EXPERIMENTAL RESULTS

4. RESULTS

4.1 Ecology of VA Mycorrhizae in some Egyptian soils:

VA Mycorrhizea are widely distributed geographically and occur in nearly the intire plant kingdom throughout the world, Gianinazzi-person & Diem, (1982); Gianinazzi-Pearson, (1986); Fitter, (1990). In large areas of the world including most of African continent, particularly in Egypt, there is little or no information about VAM occurrence. Ishac et al. (1985) reported that VA mycorrhizal fungi were present in all plants collected from different provinces. In addition, Fares (1986) found that onion, clover, maize, tomato and citrus plants grown in different Egyptian soil had high infection levels.

4.1.1 Survey of VA mycorrhizal fungi in Egyptian soils:

Table (2) lists the type of examined natural and cultivated plants, the sites of collection, percentage of root colonization, spore densities and differentiation of spores to different genera and species for each soil. From 72 plant species, 64 had VA Mycorrhizae. All cultivated plants from the agricultural areas of El Sharkia, El-Munofia, El-Behera, El-Gharbia El- Kalubia, Ismailia, Suze, Alexandria, North Sinai, South Sinai, West North coast, Banysweef and Aswan had VA Mycorrhizal colonization. Some field crops were infected by VA Mycorrhiza. The intensity values for cortical infection, M%, varied from 78.2 to zero. The average percent M values for onion, maize, colver, been , barely and wheat were 9.4, 40.2, 26.0,28.8, 450.0 and 20.6, respectively.

Table(2)Plants and their rhizosphers collected from different Egyptian localities, percentage of VA mycorrhizal colonization (M%), spore denisties/100 gm soil and percentage of fungi species.

Locality	Plant species	Family	M%	Spore No /100gsoil	Percentage of fungi spores							
					Gl-Mossea%	Gl.fasicu-latuum %	Gl-Clarum%	Gl.Mono-sporum%	Gl-Clado-nicum %	Gi-marga-rita %	A.Laevis %	S.Clavis-pora %
El-Sharkia												
1.Belbasel 1	Trifolium alex.	Leguminosae	78.2	305.5	17.0	14.0	3.0	15.0	7.0	3.0	2.0	39.0
2	Zea maize	Gramineae	69.7	291.8								
2-Bahr-El-Bakar	Vicia faba	Leguminosae	5.2	75.0	8.0	8.0	21.0	5.0	3.0	1.0	0.0	54.0
	Trifolum alex	Leguminosae	37.0	200.1								
	Zea maize	Gramineae	41.1	125.6								
	Lycopersicum esculantum	Solanaceae	21.3	90.9								
El-Salhya	Zea maize	Gramineae	71.5	355.1	3.0	12.0	0.0	1.0	5.0	0.0	3.0	76.0
El-Kassasin	Vicia faba	Leguminosae	49.2	219.								
Munofia												
Quisna	Zea maize	Gramineae	56.1	289.3	10.0	6.0	9.0	3.0	11.	8.0	16.0	37.0
	Triticum spp	Gramineae	39.9	248.0								
El-Beheira												
Damanhour	Triticum spp	Gramineae	17.1	67.0	10.0	4.0	17.0	6.0	9.0	8.0	18.0	28.0
	Triticum spp	Gramineae	18.7	78.3								
	Zea maize	Gramineae	15.9	89.0								
El-Gharbia	Pisum stativum	Leguminosae	17.9	69	19.0	18.0	0.0	10.0	2.0	1.0	0.0	40.0
Tanta	Zea maize	Gramineae	22.2	63.1								
	Trifolum alex	Gramineae	23.8	58.2								
El-Kalubia	Allium sativum	Amarylidaceae	25.9	168.0	8.0	0.0	5.0	2.0	4.0	3.0	10.0	68.0
	Trifolum alexand	Leguminosae	65.6	162.0								
	Vicia sativum	Leguminosae	74.7	160.0								
	Lactuca sativa	Compositae	60.6	410.0								
Ras El-Bar	Halocneum strobilaceum	Chenopodiaceae	0.0	0.0								
	Atriplex halimus	Chenopodiaceae	14.0	17								
	Conyza dioscoridis	Compositie	0.0	0.0								
	Zygopyllum album	Zygophyllaceae	0.0	0.0								
	Polygonum equistiforme	Polygonaceae	25	18.0								
Ismailia	Hordium vulgare	Gramineae	28.6	325.0	17.0	9.0	14.0	0.0	6.0	4.0	12.0	38.0
	Triticum spp	Gramineae	38.0	250.0								
	Vicia faba	Leguminosea	21.9	125.1								
Abo-Soltan	Launaea resedifolia	Compositae	0.0	0.0	15.0	18.0	15.0	8.0	5.0	17.0	7.0	15.0
	Anabasis setifera	Chenopodiaceae	8.2	4.4								
El-Suez	Zygophyllum coineum	Zygophyllaceae	0.0	0.0	15.0	6.0	0.0	5.0	17.0	15.0	0.0	42.0
	Zygophyllum decumbens	Zygophyllaceae	0.6	5.2								

Table(2): Cont.

Locality	Plantspecies	Family	M%	Spore No /100gsoil	Percentage of fungi spores							
					Gl-Mossea%	Gl.fasicu-latuum %	Gl-Clarum%	Gl.Mono-sporum%	Gl-Clado-nicum %	Gi-marga-rita %	A.Laevis %	S.Clavis-pora %
Garb El-Nafak	Triticum spp	Gramineae	9.2	50.0	18.0	6.0	6.0	9.0	2.0	0.0	1.0	58.0
	Vicia faba	Leguminosae	0.0	0.0								
El-tor	Trifolium alex	Gramineae	2.0	9.0	22.0	8.0	0.0	13.0	17.0	8.0	0.0	32.0
	Lycopersicum escu.	Solanaceae	5.0	20.0								
Wadi-sudr	Hordium vulg	Gramineae	1	10.0	15.0	7.0	3.0	18.0	4.0	13.0	3.0	37.0
	Lycopersicum escu.	Solanaceae	12.0	13.0								
	Trifolium alex	Gramineae	3.0	40.0								
	Allium sativum	Amaryllidaceae	0.0	10.0								
	Triticum spp	Gramineae	4.9	50.1								
	Allium cepa	Amaryllidaceae	2.2	1.5								
Wadi-firan	Triticum spp	Gramineae	7.1	50.9	19.0	0.0	7.0	3.0	0.5	5.0	0.0	61.0
	Vicia faba	Leguminosae	21.9	180.0								
Nuweibaa	Lycopersicum esculantum	Solanaceae	61.9	625.1	2.0	6.0	9.0	0.0	13.0	10.0	8.0	52.0
	Triticum spp	Gramineae	3.9	20.0								
El-Arish	Zea maize	Gramineae	6.1	90.5	17.0	10.0	0.0	12.0	9.0	9.0	0.0	43.0
	Olea europaea	Oleaceae	-	156.7								
El-Shiek zoid	Lycopersicum esculantum	Solanaceae	1.9	80.9	21.0	3.0	4.0	9.0	5.0	12.0	18.0	28.0
	Zea maize	Gramineae	1.8	50.6								
Rafah	Trifolum alex	Gramineae	7.8	117.0	20.0	0.0	19	0.0	0.0	0.0	0.0	61.0
Borg El-Arab	Cyperus laevigatus	Cyperaceae	0.0	10.4	0.0	0.0	0.0	32.0	0.0	0.0	7.0	61.0
	Zygophylum album	Zygophyllaceae	2.5	18.0								
Mersa matruh												
El-Dabaa	Triticum spp.	Gramineae	22.1	190.1	13.0	0.0	18.0	9.0	16.0	18.0	7.0	19.0
El-Gafra	Hordium vulgare	Gramineae	17.8	270.0								
Sidy-barany												
El-makafy	Hordium vulgare	Gramineae	32.1	35.0	1.0	1.0	18.0	1.0	7.0	0.0	0.0	72.0
El-Shekan	Lentis esculenta	Leguminosae	24.9	24.3								
Om-gaber	Hordium vulgare	Gramineae	15.0	14.3								
Rass El-hekma	Hordium vulgate	Gramineae	9.2	60.3	9.0	1.0	9.0	0.0	1.0	13.0	2.0	65.0
El-Sallom	Hordium vulgare	Gramineae	3.8	70.1	14.0	4.0	17.0	0.0	13.0	16.0	0.0	36.0
Siwa 1	Hordium vulgare	Gramineae	28.9	160.7	2.0	0.0	3.0	10.0	5.0	11.0	0.0	69.0
2	Triticum spp		22.1	150.0								
El-nagden	Hordium vulgare	Gramineae	18.0	75.0								
Bany sweef	Zea maize	Gramineae	53.4	155.0	5.0	1.0	4.0	12.0	3.0	11.0	9.0	55.0
Aswan	Lycopersicum esculentum	Solanaceae	15.2	98.3	15.0	1.0	11.0	6.0	3.0	15.0	0.0	49.0

Morover percent Mvalues were 14.6, 60.6 and 17.9 for tomato, lettuce and peas. It should be stated that the calculated average M values should not be depended upon because they were calculated from unequal number of observations beside the properties of the locations were diversified. In contrast, the widc range of M values for natural plants were always less than 15%.

