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Influence of arbuscular mycorrhizae on the performance of chilli (Bell) pepper (*Capsicum annuum* L.)

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Abstract

Mycorrhizal application is known to increase crops productivity and enhance their tolerance to attacks of diseases, through improvement of crops uptake of phosphorus. Semi-controlled experiment was conducted in a green house to evaluate the influence of arbuscular-mycorrhizae (AM) fungi on the improvement of chilli pepper ('tatase') production in sub-humid soils of the tropics. The experiment was arranged in complete randomized design with six replications. *Glomus mosseae* and *G. etunicatum* were used to inoculate the pepper plants. Non-mycorrhizal inoculation served as control experiment. *G. etunicatum* was found to be effective in improving the biomass production of tatase and its fruiting potentials. Mycorrhizal inoculation also reduced the number of the abscised flowers and fruits. Tatase was found to respond differently to different *Glomus spp*. Dual inoculation of the plant with both AM fungi did not improve its performance above that of single inoculation with *G. etunicatum*. This experiment showed that mychorrhizal association induced early flowering and fruit production of tatase.

Key words: *G. mosseae, G. etunicatum*, tatase, flowering, dual inoculation, fruiting, abortion, *Capsicum annuum* L.

Introduction

Pepper is one of the most important crops in Africa (FAO, 1979). It is also cultivated world wide under various environmental and climatic conditions covering an area of nearly one million hectares (Pyou *et al.*, 1980; Martilli and Quacqilarelli, 1983) because of their importance as vegetable and spices. Cultivation of pepper has increased considerably as a result of industrialization, population growth and as cash crop to farmers in the developing countries. Chilli pepper ('tatase') is indispensable in many dishes because it is less peppery, gives colour and aroma to food and is good sources of vitamins (particularly vitamin A) and minerals (Olaniyan and Fawusi, 1992). It is therefore important to enhance its productivity. 'Tatase' is very expensive and many peasants usually find it difficult to afford especially during the raining season. Its high cost is multifaceted, which includes transportation over long distances ranging from 800-1500km (from the North where it is produced to the South where it is largely consumed). This usually results in considerable loss due to damage and rottening of the fruits. Another factor is its low productivity due to abortion of the flowers and immature fruits. It is now imperative to fix (adapt) 'tatase' to the soils of the sub-humid and humid tropics. If it could be successfully grown in these regions its productivity would increase and hence reduces its exorbitant price and losses.

According to Muhammad *et al.* (1995), chilli pepper ('tatase') grows well only on drained light loamy soil with low rainfall between 650- 1300mm and optimum temperature of about 25^oC. If the temperature goes extremely high, abscission of flowers occur and the growth of the plant is retarded (Hwang and Kim, 1995). 'Tatase' is usually grown in Nigeria towards the dry season under irrigation with incorporation of manure (Denton and Ojeifo, 1990), which does not reduce pathogenic invasion. The commercial varieties in Nigeria are mainly landraces which are highly variable for many traits such as fruit size, shape, dry matter content and pungency. Pepper serves as a good source of income to the resource poor farmers of Africa. This pepper grows poorly in humid and sub-humid tropics. Its growth in these regions is characterized by low fruit yield due to flower and fruit abscission before reaching maturity stage.

Mycorrhizal application is known to increase crops productivity (Bethlenfalvay and Linderman, 1992) such as cassava, maize, wheat, alfalfa etc (Atayese *et al.*, 1993; Bryla and Duniway, 1997; Fagbola *et al.*, 1998; Osonubi *et al.*, 1998; Oyetunji, 2001), enhances crops tolerance to attacks of diseases (Salami, 1999; Odebode, 2001), through improvement in crops uptake of phosphorus (Nielson *et al.*, 1998), nitrate (Azcon-Aguila *et al* 1979; Cliquet *et al* 1997), Zn, Cu, Fe (Howeler and Cadavid,1983; Kothari *et al.*, 1990; Oyetunji, 2001).

Objective of this study was to investigate the role of arbuscular mycorrhizal (AM) fungi in adapting 'tatase' into sub-humid and humid tropics soils.

Materials and methods

Crop establishment: The experiments were conducted in 2001 at Nursery of University of Ibadan, Nigeria under controlled container conditions during the dry period (November to February). The site is on latitude 7^o 43'N and longitude 13^o 9'E. The mean annual rainfall was between 1200-1650mm which was bimodal in nature. The total pan evaporation was 1565-1750mm, mean monthly relative humidity at lowest was 61.5% and above 83.5% in August. The mean temperature ranged from 21-30^oC (minimum) to 24-35^oC (maximum).

