EFFECT OF VA-MYCORRHYZAL FUNGI INOCULA PRODUCED IN VITRO ON SOME MAIZE FUNGAL DISEASES AND GROWTH PARAMETERS UNDER FIELD CONDITIONS

BY

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ABSTRACT

Four isolates of vesicular arbuscular mycorrhizal (VAM) fungi (*Glomus* spp.) namely VAM-O (isolated from onion), VAM-B (isolated from broad bean), VAM-S (isolated from Swiss cheese) and VAM-M (isolated from maize) were used. The VAM isolates were grown *in vitro* on a barely modified (BM) cultures to produce their applicable inocula. The *in vitro* inocula were used at low (2.5/g ridge), middle (5.0/g ridge) and high levels (10.0/g ridge) equivalent to 10, 15 and 20 Kg/feddan, respectively. Two sets of field experiments were carried out during 2002 and 2003 growing seasons to evaluate the effect of VAM inoculation treatments compared to applying P fertilizer and VAM inoculation treatments + N fertilization compared to applying N fertilizer alone on the following parameters (seed germination, percentage of wilted, smutted and stunted plants, fresh and dry weight/plant, ear weight, grain yield/plant and weight of 100-kernels) during 2002 and 2003 seasons. The resultant response of known parameter was greatly varied depending on VAM isolate, inoculum level and growing season. The responses of some determined parameters were significantly better by using certain VAM inoculation treatments in comparison with application of P fertilizer. Most VAM treatments + N fertilization showed similar better responses compared to N fertilizer alone.

Key words: Vesicular arbuscular mycorrhizae, VAM, Inoculum, *in vitro*, P fertilization, N fertilization, wilt, common smut, stunt, Maize.

INTRODUCTION

Vesicular arbuscular mycorrhizal (VAM) fungi (Zygomycetous fungi from the order Glomales) form the most widespread symbiosis of the plant kingdom and colonize more than 80% of vascular plants **(Barek *et al.,* 2001)**. A symbiosis refers to an association of living organisms that benefits both partners, enabling them to survive, grow and reproduce more effectively and, above all, acquires increased resistance to environmental stresses such as drought, cold and root pathogens **(Sylvie and Williams, 1992; Mohan, (2000)**.

Isolation and inoculum production of VAM fungi present very different problems. Obtaining isolates of AM fungi is more difficult because they will not grow apart from their hosts. Spores can be sieved from soil, surface disinfested, and used to initiate "pot cultures" on a susceptible host plant in sterile soil or an artificial plant-growth medium. Inoculum is typically produced in scaled-up pot cultures. Alternatively, hydroponic or aeroponic systems are possible; a benefit of these systems is that plants can be grown without a supporting substratum, allowing colonized roots to be sheared into an inoculum of high propagule number **(Jarstfer and Sylvia, 1992 and 1994)**.

El-Fiki *et al.* (2001) isolated four VAM fungal isolates namely VAM-O, VAM-B, VAM-S and VAM-M from roots of onion (*Allium cepa*), broad bean (*Vicia faba*), Swiss cheese (*Monstera deliciose*) and maize (*Zea mays*) plants. These VAM isolates were identified as *Glomus* spp. (under publication). Inocula of these VAM isolates in form of sporangiospores or barely modified (BM) cultures (prepared *in vitro,* **"**see **plate 1")** were effective at different concentrations for improving growth of maize plants under greenhouse. The present work aimed to evaluate these *in vitro* VAM inocula as biofertilizer on crop protection, growth and yield of maize compared to P and N fertilization each alone. The VAM inoculum was used alone or combined with N fertilization.

MATERIALS AND METHODS

The symbiont-barely-modified (BM) cultures for the VAM fungi namely VAM-O, VAM-B, VAM-S and VAM-M, were prepared as described by **El-Fiki *et al.* (2001)** and used separately as VAM inocula.