A number of plant species were Juncus acutus, Juncus rigidus (Juncaceae) Cyperus leavigatus (Cyperaceae), Halocnemum strobilaceum, Arthrocnemum glaucum, (Chenopodiaceae), Zygophyllum decumbens, Zygophyllum album (Zygophyllaceae), Launaea resedifolia (Compositae) Ammophila arenaria (Geramineae), Salvia lanigera (Labiatae) and Matthiola longipetala (Cruciferae), found to be non-mycorrhizal, can be considered incompatible towards mycorrhizal fungi. This result is in agreement with earlier one, Gerdemann, (1968); Sanders et al., (1975); Hirrel et al., (1978); Harley & Smith (1983); Berch et al., (1988). On the other hand, few species of the fore mentioned families formed VA Mycorrhizae, like *Suaeda vermiculate* (Chenopodiaceae), *Lactuca sativa* and *Iphiona mucronata* (Compositae). These results are in agreement with, Williams et al., (1974) Ocampo and Hayman (1980); Allen, (1983); Harley & Harley, (1987); Berch et al., (1988) who stated some species belonging to two families, Compositae and Chenopodiaceae, form VA Mycorrhizae.

There was no obvious relationship between extracted spore numbers and percentage of mycorrhizal infection, but spores were generally absent or present in very low amount in soils where non

Table (3): Soil physico-chemical properties and average number of VA Mycorrhizal fungi.

Governorate	Location	CaCo₃ %	pH	Gravel 72 mm%	total Sand	Silt %	Clay %	Texture Class	O.M %	Total N ppm	C/N Ratio	EC mm hos /cm	Anions (gm/L)			Cations mg/L				total P ppm	spore no/100g
													HCO_3^-	CL^-	SO_4^-	Ca^{++}	Mg^{++}	Na^+	K^+		
El-Sharkia	- Belbase	2.5	7.3	-	69.8	9.5	20.7	S.C.L	3.2	300.0	61.87	1.1	2.1	3.1	5.4	0.9	4.7	4.7	0.2	28.7	298.7
	- Bhar El-Bakar	1.1	7.4	9.8	100	-	-	Sandy	1.5	310.3	28.037	3.6	2.7	24.1	13.2	7.8	10.8	21.0	0.4	13.2	122.9
	-El-Salhya	0.63	7.1	-	100	-	-	Sandy	6.2	270.0	133.18	2.1	2.3	11.9	6.8	5.1	4.1	13.8	0.3	10.5	355.1
	-El-Kassasin	2.1	7.9	11.6	73.5	7.8	18.7	sandy- loam	4.2	351.0	69.40	1.6	2.2	7.7	6.1	4.3	7.6	10.0	0.4	19.4	219.0
Munofia	Quisna	0.60	73	-	27.9	28.4	43.7	clay	2.0	580	19.99	0.7	1.5	2.9	2.6	2.1	1.8	2.3	0.8	33.1	287.0
El-Behera	Damanhour	0.80	8.0	-	21.9	33.3	44.8	clay	4.1	526.5	45.17	1.6	2.2	10.5	5.3	4.4	2.2	10.8	0.6	35.2	78.1
El-Gharbia	Tanta	1.8	7.9	-	28.9	29.2	41.9	clay	3.2	553.5	33.53	0.8	1.7	3.5	2.8	2.3	1.0	3.6	0.3	23.7	63.4
El-Kalubia		8.5	7.74	-	10.1	34.7	52.2	clay	7.3	255.0	163.76	2.81	2.4	12.2	8.4	7.6	4.2	9.9	1.3	49.6	225.0
*Ras El-Bar		5.4	8.02	-	100	-	-	sandy	0.3	90.0	19.3	9.8	5.3	90.9	8.8	16.5	5.6	79.2	3.7	9.4	7.0
Ismailia	Agric. area Abo-soltan	6.75	7.88	-	100	-	-	sandy	0.8	16.0	29.0	4.07	4.3	25.2	16.5	9.5	3.9	30.0	2.6	3.9	2.2
Suze	Sand area	8.5	7.74	-	100	-	-	sandy	9	4.16	125.48	2.81	2.7	23.0	4.3	7.34	5.4	16.96	0.30	4.16	5.2
	AH- tunnel	3.1	7.3	12.7	64.7	13.5	21.8	sand caly loam	1.44	243	34.32	3.5		29.0	8.0	9.6	7.8	22.0	0.6	3.81	25.0
North sinai	El-Arishsh1 1	3.7	7.8	-	100	-	-	Sandy	0.475	310.5	8.87	5.4	2.6	39.8	19.7	21.3	5.7	34.3	0.8	12.1	90.5
	2	24.1	7.4	-	78.6	14.6	6.8	Loamy S	0.373	256.5	8.43	6.8	3.0	42.9	29.3	13.8	3.9	55.9	0.4	27.5	156.7
	El-Shickh 1	10.4	7.4	-	100	-	-	Sandy	0.561	243.9	13.34	4.4	2.7	31.1	14.2	9.2	7.0	31.1	0.7	15.2	80.9
	Zoid 2	32.4	7.6	-	72.5	11.5	16.0	Loamy S	0.533	337.5	9.16	5.3	3.1	42.8	14.1	11.4	8.4	39.6	0.5	30.1	50.6
	Rafah	6.5	7.3	-	100	-	-	Sandy	0.494	324.0	7.88	4.2	2.6	31.4	13.0	13.6	4.4	28.5	0.4	4.8	117.0
South sinai	wadi sudr	40.9	7.6	-	81.7	8.5	9.9	sandy Loamy	0.227	148.5	17.19	10.4	3.0	83.2	35.7	31.9	6.7	79.5	1.8	3.2	11.5
	El-tor 1	42.6	7.7	-	100	-	-	Sanyd	0.359	337.5	6.17	8.4	2.7	65.3	24.8	15.7	2.8	74.1	0.9	2.81	25.0
	2	40.2	7.8	-	100	-	-	Sandy	0.287	297.0	5.6	9.4	3.2	73.1	29.5	27.9	3.7	73.8	1.4	2.6	25.5
	Wadi feran	2.1	7.3	10.5	100	-	-	Sandy	0.313	305	5	3.1	2.1	17.9	14.5	10.3	2.8	20.9	0.3	4.16	165.5
	Nuweibaa	56.8	8.1	-	80.5	5.0	14.5	sandy loam	1.99	189	6.1	8.7	3.0	68.0	29.1	6.5	5.3	87.0	1.2	19.4	625.1
Alexandria	Borg EL-Arab	93.8	8.31	-	-	100	-	calcareous	0.80	0.13	3.56	18.5	2.2	82.3	125.5	62.4	50.9	94.7	2.0	3.13	14.2
North west coast	El-Daba	28.6	7.4	-	100	-	-	Sandy	1.83	162.0	65.51	4.6	2.2	23.3	25.5	15.4	5.1	30.3	0.0	6.9	190.0
	Ras-El-Hekma	42.2	7.6	-	6.3	14.8	22.9	Loamy S	0.211	229.5	5.33	5.2	1.7	45.3	2.0	7.1	5.8	44.8	0.4	18.8	60.30
	El-Gfera	24.1	7.8	-	60.4	17.8	22.8	Loamy S	0.143	324.0	2.56	4.6	2.2	13.1	20.6	3.8	7.4	31.1	0.7	23.7	270.0
	Sidi-Barany	18.0	7.6	-	100	-	-	Sandy	0.294	270.0	6.32	5.4	2.6	43.0	15.4	5.8	6.1	38.1	0.8	31.1	350.0
		32.3	7.8	-	70.5	19.5	20.0	Loamy	0.203	243.0	4.85	5.1	3.2	42.2	11.9	5.5	1.1	41.1	0.4	15.9	19.3
	El-Saloam	44.4	7.1	-	100	-	-	Sandy	0.300	94.0	18.51	7.2	2.7	69.7	9.7	6.1	3.5	61.5	0.5	9.4	70.1
	Siwa	21.1	7.8	-	71.5	8.5	20.0	Loamy S	0.124	148.5	4.84	3.2	2.2	26.5	6.3	8.1	9.6	17.6	0.3	19.5	155.4
	El-Nagden	16.5	8.1	-	58.5	19.0	22.5	Sandy clay loam	0.178	175.5	5.88	4.2	3.3	31.6	3.1	9.3	3.5	39.7	0.5	8.7	75.2
	Bany sweef	1.8	7.98.4	-	28.9	29.2	4.9	Clay	0.554	553.5	5.82	0.8	2.7	8.8	2.8	3.2	0.8	5.8	0.5	18.2	155.0
	Aswan	25.62		-	81.1	10.0	8.9	Sandy loam	0.034	0.012	2.84	0.72	1.4	3.3	1.8	3.4	0.8	2.9	0.2	37.8	98.3

mycorrhizal plants were growing Table (2). For natural plants, sporulation may be affected by interactions between endophyte species Warner & Mosse, (1979); or may be depressed either by hyperparasitic fungi, Schenck & Nicolson, (1977) or soil fauna McGonigle & Fitter, (1988). The variations in the number of spores and percent infection between some plants grown at the same site and collected at the same time may result from local variations in edaphic factors, soil nutrients or differences in plant genotype and stage of development, Antibus & Linderman, (1985); Berch et al., (1988).

4.1.2. Physico-chemical nature of the soil and spore density:

Data concerning the relationship between the physico-chemical nature of the soils and the number of VA Mycorrhizal spores are listed in Table (3). All soils had pH values greater than 7.0. Total phosphorus contents indicate that the fertility of these soils was slightly high to low. Although, all sandy soils had very low amounts of total P, yet spore densities widely vary, slightly high, low or even absent. In contrast, clay loam and sandy clay loam soils have total P and spore numbers moderately high. High levels of soil P generally have negative effects on mycorrhizal infection and spore production but under natural vegetation, soil P will be strongly affected by other factors such as soil type, P fixing capacity, pH, nitrogen level, microbial activities and host endophyte combinations, Hayman, (1982); Schenck & Perez, (1987).

Table (4) shows the relationship between the number of spores, the rate of colonization and the salinity level. In moderate salinity areas, Table (4):Comparison between soil salinity, organic matter, calcium carbonate, number of VAM spores and rate of colonization of different plant species collected at five sites of Egyptian soils.