Healthy fruits of *Caspicum annum* L. (chilli pepper or tatase) were purchased from a local market in Ibadan. The seeds were removed from the fruits, sun dried for 7 days, and were surface sterilized in 1% sodium hypochlorite before they were sown in the nursery in steam sterilized soil in germinating trays. They were allowed to grow in the nursery for 4 weeks before they were transplanted into the containers. They were inoculated with mycorrhizae inocula by placing 10g inoculum in each hole opening made in each container. The seedlings were then placed in the holes and backfilled with soil. Each inoculum consisted of the soil, spores, hyphae and fragment of the roots of the trap host. The inocula sources were from multiplied samples initially supplied by Dr. Pat Miller of USDA-ARS, Beltsville. The plants were watered every alternate day.

Experimental layout:The soil (Oxic palenstalf) used was collected from the back of the nursery behind Botany and Microbiology department. The soil was sieved with 2mm mesh and sterilized. 10kg of the top soil was packed into each container. The containers were either inoculated with *Glomus etunicatum, G. mosseae* (Nicholson and Gerdermann) Gerderman and Trappe, a combination of the AM fungi or not inoculated. The containers were arranged in a complete randomized design with 6 replications.

Measurements: Growth parameters were recorded at 4 weeks after transplanting (WAT) and spread weekly to the 7th week. The height was taken with meter rule. The number of leaves and branches were counted visually likewise the number of flowers and fruits. The number of aborted flower and fruits were counted by picking those that dropped before maturity. Data were sunjected to ANOVA for comparing treatment means (SAS, 1996).

Results and discussion

Table 1 shows the effects of the introduced AM fungi on the growth characteristics of tatase at 4 WAT. The number of leaves produced by the tatase inoculated with *G. etunicatum* and dual inoculation with *G. etunicatum* and *G. mosseae* were significantly (P<0.05) higher than those produced by tatase inoculated with *G. mosseae* and non-inoculated. The same trend of results was obtained for number of branches produced, height of plant and number of flower produced.

Table 2 depicts the growth performance at 5 WAT as affected by the introduced AM fungi. The growth parameters of tatase inoculated with *G. etunicatum* and those with dual inoculation were significantly (P<0.05) higher than those of control and *G. mosseae* inoculated.There was no significant difference in the monitored growth parameters of *G. mosseae* inoculated pepper plant and control. *G. etunicatum* and dual inoculated tatase started producing fruits at the 5th week. Rate of abortion of flowers were not significantly different between the treatments at this particular growth stage.

Table 1. Growth performance of tatase under the influence of arbuscular-mycorrhizae (4th week after transplanting)

Mycorrhizal inoculation	Number of leaves	Height (cm)	Number of branches	Number of flower
G. etunicatum	27.25a†	22.20a	5.50a	3.50a
G. mosseae	8.50b	10.50b	0.00b	0.00b
Dual inoculation	22.25ab	21.25a	5.50a	3.25a
Control	9.75b	10.75b	0.50b	0.25b

The values are means of 6 replicates.

†The means followed by the same letter in a column are not significantly different at P< 0.05.

The influence of the AM fungi on tatase biomass production at 6th WAT is shown in Table 3. The trends above were also recorded in week 6. Exception was found in the number of fruits produced where *G. etunicatum* treated plants produced significantly greater number of fruits than those under the other treatments. There was no significant difference in the number of fruits produced by *G. mosseae* inoculated, dual inoculated and not inoculated plants. All the tatase under all the treatments started fruit production at week 6, except those inoculated with *G. mosseae*. There was no significant difference in the number of fruits and number of flowers abscised in all the treatments.

The effect of the mycorrhizae on the performance of tatase at 7th WAT is shown in Table 4. The number of leaves, plant height and number of branches production were all significantly enhanced by *G. etunicatum*. Plants with dual inoculation were not significantly different from those inoculated with *G. etunicatum*. *G. mosseae* did not significantly improve those attributes when compared with uninoculated. The number of flowers produced by the pepper treated with *G. etunicatum* was also significantly different from those of the other treatments, except dual inoculation. There was no difference between the means of all

Table 2. Growth performance of tatase under the influence of arbuscular-mycorrhizae (5 weeks after transplanting)

Mycorrhizal inoculation	Number of leaves	Height (cm)	Number of branches	Number of of flower	Number of flower aborted	Number of fruit
G. etunicatum	40.50a†	31.67a	11.50a	5.67a	0.17a	0.67a
G. mosseae	10.17b	15.38b	0.50b	1.33bc	0.00b	0.00b
Dual inoculation	36.00a	27.13a	12.67a	4.50ab	0.33a	0.33a
Control	12.17b	17.12b	1.67b	0.50c	0.00b	0.00b

The values are means of 6 replicates.