Two field experiments were conducted (at the Experimental Farm, Faculty of Agric., Moshtohor, Benha Univ.) during 2002 & 2003 seasons in a randomized complete block design, with three replications (plots) each (10.5m^2 = $^1/_{400}$ fed.) consisted of 5 ridges 3m long and 70cm apart. Inoculum (BM-culture) of a known VAM isolate was placed, at time of sowing, in a furrow (5-10 cm deep) at the rate of 2.5, 5.0 and 10 g/ridge (equivalent to 10, 15 and 20 kg/feddan, respectively). Plots fertilized with calcium super phosphate (15.5% P_2O_5) at rate of 200 kg/feddan were served as controls. The P fertilizer was added at sowing time. In parallel experiment, the same VAM inoculum levels were combined with N fertilizer (ammonium nitrate 33.5% N) at the rate of 450 kg/fed. Plots received N fertilizer only were served as control. The N fertilizer was applied at two equal doses, *i.e.* at sowing time and before the 2nd irrigation (after thinning), respectively.

Seeds of maize (*Zea mays* cv. Local) were planted, at 22nd June in 2002 and 2003 growing seasons, in hills 30cm apart. Maize plants were thinned immediately before the 2nd irrigation to two plants per hill (approximately 75 plants/plot). The normal culture practices for growing maize were used.

Percentage of seed germination was recorded 21 days after sowing. After 75 days after sowing the above ground plant parts, in taken samples, were used to determine total fresh and dry weight/plant (oven dried at 70°C for 24 hours). Concerning with symptoms only and regardless the causal agent, percentages of wilted, common smutted and stunted plants were calculated after 90 days from sowing. After harvest (110 days after sowing), averages of ear weight (g), grain yield/plant (g) and 100-kernel weight were estimated.

All data obtained, when necessary, were statistically analyzed according to the least significant difference (L.S.D.) method described by **Snedecor and Cochran** (**1982**).

RESULTS

1. Evaluation of different levels of VAM inoculation compared to application of P fertilization.

Data in **Table (1)** reveal that inoculation with any VAM isolate at any level significantly increased germination of maize seeds particularly in 2002 season compared to application of P fertilizer. VAM-O was the best of all in season 2002 (80.7-81.7%) followed by VAM-S (79.3%), VAM-B (67.0-81.3%) and VAM-M (66.0-71.0%), respectively compared to application of P fertilizer (62.3%). In the same season, seed germination was increased significantly as inoculum level was increased particularly in VAM-B and to some extent in VAM-M only. However, seed germination in 2003 season was significantly increased by all inoculum levels of VAM-O (75.8-79.2%) and the high inoculum level of VAM-B (70.0%) compared to application of P fertilizer (64.0%). All other VAM treatments particularly VAM-M and VAM-S had no effect or significantly decreased seed germination compared to application of P fertilizer. Only VAM-O (at 5.0 and 10.0 g/ridge inoculum levels) in season 2002 and VAM-B and VAM-S (at 10.0 g/ridge inoculum level) in season 2003 significantly reduced percentages of maize plants showing wilt symptoms. On the other hand, VAM-M (at 2.5 and 5.0 g/ridge levels) and VAM-O (at 2.5 g/ridge level) significantly increased percentage of wilted plants in season 2002 (14.5-17.0%) compared to application of P fertilizer (9.6%). In this respect, all other VAM treatments in both seasons had no significant effect. Inoculation with different inoculum levels of VAM-M only significantly decreased incidence of the common smut (0.4%) in season 2002 only compared to application of P fertilizer (1.8%). All other VAM treatments in both seasons had no significant effect. However, percentage of stunted maize plants was significantly reduced by applying different VAM treatments particularly VAM-S at 5.0 and 10.0 g/ridge inoculum levels (0.0%) compared to application of P fertilizer (4.0%). All VAM treatments had no significant effect on percentages of wilted and stunted maize plants in season 2003 compared to application of P fertilizer.