Loca-lity	Soil tex ture	Plant species	M%	No of sp/100g	Salinity (µmhos. cm^{-1})	OM %	$CaCO_3$ %
Wadi Sudr	Loamy sandy	*Hordeum Vulgar*	1	10.0	10.4	0.23	40.9
		Lycopersicumesculentum	12	13.0			
		Trifolium alex	3.0	40.0			
		Allium sativum	0.0	10.0			
		Triticum spp.	4.9	50.1			
		Allium Cepa	2.2	1.5			
El-Tour	Sandy	*Trifolium alex*	12.0	9.0	8.4	0.36	42.6
	Sandy	*Lycopersicum esculantum*	5.0	20.0	9.4	0.29	40.2
Nuweiba	Sandy loam	*Lycopersicum esculantum*	61.9	625.1	8.7	19.9	65.8
		Triticum spp	3.9	20.0			
Borg El-Arab	Calc-areous	*Iphiona mucronata*	42	22.0	21.0	0.80	93.7
		Pallenis spinosa	45.8	14.0	22.0	0.70	93.5
		Suacda vermiculata	50	21.8	17.0	0.70	93.7
		Hellanthemum lippii	29	10.8	16.0	0.85	93.7
		Thymelaea hirsuta	15	3.2	20.0	0.54	94.0
		Ammophila arenaria	0.0	5.4	25.5	0.8	94.0
Saline area of Ras-El-Bar	Sandy	*Halocnemum sp.*	0.0	0.0	59.0	0.30	4.5
		Arthrocnemum glaucum	0.0	0.0	59.0	0.32	5.6
		Juncus acutus	0.0	0.0	43.0	0.33	5.0
		Juncus rigidus	0.0	0.0	25.5	0.37	5.0
		Inula cithmoides	0.0	0.0	28.0	0.15	7.5
		Conyza dioscoridis	16.7	10.4	19.0	0.18	4.0
		Cyperus laevigatus	0.0	0.0	25.5	0.37	5.0
		Tamarix nitotica	24.4	18.7	35.0	0.73	4.5
		Zygophyllum albuim	13.3	7.0	16.0	0.20	8.5

As for the affect of soil salinity on the VAM infection, It's noticed that Wadi Sudr, El-Tor and Nuweiba have low rate of colonization and spore number except in case of Nuweiba sandy loam soil which have high organic matter content, 19.9%, and have high rate of colonization and spore number, 61.9 m% and 625.1 spores / 100 g soil, respectively. There were no spores of VA mycorrhizal fungi found in the highly saline area of Ras El-Bar. Exceptions were found for three rhizosphere soils where *conyza dioscoridis, Tamarix nitotica and zygophyllum album* were naturaly grown, although their salinity levels varied from 16.0 to 35.0 dsm^{-1}.

Generally, soil salinity appeared to be a limiting factor. There was a negative relationship between the number of VA Mycorrhizal fungi spores and soil sodium concentration. Similar results were reported by Hirrel, (1981); Trappe, (1981); Tinker & Gildon, (1983); Kim & Weber, (1985); Rozema et al., (1986); Van Duin et al., (1990). In addition, the germination of *Gigaspora margarita* and *Glomus mosseae* spores are reduced in the presence of high NaCl concentration, Hirrel & Gerdemann, (1980); Estaun, (1990). However, Bowen (1980) reported that typical VA mycorrhizal infection and spores could be found in a soil with 500 ppm Cl^{-1}.

Soils collected from cultivated areas which had high organic matter, have high spore numbers. It is possible that organic matter stimulate the growth of both fungus and host, therefore, enhance symbiosis. Organic matter may play an important role in providing the substrate for limited saprophytic existence of VA mycorrhizal fungi, Fassi et al., (1972); Blaschke, (1979); Brechelt, (1990).

4.1.3. Morphological Characteristics and Identification of VA Mycorrhizal Species Isolated from Egyptian Soils:

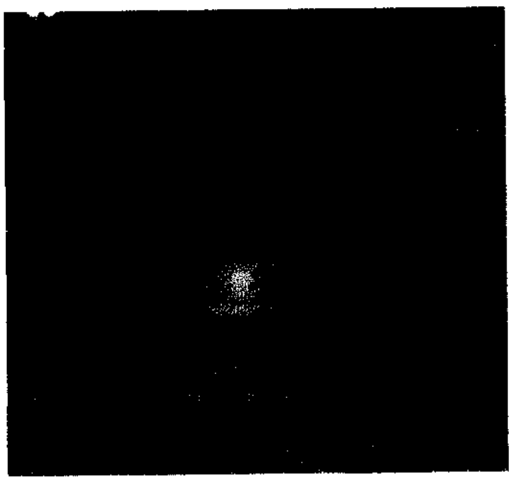
The morphological characteristics of VA mycorrhizal spores found in different Egyptian soils are presented in Table (5) and illustrated in plate (1). The shape of the spores were spherical, globose, ellipsoid or irregular and their longest dimension generally ranged from 40-740 um. The spores were surrounded by wall, which varied in thickness, in function of the spore species, and had either aseptate, cylindric to flaring inflated or constricted hyphae. Some spores were attached to a suspensor like cell, bulbous attachment. Generally, spores were borne terminally on the hyphae either singly or in clusters. Sporocarps were also detected in some sites. The colours of spores were hyaline, yellow, brownish yellow black, blackish brown and greyish. These characteristics are in agreement with those recorded by Gerdemann & Trappe, (1974); Hall & Fish, (1979); Schenck & Smith, (1982); Trappe, (1982); Hall, (1984) and Morton and Benneyl (1990).

Table (5): Morphological characteristics of VA-Mycorrhizal fungi species isolated from Egyptian soils.

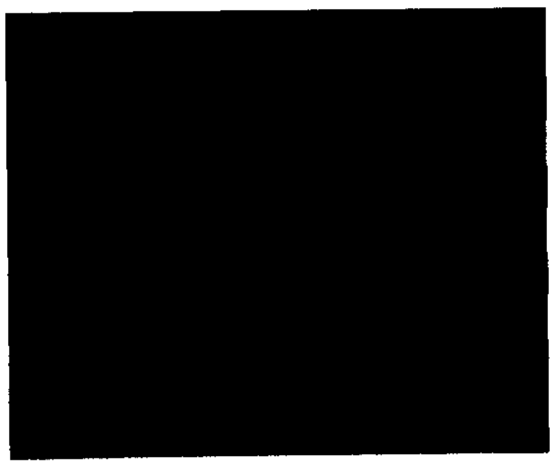
Spore							subtending hyphae	VA mycorrhizal fungal species
sporocarp	shape	colour	form	diameter um	contents	wall		
present (contain 2-6 spores)	globose ovoid with projecting base	yellow, brown	single	110-300	white to hyaline or globular	two layers with thick brownish yellow inner layer	A septate, inflated or constricted hyphae. Curved septum at the base in the neck of the funnel of hyphae which separated the spore contents from the sporophyte	Glomus mosseae (Nicol & Gerd)
Present	globose or subglobose or ellipsoid	greyish, brown, yellow	aggregated in small compact clusters	40-85	numerous lipid globules	thickness (5-12um) hyaline to light yellow	aseptate inflated	Glomus fasiculatum Gerdemann & Trappe
Absent	globose to subglobose	hyaline	single or in small clusters	60-1240	globules of variable size or granules	two layers (8-28um)	15-80um wide with thick wall and chlamydospores produced at apex	Glomus clarum (Nicolson & Schen K).
Present (contains) clamydospore)	globose to subglobose, ellipsoid	brown to yellow	in globose toellipsoid sporocarps	148-334	oil globules	4-10 um, composed of thin outer wall thickinner wall	8-12, um in diam strongly recurved, thin walled	Glomus monosporum (Gerdemann & Trappe).
Absent	globose to subglobose	yellow to brown	single	120-320	globular	6-10um, composed of a hyaline thin outer layer and yellow thick inner layer	aseptate, curved, wall	Glomus cladonicum (Nicol & Gerd)
Absent	globose	white to light brown	single	459-460	small oil droplets	smooth, 5-24 um thick bulbous attached to the spore	suspensor-like cell 27-58 um, smooth walls, thick at the point of attachment to the spore	Gigaspora margrita (Becker & Hall
Absent	globose,	red-brown, yellow, brown	single	110-280	homogenous or hyaline	three layers, yellow brown outer wall and hyaline inner membranes.	-	Acaulospora larvis (Gerdemann & trappe).
Present globose to sub-globose	Broadly clavate	brownish to black	formed in single tightly packed layer around a central plexus of hyphae	140-175	granular	1.5-5µm, the sides at the spore apex thickened to 17-25 µm, yellow,brownish black.	aseptate and chlamydosprores produced to apex	Sclerocystis clavispora (Trappe)

A- Clusters of azygospores of *Glomus fasiculatum* (65 um) with a septate inflated subtending hyphae

B- Brown clamendospore of *Glomus monosporum* with strongly recurved thin walled substending hyphae



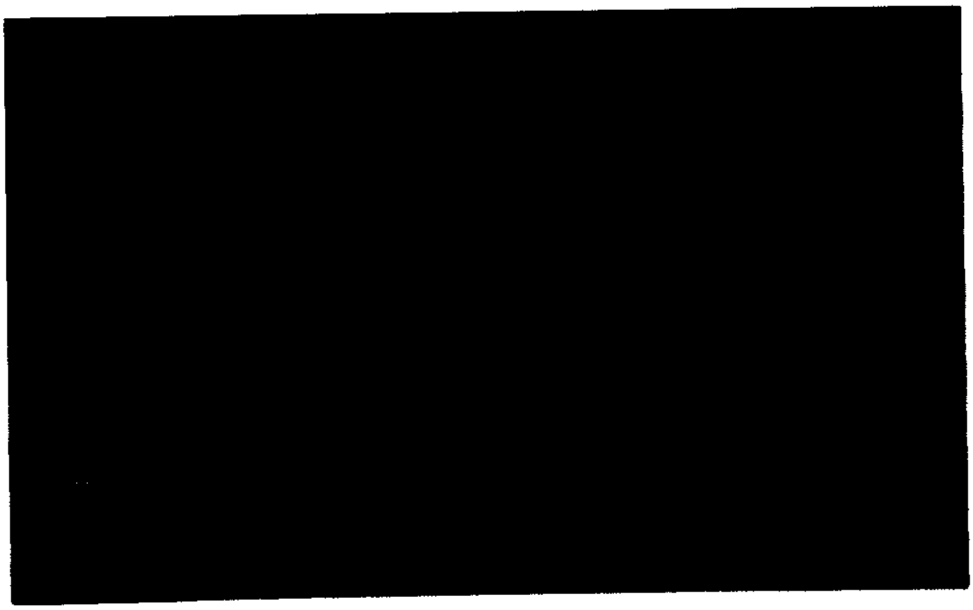
C- Brown axygospore of *Glomus cladonicum* (150 um) with a septate curved wall subtending hyphae.