†The means followed by the same letter in a column are not significantly different at P < 0.05.

Table 3. Growth performance of tatase under the influence of arbuscular-mycorrhizae (6 weeks after transplanting)

Mycorrhizal inoculation	Number of leaves	Height (cm)	Number of branches	Number of of flower	Number of flower aborted	Number of fruit	Number of aborted
G. etunicatum	51.67a†	38.98a	17.00a	7.83a	2.33a	2.33a	0.67a
G. mosseae	15.00b	20.43b	5.00b	2.33b	0.17b	0.00b	0.00b
Dual inoculation	49.33a	34.97b	17.33a	7.17a	1.83a	0.50b	0.17b
Control	24.33b	21.28b	5.00b	4.00ab	0.67b	0.17b	0.17b

The values are means of 6 replicates.

†The means followed by the same letter in a column are not significantly different at P < 0.05.

Table 4. Growth performance of tatase under the influence of arbuscular-mycorrhizae (7 weeks after transplanting)

Mycorrhizal inoculation	Number of leaves	Height (cm)	Number of branches	Number of of flower	Number of flower aborted	Number of fruit	Number of aborted
G.etunicatum	62.83a	41.05a	19.83a	12.83a	1.67a	5.17a	0.17a
G. mosseae	26.00c	23.17b	9.92b	6.00bc	0.83a	0.00b	0.00a
Dual inoculation	56.83b	34.7a	15.83ab	10.83ab	0.83a	0.67b	0.17a
Control	28.17c	22.47b	6.50b	4.83c	0.17a	0.00b	0.00a

The values are means of 6 replicates.

†The means followed by the same letter in a column are not different at $P < 0.05$.

the treatments as per the number of flower abscised. The pepper inoculated with *G. mosseae* and that of control did not produced fruits at 7th WAT while those inoculated with *G. etunicatum* and dual inoculation produced some fruits. However, the number produced by *G. etunicatum* inoculated was significantly higher than the dual inoculation.

Chilli pepper was found to respond to mycorrhizal inoculation, but the response depends on the species used. The study revealed that tatase responded positively more to *G. etunicatum* than *G. mosseae*. *G. etunicatum* was found to improve the performance of tatase in the sub-humid region. Mycorrhizal application brought about an improvement in both the growth and fruit production in chilli pepper. This experiment showed that mychorrhizal association induced early flowering in tatase. This can be of great benefit to the pepper to avoid the severity of disease incidence which is usually a major problem to production of tatase and other peppers in the humid tropics (Kim and Hwang, 1992; Marinkovic *et al* 1992; Odebode *et al* 1995; 1997; Odebode and Shehu, 2001). No incidence of disease symptoms were observed during the experimental period. This agreed with the earlier findings of Salami, 1999. Early fruits production (5th week after transplanting) was also obtained through the introduction of AM fungi. This suggested that mycorrhizal association can be used to help tatase tolerate the period of higher water stress because the pepper requires low rainfall.

The number of leaves produced by the *G. etunicatum* and dual inoculation was greater than those produced by *G. mosseae* and those not inoculated. This was manifested in the growth performance of the pepper. The number of fruits that eventually developed into fruits was higher in *G. etunicatum* inoculated tatase than those of other treatments. The implication was that the flowers of the pepper under *G. etunicatum* took less time to develop into fruits than those under other treatments. It suggested that mycorrhizal inoculation can hasten the period of fruits development in tatase. The fruit development started at the fifth week after transplanting in the pepper inoculated with *G. etunicatum*, while those inoculated with *G. mosseae* did not start fruiting even at the seventh week when the experiment was terminated. Those that were not inoculated, fruit development started at the sixth week, were all aborted before the seventh week.

This study revealed that the number of flowers and fruits produced by tatase is a function of number of branches produced. The higher the number of branches the higher the number of flowers and fruits produced. Branching habit of this plant was positively influenced by mycorrhizal inoculation. Another deduction was that abortion of both, the flowers and the fruits could also be significantly reduced with mycorrhizal inoculations. Abortion of the flowers and fruits could be due to nutritional factor which mycorrhizal application was able to improve. Further investigations need to be carried out to screen the response of tatase to different *Glomus* species in the humid and sub-humid tropics.

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