The same data in **Table (1)** show that the fresh and dry weight/plant, ear weight, grain yield/plant and weight of 100-kernels were significantly increased, during 2002 and 2003 seasons, by using the most tested VAM inoculation treatments. Using VAM-O at 5 g/ridge level produced the highest increase in the fresh weight (g/plant) in season 2002 followed by the same isolate and VAM-B at 10.0 g/ridge level, respectively whereas, VAM-O and VAM-S used at the 2.5 g/ridge level produced the lowest increase. Using 2.5 g/ridge level of VAM-M significantly decreased fresh weight/plant whereas its middle level had no significant effect in 2002 season compared to P fertilization (204.7). The same trend was observed also in season 2003. Using VAM-O at 5.0 and 10.0 g/ridge levels in both seasons and VAM-B and VAM-M at the 10.0 g/ridge level in 2002 and 2003 seasons respectively caused the highest significant increase in dry weight (g/plant) compared to P fertilization. However, using VAM-M at the low and middle levels and VAM-S at the 2.5 g/ridge level in both seasons in addition to VAM-O at the 2.5 g/ridge level in season 2002 and VAM-S at the low and middle levels in season 2006 had no significant effect in this respect. All VAM inoculation treatments significantly increased ear weight (g) particularly in 2002 season compared to application of P fertilizer. Using VAM-B and VAM-S at the 10.0 g/ridge level in 2002 season and VAM-O at 5.0 and 10.0 g/ridge levels in 2003 season were the best of all treatments in this respect. However, using the 5.0 and 10.0 g/ridge levels of VAM-M and the 2.5 g/ridge level of VAM-B had no significant effect on ear weight compared to P fertilization.

Table (1): Effect of VAM inoculation treatments alone against application of P fertilizer (control) on different parameters under field conditions during 2002 and 2003 seasons.

Season	VAM isolate & inoculum level (g/ridge)	Parameters								
		Seed germination %	Wilt %	Smut %	Stunt %	Fresh weight (g/plant)	Dry weight (g/plant)	Ear weight (g)	Grain yield (g/plant)	100-Kernel we. (g)
Control (P alone *)		62.3	9.6	1.8	4.0	204.7	66.3	133.4	50.1	25.0
2002	VAM-B 2.5g	67.0	11.8	1.8	0.9	230.2	75.7	155.8	70.0	26.9
	VAM-M 2.5g	66.0	14.5	0.4	2.2	180.6	66.8	153.6	58.3	25.1
	VAM-O 2.5g	80.7	17.0	1.3	2.2	216.5	73.2	153.9	58.2	26.7

	VAM-S 2.5g	79.3	11.9	1.8	1.3	217.6	72.1	152.1	54.2	26.4
	VAM-B 5.0g	73.0	9.7	1.8	0.9	244.5	79.9	156.6	74.5	28.2
	VAM-M 5.0g	67.3	14.5	0.4	1.8	212.1	70.4	154.2	61.2	25.4
	VAM-O 5.0g	80.7	5.5	1.8	1.3	273.4	84.6	158.3	64.3	27.5
	VAM-S 5.0g	79.3	10.4	1.8	0.0	230.6	81.8	151.1	73.6	26.7
	VAM-B 100 g	81.3	9.2	1.8	0.9	250.6	83.0	172.2	80.6	28.1
	VAM-M 10.0g	71.0	8.7	0.4	2.7	222.8	74.6	154.2	60.4	25.3
	VAM-O 10.0g	81.7	6.1	1.3	1.3	266.7	82.3	155.8	57.3	28.1
	VAM-S 10.0g	79.3	7.9	1.8	0.0	221.4	78.4	164.8	75.5	28.9
LSD. At 5%		2.79	3.17	0.60	0.99	11.13	7.30	9.28	5.77	1.57
Control (P alone *)		64.0	16.3	1.4	1.3	163.9	51.8	99.4	35.1	25.0
2003	VAM-B 2.5g	64.0	14.5	1.9	1.0	181.9	54.5	115.6	61.5	27.2
	VAM-M 2.5g	60.8	13.4	1.9	1.0	175.2	49.5	86.1	29.6	24.4
	VAM-O 2.5g	75.8	17.5	1.4	1.3	183.9	58.8	123.3	58.5	26.7
	VAM-S 2.5g	64.7	14.5	1.9	1.0	176.8	47.7	128.6	76.4	28.1
	VAM-B 5.0g	66.3	10.1	1.9	1.0	188.9	59.2	125.6	65.4	28.6
	VAM-M 5.0g	63.7	12.4	1.9	1.0	181.1	54.5	104.5	37.9	26.4
	VAM-O 5.0g	79.2	9.1	2.4	1.3	202.8	65.2	155.8	84.0	27.5
	VAM-S 5.0g	68.7	10.1	1.9	1.0	184.6	51.6	128.7	79.7	28.1
	VAM-B 100 g	70.0	2.6	1.9	0.7	197.9	58.8	139.7	73.1	29.2
	VAM-M 10.0g	64.2	11.7	1.9	0.7	187.8	62.1	136.1	59.8	26.7
	VAM-O 10.0g	77.3	10.8	1.4	0.7	197.8	60.9	154.2	80.4	26.7
	VAM-S 10.0g	68.7	2.7	1.9	1.0	193.3	53.1	136.7	87.0	28.3
LSD. At 5%		3.04	2.41	NS	NS	8.79	5.16	20.77	15.3	0.80