D- Globose hyaline azygospore of *Glomus clarum* (230 um) with subtending hyphae.

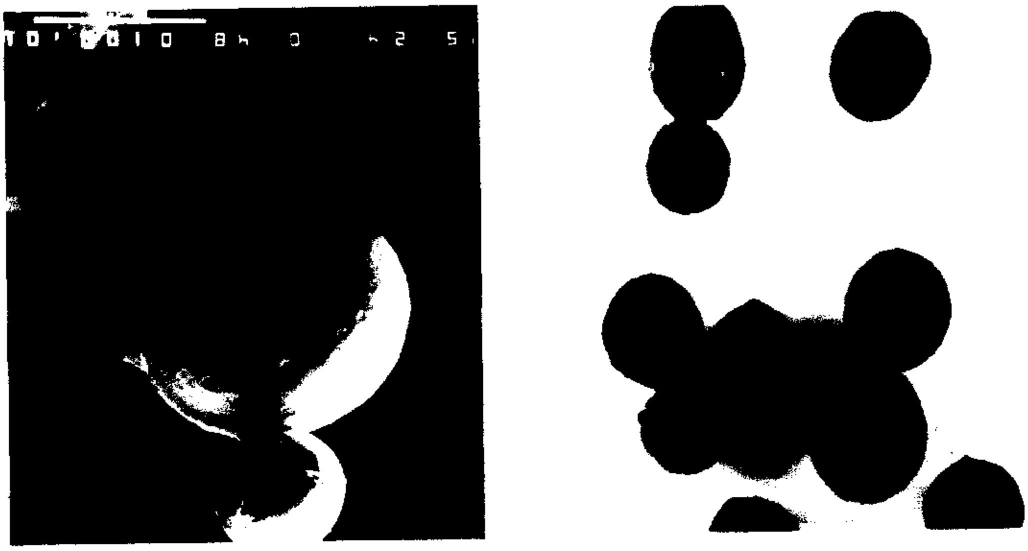
Plate 1: Some spores of Vasicular-Arbuscular Mycorrhizae in some Egyptian soil.

E- Chlamedospore of *Glomus mosseae* (200um) with aspetate curved subtending hyphae.



F- Azygospore of *Acaulospora larvis* (200 um).

Plate 1(Cont.): Some spores of Vasicular-Arbuscular Mycorrhizae in some Egyptian soil.



G. Sporocarps of Sclerocystis clavispora

H. Transverse sectionof stained *Sclerocystis clavispora* spore showing the arrangement of spores inside the sporocarp.

I. Azygospore of *Gigaspora margrita* (360um) with bulbous based subtending hyphae.

Plate 1(Cont.): Some spores of Vasicular-Arbuscular Mycorrhizae in some Egyptian soil.

4.2. Studies of VA Mycorrhizae and Rhizobia functions on Acacia growth:

Phosphorus is an extremely important nutrient for growth and effective nodulation of legumes and its deficiency can greatly limit plant growth, Gianinazzi-Pearson & Gianinazzi, (1989); Hetrick, (1989). VA Mycorrhizal infection of Acacia plants growing under P-deficient soil generally causes enhanced growth of the host plant, Mahaveer and Naveen, (1996) and Wafaa, et al., (1998). The benefits of the mycorrhizal association to legume host plant growth have been attributed to (I) improved nutrition particularly phosphorus, Thomson et al., (1990); Chandrashekara et al., (1995); Joner & Jakobsen, (1995); Onguene & Habte, (1995); Rheinheimer et al., (1997). The external mycelium being able to take up phosphate outside the depletion zone around each root, translocate and release it to the cortex of the host root, Fredeen & Terry, (1988); Gianinazzi Pearson & Gianinazzi, (1988); Evans & Miller, (1990).

(ii) Improved nodulation as a result of better P nutrition, Crush, (1974); Abbot & Robson, (1977); Asimi et al., (1980); Barea et al., (1980); Rose & Youngbreg, (1981); Newbould & Rangeley, (1984); Khan et al., (1988); Onguene & Habte, (1995) and hence greater N_2 fixation, Smith, (1980); Kucey & Paul, (1982); Dart et al., (1992). In addition, some studies have shown that mycorrhizal hyphae may also absorb and translocate NH_4 directly from soil to root cells, Chambers et al., (1980); Ames et al., (1983); Oliver et al., (1983); Bass, (1990). The concentration of nutrients in plant tissues, particularly P and N, depend very much on the overall nutrient supply and the extent of the infection, Hall et al., (1984); Tester et al., (1985); Baath & Spokes, (1989); Fairchild & Miller, (1990) Onguene & Habte, (1995).

However, the beneficial effects of VA mycorrhizal infection on legumes decreases with increasing P fertilization and it is now well established that the percentage of root infected by VA mycorrhizal fungi is often reduced by application of P to soil (Miranda et al., 1989; Thomson et al., 1990; Ravolanirina et al., 1990; Omar, 1998).

Arbuscular mycorrhizal fungi (VAM) also enhanced absorption of trace elements (Zn, Cu, Fe, Co, Mn, Mo) from deficient soils, Faber et al., (1990); Kothari et al., (1991); Li et al., (1991); Weissenhorn et al., (1994 and 1995).

4.2.1. Physico-chemical properties of the investigated soil.

Sandy soil was used in greenhouse experiments. The samples of this soil were subjected to data abtained for the physico-chemical analysis are presented in Table (1).

4.2.2. Density of VA Mycorrhizal spores and colonization percentages:

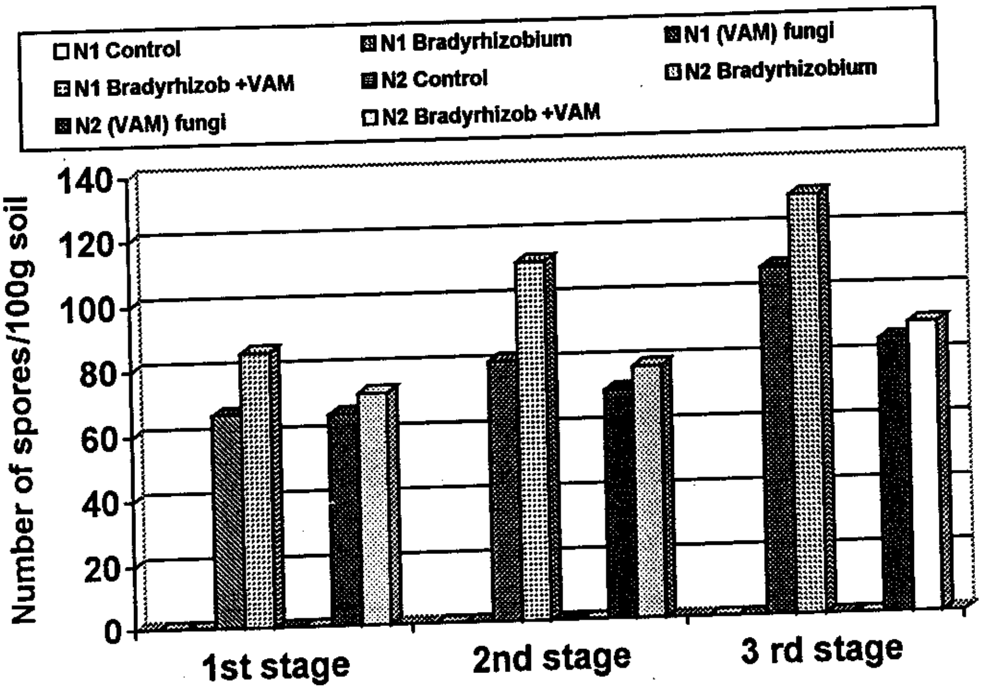
Table (6) and Fig.(1) show the effect of different treatments on the density of VA Mycorrhizal spores and colonization percentages on infected Acacia roots. Results clearly indicate that VA Mycorrhizal spores and colonization percentage are significantly higher in all harvest stages (3,6 and 9 months) for inoculated plants by VA Mycorrhizal fungi particularly for plants inoculated by VAM plus *Bradyrhizobium* and application of 20 nitrogen unit was significantly better than 40 nitrogen

Table (6): Number of mycorrhizal spores and VAM fungal colonization of Acacia plants treated by VAM fungi and *Bradyrhizobium* inoculation and two levels of nitrogen fertilizers.

