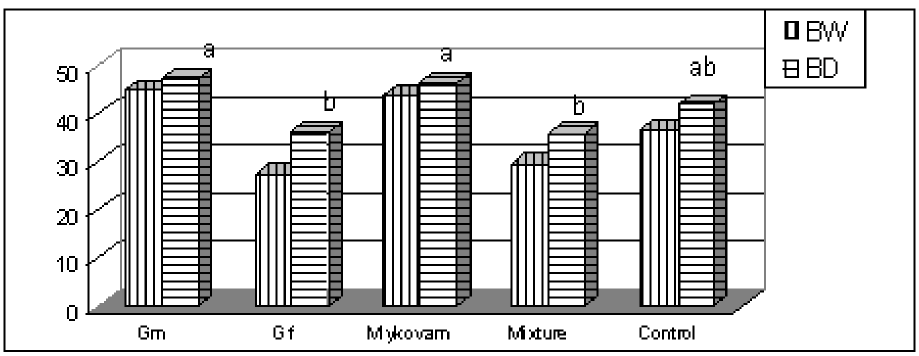


Figure 2. Effect of VAM fungi on bulb weight and diameter of Yellow Granex in nematode-free soil (top) and infested soil (bottom). (Legend:Gm = *Glomus mosseae*, Gf = *G. fasciculatum*, Mixture – Gm, Gf, and Mykovam combined).



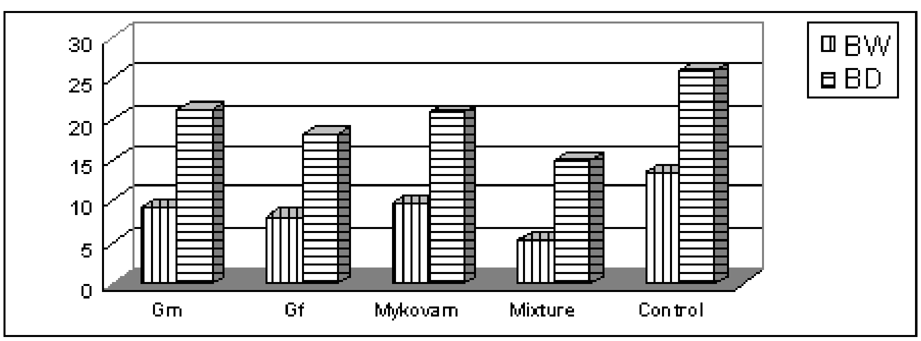


Figure 3. Effect of VAM fungi on bulb weight and diameter of Red Creole in nematode-free soil (left) and infested soil (right). (Legend:Gm = *Glomus mosseae*, Gf = *G. fasciculatum*, Mixture – Gm, Gf, and Mykovam combined).

There was no significant interaction between VAM and fertilizer levels at p=0.05. Timing of VAM application at seedbed or at transplanting did not also affect the yield of Yellow Granex and Red Creole onions (Table 1). When the roots of both onions were examined for mycorrhizae, results showed that even those roots of onions which were not given mycorrhizal treatments were also colonized by the fungus (Table 2) indicating that there are indigenous mycorrhizae in the experimental area. Mycorrhizal infection in Yellow Granex ranged from 89% to 100%, which was higher compared to Red Creole with only 66% to 86% infection. This could possibly explain the difference in their reaction in nematode-infested soil. Yellow Granex was more susceptible to VAM fungi, which helped the onion to have greater tolerance to nematode damage.

Table 1. Effect of VAM on yield of bulb onions at harvest.