* P fertilization with super phosphate at 200 kg/feddan was used as control.

Most VAM inoculation treatments increased grain yield (g/plant) and weight of 100-kernels in both 2002 and 2003 seasons. Using the 10.0 g/ridge level of VAM-B VAM-S in seasons 2002 & 2003, respectively produced the highest increases in grain yield/plant. Meanwhile, VAM-S at the 2.5 g/ridge level in 2002 season and VAM-M at 2.5 and 5.0 g/ridge levels in 2003 season had no significant effect compared to P fertilization. Concerning weight of 100-kernels, using VAM-S, VAM-B and VAM-O (all at 10.0 g/ridge level) in 2002 season and VAM-B (at 5.0 and 10.0 g/ridge levels) and VAM-S (at all levels) in 2003 season were the best VAM inoculation treatments in this respect. However, VAM-M (at all levels) in 2002 season and VAM-M (at the low level) in 2003 season had no significant effect when compared with P fertilizer application.

2. Evaluation of different levels of VAM inoculation + N fertilization compared to the application of N fertilization alone.

Data in **Table (2)** show that N fertilization + VAM inoculation treatments (except VAM-M at all levels and VAM-S at 2.5 g/ridge level in 2003 season only) significantly increased seed germination in both seasons more than N fertilizer alone. N fertilization + inoculation with VAM-O particularly at its 10.0 g/ridge level produced the highest significant increase in seed germination in 2002 season (85.33%) and 2003 season (82.17%) compared to 63.33 and 73.5% for application of N fertilizer alone in both seasons, respectively. However, seed germination in 2003 season was significantly decreased by using combination between N fertilization and all levels of VAM-M (63.17-69.17) and 2.5 g/ridge level only of VAM-S (70.17%) compared to N fertilizer alone. Levels of VAM-M only were significantly varied concerning their effect on seed germination. VAM-M at 10.0 g/ridge level in season 2002 and middle level in season 2003 produced the highest increase compared to other its levels. Also, percentages of wilted plants were significantly decreased in both seasons by N fertilization + all VAM inoculation treatments (except VAM-M at 2.5 g/ridge level in the first season and its all levels in the second season) compared to N fertilizer alone. The lowest percentages of wilted plants in the first season were produced by N fertilization combined with the 10.0 g/ridge level of VAM-O (1.65%), VAM-B (3.6%) and VAM-S (3.73%), respectively compared to N fertilizer alone (10.66%). In 2003 season, wilted plants (%) were minimized by N fertilizer + different levels of VAM-S (0.74-1.46%) meanwhile significantly decreased by N+VAM-B at different levels (8.49-9.63%) compared to N fertilizer alone (4.68%). It is interest to state that percentages of wilted plants were significantly decreased by increasing levels of VAM-B, VAM-O and VAM-S while the opposite was noticed in VAM-M. Using N fertilization + any VAM inoculation treatment significantly decreased the common smut disease incidence in 2002 season only (1.91-2.22%) compared to N fertilizer alone (3.11%). Utilizing N+VAM-M (at different levels) were the best in this respect. Percentages of stunted maize plants in both seasons seemed not significantly affected by N+VAM treatments compared to N fertilizer alone.