		Number of spores/100 g soil*			colonization% *		
		1st stage	2nd stage	3rd stage	1st stage	2nd stage	3rd stage
N_1**	Control	0.00 c	0.00 d	0.00 d	0.00 c	0.00 c	0.00 e
	Bradyrhizobium	0.00 c	0.00 d	0.00 d	0.00 c	0.00 c	0.00 e
	(VAM) fungi	66.25 b	80.50 b	107.30 b	25.00 b	31.50 b	47.75 c
	Bradyrhizob+ VAM	85.00 a	110.80 a	130.50 d	35.50 a	56.75 a	72.75 a
N_2***	Control	0.00 c	0.00 d	0.00 d	0.00 c	0.00 c	0.00 e
	Bradyrhizobium	0.00 c	0.00 d	0.00 d	0.00 c	0.00 c	0.00 e
	(VAM) fungi	65.75 b	70.75 c	85.00 c	21.25 b	29.75 b	38.25 d
	Bradyrhizob + VAM	71.75 b	78.00 b	90.00 c	22.75 b	30.50 b	60.75 b
	L.S.D at 5%						
	N. (A)	3.334	3.553	3.446	2.430	2.117	2.128
	inoc (B)	4.716	5.024	4.873	3.437	2.994	3.009
	Nx inoc A x B	6.669	7.105	6.892	4.860	4.234	4.256

* Values represent the mean of 4 replicates. Means in each column followed by the same letter are not significantly different according to Duncan's multiple range test .

** N_1 = 20 nitrogeN unit . *** N_2 = 40 nitrogeN unit .



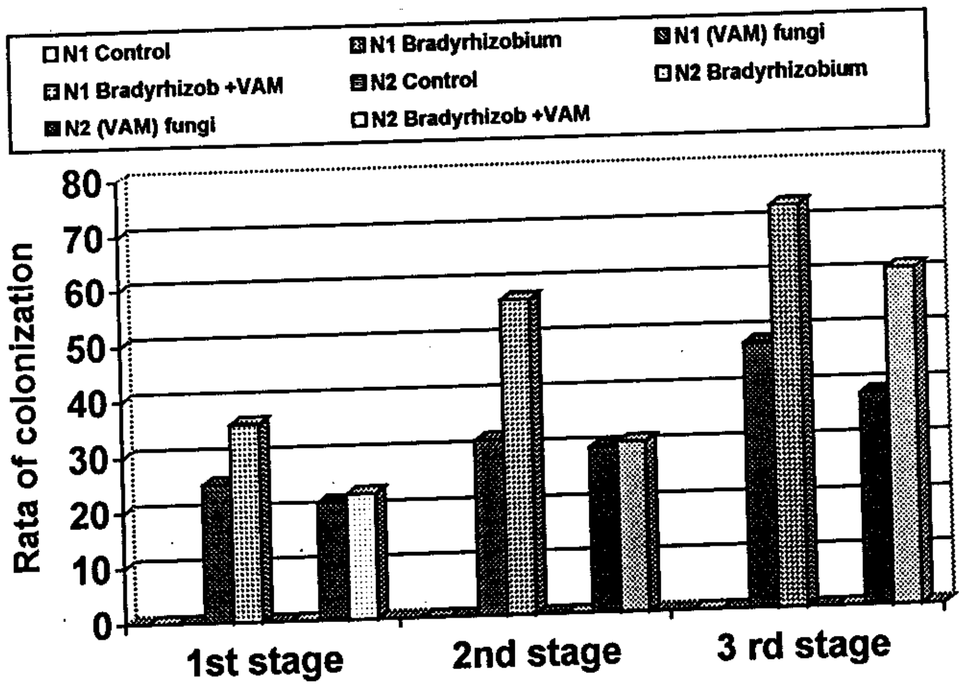


Fig (1): Number of mycorrhizal spores and (VAM) fungal colonization of Acacia plants influenced by different treatments of (VAM)fungi and *Bradyrhizobium* and two levels of nitrogen fertilizers.

J- Part of Acacia root showing internal hyphae and vesicles.

K- General view of root cortex stained with trypan blue showing a network of internal hyphe with vesicle and arbuscules. The separately branched arbuscules in not fully developed.

L,M- Root segment of Acacia plant showing internal and external hyphal network and chlamydospores releasing from late infected plant.

Plate 2:Root of Acacia plants colonized by different VA mycorrhizal species stained with trypan blue.

unit for the production of micorrhizal spores and colonization percentages as the number of spore in the three stages were respectively 85.00, 110.80 and 130.50/100g soil, while colonization percentages were 35.50, 56.75 and 72.75, respectively .

4.2.3. Acacia plants growth response.

The effect of soil incoulation with VAM fungi on Acacia plants grown on sandy soil containing rock phosphate and two levels of ammonium sulphate was studied. The obtained results are presented in Tables (7, 8, 9, 10) and Figs. (2,3,4,5). The results show that the growth parameters of Acacia plants were higher for noninoculated treatments fertilized by 40N unit than those recorded for inoculated plants by either VAM or Brady rhizobium were significantly higher than control during the three stages growth. Althought parameters were higher for plants fertilized by 40 N unit than those fertilized by 20 N unit . This results is definitly attributed to the addition of N fertilizers. Also data recorded that growth parameters of Acacia plants inoculated by either VAM or *Bradyrhizobium* at the three stages were significantly higher than control.

It was observed that inoculation by either VAM fungi or *Bradyrhizobium* resulted in increasing shoot length , shoot fresh weight, shoot dry weight and number of branches for plants fertilized by 20 N unit more than fertilization by 40 N unit. However, inoculation by VAM fungi had greater effect than inoculation by *Bradyrhizobium*. Root exhibit opposite trends, such responses are related to the fact that low N application will led to increase inoculation consequently, root prolifylation will decrease .

Table (7): Effect of inoculating Aeacia plants, fertilized by rock phosphate and two N levels, (VAM) and *Bradyrhizobium* on shoot and root length and number of branches.

Treatments		Shoot length *			Root length*			Number of branches *		
		1^{st} stage	2^{nd} stage	3^{rd} stage	1^{st} stage	2^{nd} stage	3^{rd} stage	1^{st} stage	2^{nd} stage	3^{rd} stage
N1**	Control	23.00 d	26.00 e	41.25 e	16.25	19.75 d	26.50 d	3.00	2.75	3.25 b
	Bradyrhizobium	36.75 bc	51.00 b	65.00 b	16.75	21.75 d	34.00 bc	4.00	3.75	5.25 ab
	(VAM) fungi	38.75 b	50.25 bc	64.75 b	23.50	34.00 b	49.50 a	3.50	3.75	5.25 ab
	Bradyrhizob +VAM	50.00 a	59.00 a	88.25 a	25.75	43.00 a	52.75 a	5.00	5.75	7.00 a
N2***	Control	36.00 bc	42.75 d	47.50 de	18.75	24.00 cd	30.00 cd	1.75	3.25	2.75 b
	Bradyrhizobium	33.50 c	41.75 d	50.75 d	17.75	29.25 bc	36.00 bc	3.50	4.75	4.75 ab
	(VAM) fungi	39.75 b	53.00 ab	57.75 c	23.75	31.50 b	39.75 b	2.75	4.25	6.750 a
	Bradyrhizob + VAM	40.00 b	44.25 cd	59.00 bc	24.00	28.75 bc	35.00 bc	3.00	3.00	2.75 b
L.S.D. at 5% level										
N.		N.S	N.S	3.252	N.S	N.S	3.071	0.8914	N.S	N.S
inoc		3.118	4.345	4.600	2.268	3.543	4.343	N.S	N.S	1.793
Nx inoc		4.480	6.145	6.505	N.S	5.010	6.142	N.S	N.S	2.535

* Values represent the mean of 4 replicates. Means in each column followed by the same letter are not significantly different according to Duncan's multiple range test .

** N_1 = 20 nitrogeN unit . ***N_2 = 40 nitrogeN unit .

Table (8): Fresh shoot and root weight for Acacia plants influenced by inoculation with mycorrhizal fungi, *Bradyrhizobium* (inoc) and rates of nitrogen fertilizer (N).

Treatments		Shoot fresh weightg*			Root fresh weightg*		
		1st stage	2nd stage	3rd stage	1st stage	2nd stage	3rd stage
N_1**	Control	5.140 e	6.715 f	7.855 f	1.0430	1.662 e	1.800 e
	Bradyrhizobium	14.280 b	14.880 cd	26.180 b	2.095	3.493 d	5.273 d
	(VAM) fungi	13.380 bc	17.270 bc	27.530 b	2.330	4.717 bc	9.335 b
	Bradyrhizob + VAM	16.76 a	21.530 a	42.160 a	2.707	5.565 ab	12.70 a
N_2***	Control	6.57 e	10.87 e	12.700 e	1.932	4.433 cd	7.230 c
	Bradyrhizobium	11.090 d	15.100 bcd	17.660 d	2.480	5.580 ab	8.005 bc
	(VAM) fungi	11.360 cd	17.730 b	20.700 c	2.803	6.343 a	8.265 bc
	Bradyrhizob + VAM	10.360 d	13.420 d	15.160 de	2.22	3.780 cd	6.635 cd
L.S.D. at 5% level							
	N.	1.061	N.S	1.516	N.S	0.525	N.S
	inoc	1.500	1.787	2.144	0.6125	0.7426	1.261
	Nx inoc	2.121	2.527	3.032	N.S	1.050	1.784