	Bulb weight (g)(n=20)		Bulb diameter (g) (n=20)		Total Yield, tons/ha	
Treatment	Full RFR[1]	? RFR[1]	Full RFR[1]	? RFR[1]	Full RFR[1]	? RFR[2]
Yellow Hybrid EM 90						
No VAM added	89.3	73.4	54.0	51.6	29.0	28.2
VAM at seedbed	72.0	81.4	96.0	53.3	26.8	29.7
VAM at transplanting.	81.9	81.4	53.6	51.8	29.3	28.0
Red Viking de Luxe						
No VAM added	51.4	50.2	48.2	46.3	1.7	1.7
VAM at seedbed	48.2	43.5	46.3	44.8	1.6	1.5
VAM at transplanting	49.3	46.2	46.9	45.9	1.7	1.5

[1]RFR = Recommended fertilizer rate (Full, 120-240-120 kg NPK/ha), ?RFR= 60-120-60 kg NPK/ha.

Table 2. Percent mycorrhizal root infection on bulb onions at different fertilizer levels.

	Yellow Granex [1]		Red Creole [1]	
Treatment	Full RFR[2]	? RFR[2]	Full RFR[2]	? RFR[2]
No VAM added	100	95.3	72.2	73.3
VAM at seedbed	95.3	100.0	66.7	77.7
VAM at transplanting.	89.3	97.3	85.6	71.1

[1]Means of 5 plants per plot

[2]RFR = Recommended fertilizer rate (Full, 120-240-120 kg NPK/ha). ? RFR= 60-120-60 kg NPK/ha.

There was also no significant difference on growth of Yellow Granex and Red Creole using the two fertilizer levels. This indicates that the application of full fertilizer recommendation is unnecessary in areas where indigenous mycorrhizae are present in the soil. VAM have been reported to influence the nutritional status and physiology of the host plants thereby improving plant's growth (Powell et al. 1982). Earlier experiment has also shown that VAM fungi enhanced phosphorous uptake of onion plants even in unfertile soil. Application of VAM fungi has been found advantageous in problem than in fertile soil as we have observed in other high value crops.

The incidence of root galls was not also influenced by VAM. There were no differences in the number of nematode juveniles in the roots that were recorded. Results of field trials confirm the results of our greenhouse experiments. Mycorrhizal roots did prevent the penetration of *M. graminicola* as well as *Phoma terrestris* infection as we observed symptoms of the disease. Mycorrhizae helped plants tolerate root-knot infection as evidenced by higher onion yield even in the presence of *M. graminicola*. The enhancing effect of VAM fungi on onion yield, however, was very evident in the greenhouse experiments where we were able to exclude mycorrhizae from the control treatments by using sterilized soil.

Conclusions

Mixture of the three VAMF species was the best inoculant for Yellow Granex even in the presence of *M. graminicola.* Mycorrhizal inoculant increased the tolerance of onion from root-knot nematode damage as well as *P. terrestris* infection. It also enhanced the growth of Yellow Granex and Red Creole onions in P-deficient soil with or without *M. graminicola,* and onion yield of Yellow Granex in *M. graminicola*-infested soil. Application of mycorrhizal inoculant did not only reduce P inputs but also reduced by half the total NPK requirements of onions thereby reducing the fertilizer costs for the farmers. Mycorrhizal inoculant as biofertilizer is an environment-friendly nutrient supplement for onions and should be part of onion production system.

References

Gergon EB (2000). Host suitability of common field crops and weeds to rice root-knot nematode. Journal of Philippine Phytopathology 36, 16-31.

Gergon EB, Miller SA, Halbrendt JM and Davide RG (2002). Effect of rice root-knot nematode on growth and yield of Yellow Granex onion. Plant Disease 86, 1339-1344.

Powell CL, Clark GE and Verberne NJ (1982). Growth response of four onion cultivars to several isolates of VA mychorrhizal fungi. New Zealand Journal of Agricultural Research 25, 465-470.

Siddiqui ZA and Mahmood I (1996). Role of plant symbionts in nematode management: a review. Bioresource Technology 54, 217-226.

Thomas G, Sundararaju P, Ali S and Ghai SK (1989). Individual and interactive effects of VA mycorrhizal fungi and root-knot nematode, *Meloidogyne incognita*, on cardamon. Tropical Agriculture (Trinidad) 66, 21-24.