The same data in **Table (2)** illustrate that the determined growth and yield parameters were responded differently but all were significantly increased as result to combining N fertilization with VAM treatments compared to their corresponding values when N fertilization was used alone. In this respect, using N + VAM-O at the high (10.0 g/ridge) level produced the highest significant increase in the fresh and dry weight (g/plant) in both 2002 & 2003 seasons. However, N+VAM-B at all levels and VAM-S at 10.0 g/ridge level in 2002 season and VAM-M at all levels in both seasons produced the lowest increase in the fresh weight/plant.

Table (2): Effect of VAM inoculation + N fertilization against N fertilization alone on different parameters under field conditions during 2002 and 2003 seasons.

Season	VAM isolate & inoculum level (g/ridge)	Parameters								
		Seed germination %	Wilt %	Smut %	Stunt %	Fresh weight (g/plant)	Dry weight (g/plant)	Ear weight (g)	Grain yield (g/plant)	100-Kernel we. (g)
Control (P alone *)		63.3	10.7	3.1	0.4	305.6	110.4	144.2	61.1	26.67
2002	VAM-B 2.5g	82.3	7.3	2.2	0.0	318.3	124.5	199.4	125.6	29.36
	VAM-M 2.5g	73.7	5.0	0.9	0.0	327.8	106.1	183.6	103.5	26.83
	VAM-O 2.5g	83.7	4.4	2.2	0.4	323.1	113.8	191.7	102.3	29.17
	VAM-S 2.5g	85.0	6.8	1.8	0.0	339.1	127.8	216.5	123.9	29.94
	VAM-B 5.0g	83.0	4.6	2.2	0.0	322.2	124.9	198.1	121.2	29.92
	VAM-M 5.0g	75.3	5.3	0.9	0.0	332.8	118.3	206.7	111.7	28.70
	VAM-O 5.0g	83.3	6.0	2.2	0.9	343.9	123.3	193.4	119.8	29.72
	VAM-S 5.0g	84.0	5.9	2.2	0.0	325.0	118.7	193.3	106.8	29.95
	VAM-B 100 g	84.3	3.6	2.2	0.0	318.8	122.9	186.3	97.6	29.05
	VAM-M 10.0g	79.0	11.1	0.9	0.0	326.1	113.4	181.1	103.8	26.47
	VAM-O 10.0g	85.3	1.7	2.2	0.9	355.8	132.2	193.7	122.5	30.00
	VAM-S 10.0g	83.0	3.7	1.8	0.0	318.2	117.6	182.9	104.0	29.36
LSD. At 5%		3.61	2.30	0.73	NS	10.79	7.78	6.53	16.4	0.763
Control (P alone *)		73.5	4.7	4.3	1.3	224.5	61.3	107.0	54.7	26.67

2003	VAM-B 2.5g	76.7	1.5	1.9	0.7	239.1	63.8	151.7	78.7	30.00
	VAM-M 2.5g	65.3	9.6	2.9	0.7	241.6	64.0	141.9	81.0	27.50
	VAM-O 2.5g	81.3	2.6	3.3	0.7	247.2	70.1	167.0	94.1	27.50
	VAM-S 2.5g	74.5	1.8	2.4	0.7	255.7	71.6	164.4	105.3	29.17
	VAM-B 5.0g	77.7	0.7	2.4	0.7	249.6	68.3	163.3	95.0	30.83
	VAM-M 5.0g	69.2	8.5	2.9	0.7	239.4	66.9	139.7	72.7	27.78
	VAM-O 5.0g	81.3	2.7	2.9	0.7	250.7	73.4	176.7	109.7	29.44
	VAM-S 5.0g	73.3	2.3	1.9	0.7	246.7	71.0	164.4	104.7	29.17
	VAM-B 100 g	76.7	0.9	1.9	0.7	245.7	68.8	151.4	99.8	30.28
	VAM-M 10.0g	63.2	9.4	2.4	0.3	242.1	64.9	137.8	68.0	26.67
	VAM-O 10.0g	82.2	2.3	1.9	0.3	261.1	77.7	177.2	106.9	29.44
	VAM-S 10.0g	70.2	1.9	1.9	0.7	242.8	69.2	159.7	100.4	28.61
LSD. At 5%		3.02	1.221	NS	NS	7.38	3.77	20.59	16.89	1.088

* N fertilization (Ammonium nitrate 33.5% N) alone at 450 kg/feddan was used as control.