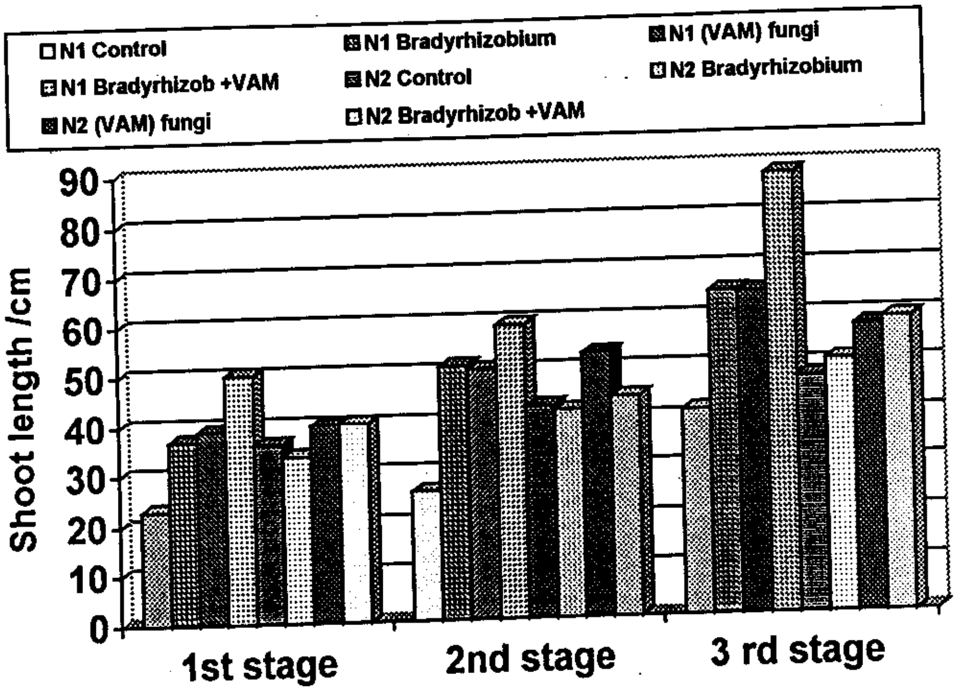
* Values represent the mean of 4 replicates. Means in each column followed by the same letter are not significantly different according to Duncan's multiple range test .
** N_1 = 20 nitrogeN unit . ***N_2 = 40 nitrogeN unit .

Table (9): Shoot and root dry weight of Acacia plants influenced by treatments VAM fungi, *Bradyrhizobium* and two levels of nitrogen fertilizer.

Treatments		Shoot Dry weight g *			Root Dry weight g*		
		1st stage	2nd stage	3rd stage	1st stage	2nd stage	3rd stage
N_1**	Control	1.310 c	2.005 e	2.092 g	0.092	0.7825 d	0.8475 e
	Bradyrhizobium	2.493 b	3.408 c	5.560 c	0.988	1.643 c	2.477 d
	(VAM) fungi	3.237 a	3.888 b	6.338 b	1.115	2.217 b	4.530 b
	Bradyrhizob + VAM	3.703 a	4.773 a	9.310 a	1.273	2.615 ab	5.965 a
N_2***	Control	1.388 c	2.408 e	2.810 f	0.910	2.085 bc	3.398 c
	Bradyrhizobium	2.453 b	3.338 cd	3.905 e	1.133	2.622 ab	3.787 bc
	(VAM) fungi	2.513 b	3.920 b	4.573 d	1.323	2.985 a	3.895 bc
	Bradyrhizob + VAM	2.287 b	2.970 d	3.362 ef	1.045	1.653 c	3.118 cd
L.S.D. at 5 % level							
	N	0.23631	0.2053	0.2876	N.S	0.2483	N.S
	inoc	0.3720	0.2904	0.4067	0.2904	0.3511	0.6169
	Nx inoc	0.5261	0.4104	0.5752	N.S	0.4965	0.8724

* Values represent the mean of 4 replicates. Means in each column followed by the same letter are not significantly different according to Duncan's multiple range test .

** $N_1 = 20$ nitrogeN unit . *** $N_2 = 40$ nitrogeN unit .



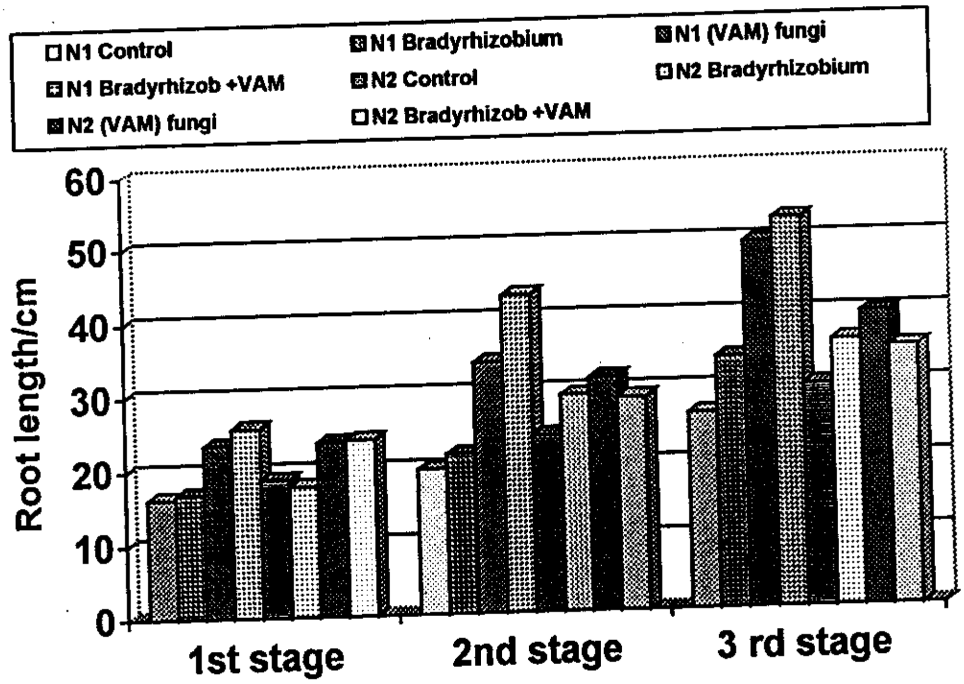
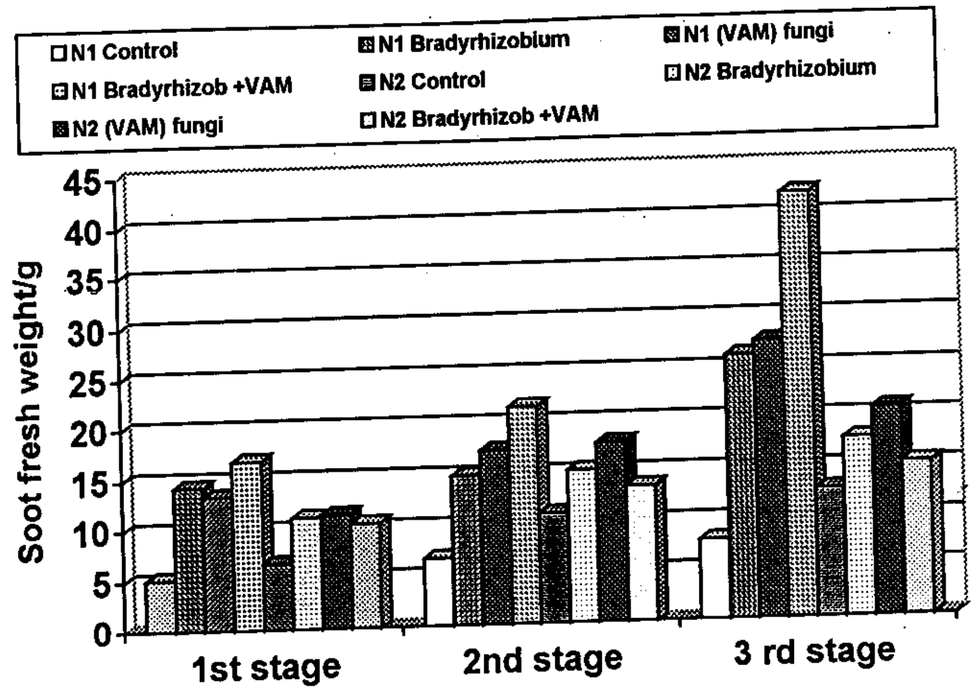


Fig (2): Effect of inoculation with mycorrhizal funig (VAM) and *Bradyrhizobium* on shoot and root length of Acacia plants which fertilized with rock phosphate and two levels of N fertilizer.



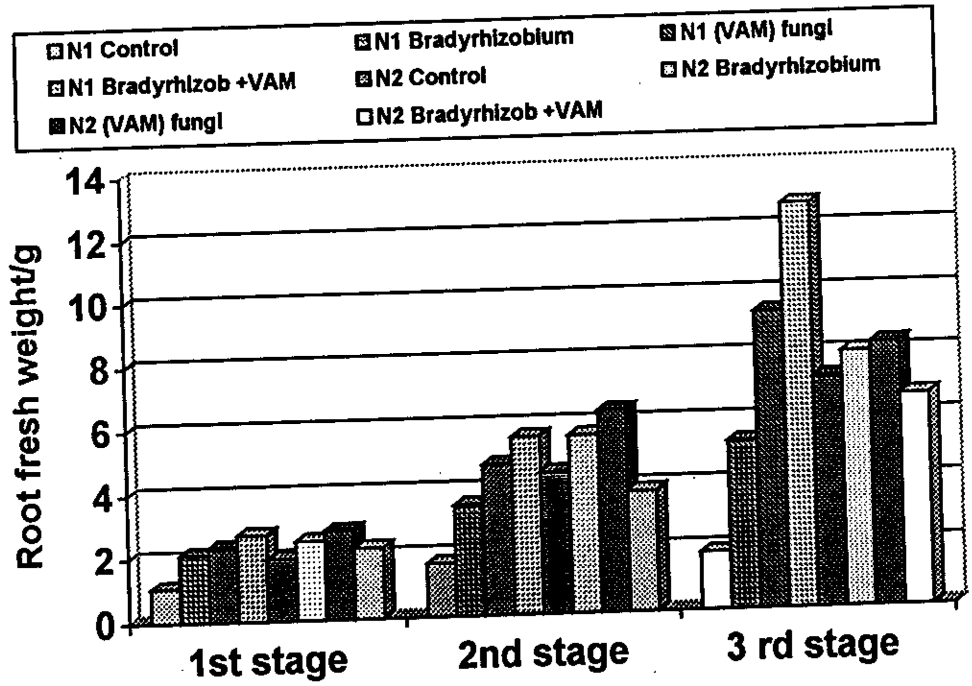
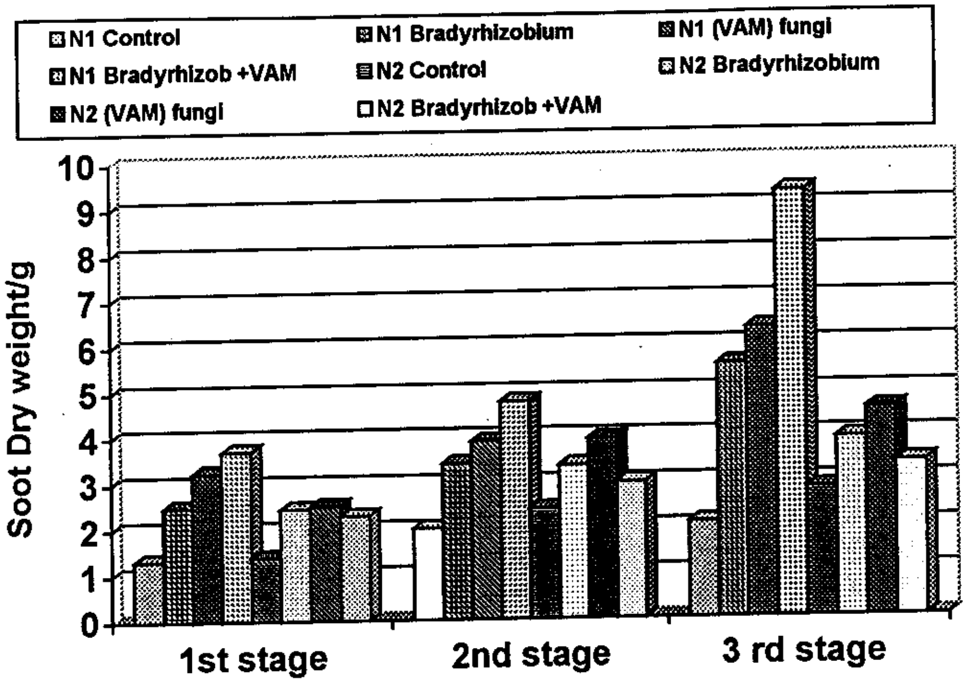


Fig (3): Acacia plants shoot and root of fresh weights as influenced by inoculation VAM mycorrhizal fungi, *Bradyrhizobium* and nitrogen fertilizers.



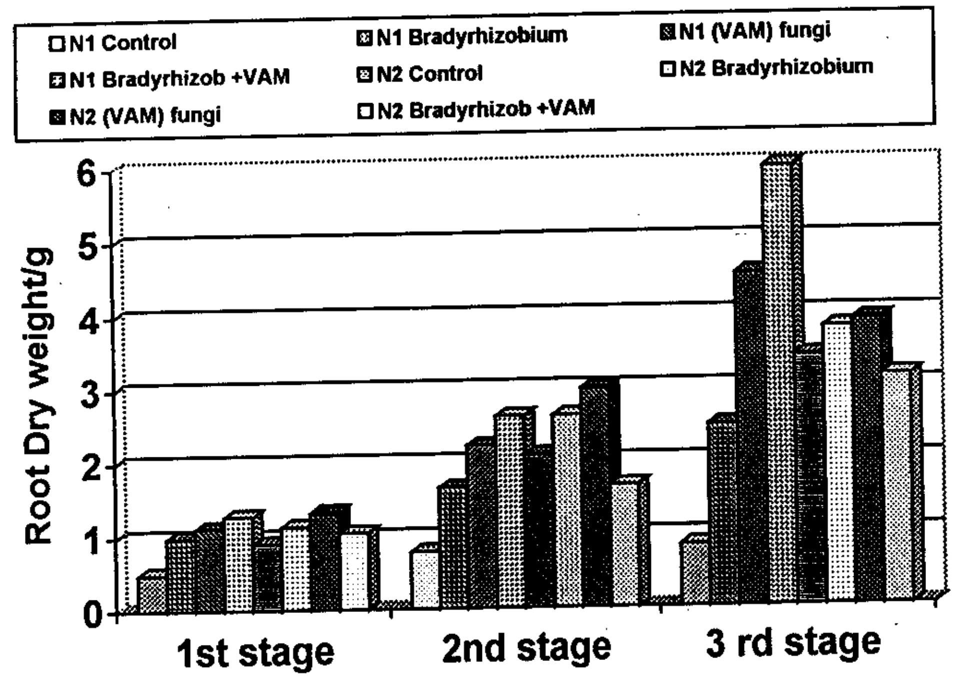


Fig (4): Acacia plants Shoot and root dry weights as influenced by VAM fungi, *Bradyrhizobium* inoculation and two levels of nitrogen fertilizers.

Inoculation by VAM fungi and *Bradyrhizobium in the presence of low* nitrogen rate of application resulted in highly significant increases in plant height. It reached 75.75 and 102 and 141.0 Cm at 3,6 and 9 monthes respectively.

4.2.4.Total chlorophyll contents:

Chlorophyll contents in Acacia leaves are given in Table (11) and Fig. (6). The greatest amounts of chlorophyll were recorded for plants inoculated by either VAM or *Bradyrhizobium* compared with non-inoulated ones. The recorded values of chlorophyll in plants inoculated with mixed inoculums fertilized by 20 unit of N 63.475, 71.30 and 79.38 while they decreased upon increasing nitrogen fertilization by 40 unit to 64.575, 58.00 and 66.10 during the three stages respectively.

Table (11): Effect of inoculation by VAM fungi and *Bradyrhizobium* combined with two levels of nitrogen fertilizer on chlorophyll contents of Acacia leaves.

Treatments		Chlorophyll contents *		
		1[st] stage	2[nd] stage	3[rd] stage
N_1**	Control	47.00	51.60 [c]	53.17 [c]
	Bradyrhizobium	56.525	61.47 [b]	65.85 [b]
	(VAM) fungi	55.250	62.10 [b]	64.92 [b]
	Bradyrhizobium+VAM	63.475	71.30 [a]	79.38 [a]
N_2***	Control	49.825	49.83 [c]	56.22 [c]
	Bradyrhizobium	57.950	60.30 [b]	63.70 [b]
	(VAM) fungi	62.525	59.47 [b]	64.95 [b]
	Bradyrhizobium+VAM	64.575	58.00 [b]	66.10 [b]
	L.S. Dat 0.5 N	2.413	2.239	2.027
	inoc	3.412	3.167	2.867
	Nx inoc	N.S.	4.479	4.055

* Values represent the mean of 4 replicates. Means in each column followed by the same letter are not significantly different according to Duncan's multiple range test.
** N_1 = 20 nitrogeN unit . *** N_2 = 40 nitrogeN unit .

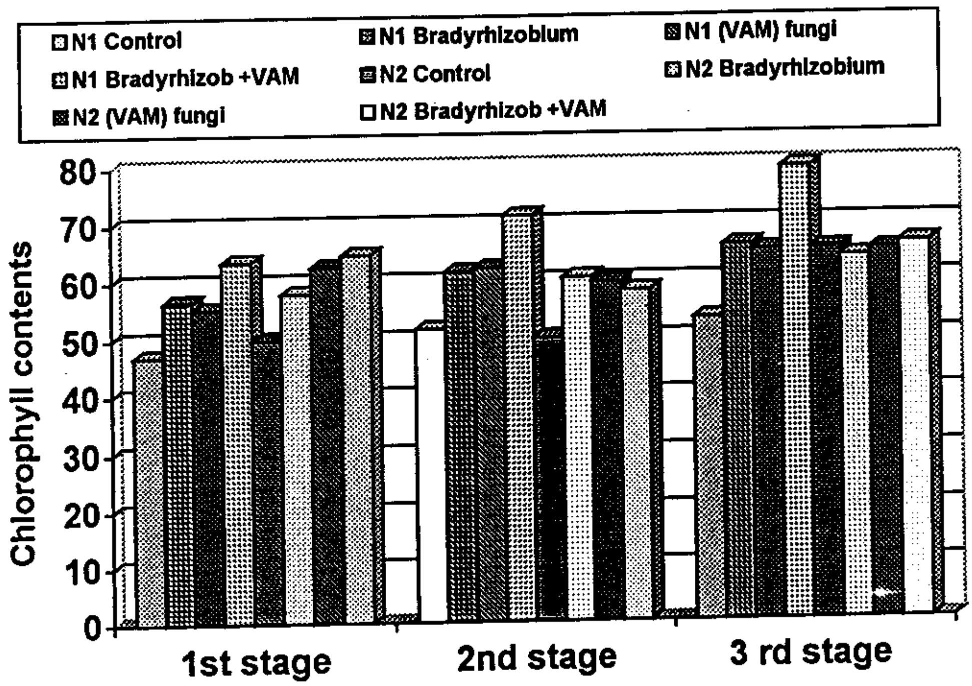


Fig (6): Effect of inoculation with (VAM) fungi and *Bradyrhizobium* combined with two levels of nitrogen fertilizer on clorophyll of Acacia leaves.