Concerning yield components, VAM-S and VAM-B at the 2.5 g/ridge level and VAM-O at 10.0 g/ridge level in 2002 season produced the highest significant increase in ear weight, grain yield/plant and 100-kernels weight, respectively compared to their corresponding values when N fertilization was used alone. Utilizing VAM-O at high level, VAM-O at middle level and VAM-B at middle level gave the best results for the three yield parameters in 2003 season. However, N+VAM-M particularly at low and high levels produced the lowest significant increases in these yield parameters in both seasons compared to applying N fertilizer alone.

DISCUSSION

Comparing with P fertilization, using VAM-O (particularly at the middle and high levels) caused the maximum increase in seed germination and minimum percentage of wilted plants. Using VAM-M and VAM-S (both at the low and middle levels) were the best for reducing percentage of common smutted and stunted plants, respectively (particularly in 2002 season). Using the most tested VAM inoculation treatments particularly VAM-O (at the middle level) and VAM-B (at the high level) significantly increased fresh and dry weight/plant in both seasons. Also, ear weight (g) was significantly increased by all VAM inoculation treatments particularly in 2002 season. Using VAM-B and VAM-S (at the high level) in 2002 season and VAM-O (at the middle and high levels) in 2003 season were best in this respect. Using the 10.0 g/ridge level of VAM-B (in 2002 season) and VAM-S (in 2003 season) produced the highest increases in grain yield/plant. However, using VAM-S, VAM-B and VAM-O (all at the high level) in 2002 season and VAM-B (at the middle and high levels) and VAM-S (at all levels) in 2003 season were the best VAM inoculation treatments for increasing weight of 100-kernels.

However, seed germination in both seasons was significantly increased by all other N+VAM treatments except VAM-M (at all levels) and VAM-S (at 2.5 g/ridge level) in 2003 season only compared to N fertilization alone. Using N+VAM-O (particularly at high level) produced the highest significant increase in seed germination in both seasons. Using N+VAM-B (at all levels) and VAM-S (at low level) significantly decreased seed germination in 2003 season. Using VAM-M at 10.0 g/ridge level in season 2002 and middle level in season 2003 produced the highest increase compared to other its levels. All N+VAM treatments (except VAM-M at 2.5 g/ridge level in the first season and its all levels in the second season) significantly decreased % wilted plants in both seasons. Using N + 10.0 g/ridge level of VAM-O, VAM-B and VAM-S (in 2002 season) and any level of VAM-S (in 2003 season) recorded the lowest percentages of wilted plants. It is interest to state that percentages of wilted plants were significantly decreased by increasing levels of VAM-B, VAM-O and VAM-S while the opposite was noticed in VAM-M. All N+VAM treatments particularly VAM-M (at different levels) significantly decreased the common smut disease incidence in 2002 season only. Percentages of stunted maize plants in both seasons seemed not significantly affected. All N+VAM inoculation had positive significant effect on all the determined growth and yield parameters. Using N+VAM-O (at high level) produced the highest increase in the fresh and fry weight (g/plant) in both 2002 & 2003 seasons. Using VAM-S and VAM-B (at low level) and VAM-O (at high level) in 2002 season produced the highest increase in ear weight, grain yield/plant and 100-kernels weight, respectively. While, VAM-O (at high level), VAM-O (at middle level) and VAM-B (at middle level) gave the best results for the three yield parameters, respectively in 2003 season.

In fact, the VAM colonized plants are better nourished and better adapted to its environment consequently its growth and health is improved and protection against environmental conditions detrimental to their survival is increased **(Sylvia & Williams, 1992)**. That symbiosis tends to reduce the incidence of root diseases and minimizes the harmful effect of certain pathogenic agents **(St-Arnaud *et al.*, 1996)**. However, the tested VAM isolates might be varied concerning their beneficial effects to the maize plants under certain circumstances. To increase the effectiveness of phosphate extraction from the soil, **Jakobsen *et al.* (1992a, 1992b)** reported that, some VAM fungal species mainly explore the soil immediately adjacent to the root, while others explore it more distantly. Efficiency of VAM fungi was greatly varied. The VAM fungi seemed to be more effective under low than high levels of P application **(Trotta, *et al.*, 1991; McArthur and Knowles,**

1993; Mahaveer and Adholeya, 2000). The seed yield of VAM inoculated-plants, under field conditions characterized by a 10.0 g/ridge level of P and N, increased by 28 and 17% in comparison with non- and only rhizobia- inoculated soybean, respectively **(Vejsadova, *et al.*, 1993)**. **Gurumurthy and Sreenivasa (1996)** studied the response of *Capsicum annum* to different levels of *Glomus macrocarpum* (0, 25, 50, 75 or 100 g/10 kg unsterile soil) in 2 soil types. A matching trend was recorded in fresh fruit weight and plant dry weight, which increased with the increase in inoculum level up to 50 g/10 kg soil in both the soil types. All these parameters were significantly higher in red soil than black clay soil. **Das, *et al.* (1997)** inoculated seeds of *V. radiata* with Rhizobium and/or VAM (*Glomus fasciculatum*) culture applied at 15 kg/ha. Shoot and root lengths, number of pods/plant and dry weight of pods were increased with dual inoculation compared with the uninoculated control. Seed yield was significantly higher with Rhizobium + VAM compared with no inoculation.

The present results indicated that the VAM fungi are not specific in terms of the partner plant they choose, which means that the same fungus can be colonized a large number of plant species **(Natalia Requena *et al.*, 1999** and **Buee *et al.*, 2000)**. In addition, variations among VAM isolates might be more benefit to a host plant than others under certain conditions and might be only benefit in infertile soils. The benefit provided by mycorrhizas decreased as the degree of (inoculum level) mycorrhizal colonization of roots increased **(Gange, 1999)**. The VAM-M (isolated from maize), however, showed the lowest improvement in the most determined parameters concerning plant growth, yield components and disease incidence particularly wilt disease. These results could be explained in light of the well-known detrimental effects of the monoculture crop rotation. In the present study, VAM-M was inoculated into to the same crop from which it was isolated and this resulted in similar depressions and detrimental effects associated with monoculture crop rotation. **Johnson *et al.* (1992)** suggested that, compared to other fungi, proliferating VAM fungal species might be less beneficial (or perhaps detrimental) to the crop in which they proliferate. **Barnola *et al.* (1996)** stated that the VAM fungus *Glomus intraradices* decreased pepper mass, whereas *G. microcarpum* increased mass of corn plants under greenhouse conditions (pasteurized soil) compared with the controls. However, *G. intraradices* had no significant effect on pepper mass under field conditions, whereas it significantly decreased mass of sweet corn. However, **Dickson *et al.* (1999)** found that the fungal isolates that perform poorly in some experiments may provide substantial benefits to plants in other trials where growing conditions are more suitable for that particular fungus.

El-Fiki *et al.* (2001) investigated effect of adding VAM inocula (BM-cultures) to the potted sterilized soil at different levels (1, 2, 4 and 6 g/pot) on different growth parameters maize plants. Degree of improvement, however, was quite varied and depended on the growth parameter tested, VAM isolate and its inoculum level. They added that, the VAM-O (isolated from onion) was more effective at the lowest inoculum level and this trend was completely reversed in VAM-S (isolated from Swiss cheese) while, VAM-B (isolated from broad bean) gave the best results at the intermediate inoculum levels. **Srivastava *et al.* (2001)** conducted a replicated field trial, with 12-year-old trees of guava at three levels of *Glomus mosseae i.e*. 2.5, 5.0 and 10 kg symbiont mixed with farmyard manure (FYM), with and without FYM. The percent wilting of trees recorded was lower (44.8 to 75.2%, mean 62.0%) in VAM fungi-treated trees than the two controls (80.6 and 100%, mean 90.3%). However, the response was not in accordance with the dosage. Based on the overall performance, the use of VAM symbiont at the rate of 5 kg/tree appeared to be beneficial.

In fact, the VAM fungi could increased growth and yield of their hosts as well as their disease resistance through different ways. **Sharma & Adholeya (2000)** stated that, in most instances, VAM significantly change the physiology and chemical constituents of the host, the pattern of root exudation, and the microbial composition of the rhizosphere. In this respect, the VAM effects on plant nutrition, especially P nutrition is a mechanism of disease control. **Garcia-Garrido1 & Ocampo (2002)** mentioned that the response of plants to VAM fungi involves a temporal and spatial activation of different defense mechanisms. The activation and regulation of these defenses have been proposed to play a role in the maintenance of the mutualistic status of the association, however, how these defenses affect the functioning and development of VAM remains unclear. A number of regulatory mechanisms of plant defense response have been described during the establishment of the VAM symbiosis, including elicitor degradation, modulation of second messenger concentration, nutritional and hormonal plant defence regulation, and activation of regulatory symbiotic gene expression.

CONCLUSION

The VAM fungi now could be isolated and grown in axenic cultures and their inocula could be produced in mass production *in vitro*. The *in vitro* VAM inocula could be contributed in agriculture systems, in similar way as the nodule bacteria (*Rhizopium* spp.), and gradually could be integrated with conventional agricultural practices. The appropriate management of VAM fungi in agriculture allows a substantial reduction in applications of fertilizers and pesticides, reducing farm work, maintenance and costs of production, while maintaining yields at their highest levels. The *in vitro* VAM inocula could be used instead of P fertilizers and maximized beneficial responses of N fertilizers.

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نقييم تأثير لقاح فطريات الميكورهيزا الحويصلية الشجيرية المنتج معمليا على إصابة نبات
الذرة ببعض الفطريات وصفاتها النباتية والمحصولية تحت ظروف الحقل

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تم في هذه الدراسة استخدام أربعة عزلات من فطريات الميكورهيزا الحويصليّة الشجيرية سبق عزلها من جذور البصل (VAM-O) ، الفول (VAM-B) ، القشطة (VAM-S) ، الذرة (VAM-M). وللحصول على لقاح تلك العزلات تم تنميتها تحت ظروف المعمل على بيئة شعير محورة – و تم استخدام هذا اللقاح (المنمى على بيئة الش المحورة) بثلاثة مستويات عاليةَ ومتوسطةَ ومنخفضةَ (تقابل 10, 15 و20 كيلوجرام/فدان على التوالي) من خلال مجموعتين من تجارب الحقل تم تنفيذهما أثناء موسمى 2002 ، 2003 لتقييم تأثير استعمال لقاح تلك العزلات م (مقارنة بالسماد الفوسفاتى) أو مصحوبا باستخدام السماد الآزوتى (مقارنة بالأخير منفردا) على المعايير التال إنبات بذور الذرة ، النسب المئوية لنباتات الذرة الذابلة والمتقزمة والمصابة بالتفحم العادى وكذلك الأوزان الغ للنبات ، وزن الكوز ، وزن محصول البذور للنبات بالإضافة إلى وزن الـ 100 حبة.

أظهرت النتائج اختلاف الاستجابة لتأثير المعاملات المستخدمة تبعا لمعيار القياس ، مصدر العزلة الف تركيز اللقاح المستخدم ، موسم النمو. وبشكل عام كانت استجابة بعض المعايير لبعض معاملات تلقيح معينة (ومعدلات تلقيح) أفضل معنويا عند مقارنتها باستخدام السماد الفوسفاتى كما كانت الاستجابة لبعض معاملات ا المترافقة مع استعمال السماد الآزوتي أفضل معنويا عند مقارنتها باستعمال الأخير منفردا.