4.2.5. Nodules formation:

The number of nodules and nodules fresh and dry weights are presented in Table (12) and Fig. (7). It is clearthat nodules number, fresh weight and dry weight were increased in the presence of Bradyrhizobium by mycorrhizal inoculation and decreased by increased soil nitrogen. The highest number of nodules in Acacia plants are 157.8/plant was recorded after 9 months of cultivation in sandy soil for mixed inoculation treatment provided 20 N unit. It was also noticed that nodule dry weight obtained from Acacia roots were appreciably affected by inoculation by VAM fungi and Bradyrhizobium but not significantly affected by increasing the application of N in the last two harvests. Data in Table (12) indicate that the highest nodules dry weight after 9 months of cultivation, 0.280, is obtained for inoculation treatment by *Bradyrhizobium* and VAM fungi, as well as provided with 20-nitrogen unit.

4.2.6. Nitrogen content of nodules:

Data given in Table (13) and Fig. (8) show that nitrogen contents of Acacia nodules increased by increasing applied N but decreased by time. Also it was observed that mixed inoculation with *Bradyrhizobium* and VAM fungi resulted in higher nodules nitrogen content than inoculation with *Bradyrhizobium* alone.

So, the highest nodules nitrogen content of Acacia plants are 4.510%, for treatment inoculated with mixed VAM fungi & *Bradyrhizobium* provided by 40 N unit after 3 months of cultivation.

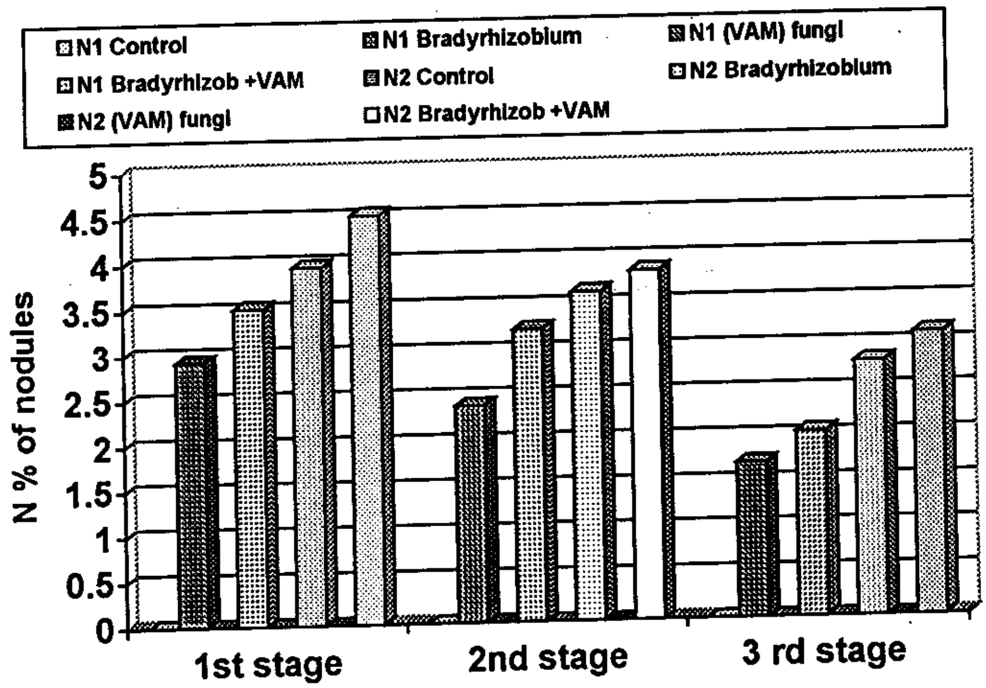


Fig (8): Effect on inoculation with *Bradyrhizobium* and VAM fungi combined with two levels of N-fertilization on Acacia nodules total nitrogeon content seedlings.

Table (13): Effect of inoculation by *Bradyrhizobium* and (VAM) fungi combined with two levels of N-fertilization on Acacia nodules total nitrogen content of Acacia nodules.

Treatments		N % of nodules*		
		1[st] stage	2[nd] stage	3[rd] stage
N_1**	Control	0.00 [e]	0.00 [e]	0.00 [e]
	Bradyrhizobium	2.923 [d]	2.392 [d]	1.710 [d]
	(VAM) fungi	0.00 [e]	0.00 [e]	0.00 [e]
	Bradyrhizobium+VAM	3.515 [c]	3.230 [e]	2.040 [c]
N_2***	Control	0.00 [e]	0.00 [e]	0.00 [e]
	Bradyrhizobium	3.95 [b]	3.630 [b]	2.810 [b]
	(VAM) fungi	0.00 [e]	0.00 [e]	0.00 [e]
	Bradyrhizobium+VAM	4.510 [a]	3.852 [a]	3.122 [a]
	L.S.D at 5 % level			
	N	0.03263	0.06923	0.02308
	inoc	0.04615	0.09790	0.03263
	Nx inoc	0.06527	0.1385	0.04615

* Values represent the mean of 4 replicates. Means in each column followed by the same letter are not significantly different according to Duncan's multiple range test.
** N_1 = 20 nitrogeN unit. ***N_2 = 40 nitrogeN unit.

4.2.7. Total soil nitrogen:

Table (14) show the results obtained for total soil nitrogen for all treatments. The data indicate that inoculation with both *Bradyrhizobium* and VAM fungi increased total soil nitrogen. Also application of 40 N unit resulted in significant increase in total soil nitrogen than that received 20 unit. During the experimental period, (9 months) total soil nitrogen for all treatments decreased gradually with time .

The obtained results show that the highest total soil nitrogen content was recorded for mixed inoculation treatments supplied with 40 N unit. It reached 909.8 ppm compared with 330.5 ppm for the control. It was also found that total soil nitrogen significantly increased by VAM fungi inoculation. This may be related to the release of phosphorus, which stimulated N_2^-fixation by the native organisms.

Table (14): Total soil nitrogen of Acacia rhizosphere as affected by inoculation with VAM fungi or Bradyrhizobium.

Treatments		Total soil N (ppm)*		
		1st stage	2nd stage	3rd stage
N_1**	Control	290.8 h	268.0 g	240.5 h
	Bradyrhizobium	540.3 d	516.8 d	4787.5 d
	(VAM) fungi	323.0 g	303.8 f	275.0 g
	Bradyrhizobium+VAM	717.5 b	679.3 b	635.8 b
N_2***	Control	330.5 f	304.0 f	285.8 f
	Bradyrhizobium	629.0 c	598.3 c	573.0 c
	(VAM) fungi	413.5 e	390.8 e	358.3 e
	Bradyrhizobium+VAM	909.8 a	880.3 a	860.3 a
	L.S.D. at 5%			
	N	3.704	4.215	3.679
	inoc	5.238	5.960	5.229
	Nx inoc	7.408	8.429	7.394

* Values represent the mean of 4 replicates. Means in each column followed by the same letter are not significantly different according to Duncan's multiple range test.
** N_1 = 20 nitrogeN unit. ***N_2 = 40 nitrogeN unit.

Table (15):Concentration of nitrogen element in Acacia plants fertilized with two levels of nitrogen fertilizer as influenced by VAM and *Bradyrhizobium* inoculation.

Treatments		Shoot N %			Root N%		
		1st stage	2nd stage	3rd stage	1st stage	2nd stage	3rd stage
N_1**	Control	1.730 d	1.855 f	1.868 f	2.568 e	2.700 e	2.743 e
	Bradyrhizobium	2.463 b	2.457 b	2.513 b	2.888 c	3.037 bc	3.130 b
	(VAM) fungi	2.338 c	2.168 e	2.375 bcd	2.715 d	2.822 d	2.925 d
	Bradyrhizobium+VAM	2.755 a	2.900 e	2.912 a	3.383 a	3.457 a	3.635 a
N_2***	Control	2.338 c	2.270 d	2.203 e	2.933 c	3.000 c	3.060 c
	Bradyrhizobium	2.463 b	2.463 b	2.438 bc	2.885 c	3.025 bc	3.053 c
	(VAM) fungi	2.365 c	2.370 c	2.237 de	2.688 d	2.713 e	2.957 d
	Bradyrhizobium+VAM	2.340 c	2.342 c	2.345 cde	3.045 b	3.108 b	3.148 b
	L.S.D. at 5% level						
	N	0.03288	N.S	0.07711	N.S	N.S	0.02325
	inoc	0.04650	0.03288	0.1091	0.06576	0.2236	0.03288
	Nx inoc	0.06576	0.04650	0.1542	0.09300	0.09300	0.04650

* Values represent the mean of 4 replicates. Means in each column followed by the same letter are not significantly different according to Duncan's multiple range test .

** N_1 = 20 nitrogeN unit . ***N_2 = 40 nitrogeN unit .

4.2.8. Nitrogen Concentration and Content of Acacia plants:

Results in Table (15,16) and Fig. (9) show that N concentrations and contents in non-inoculated Acacia shoots and roots are higher for those fertilized by 40 N unit than those received 20 N unit. Inoculation by *Bradyrhizobium* or VAM fungi give higher nitrogen % and total nitrogen content than the control. The highest value was observed in treatment: received both inoculation.

With respect to nitrogen fertilizer, application of more nitrogen ferilizer to soil have no effect on nitrogen % in shoots but decrease total nitrogen contents. This result is due to the decrease of dry weights . The highest nitrogen % and content of shoots recorded after 9 months of cultivation for inoculated treatment by *Bradyrhizobium* and VAM fungi and provided by 20 nitrogen unit being 2.912% and 33.84 mg/shoot, respectively.

Concerning the response of roots, it is noticed that application of 40 nitrogen unit increased nitrogen content more than the application of 20 N unit for noninoculated plants. However, inoculating Acacia plants by VAM and *Bradyrhizobium* resulted in lower nitrogen content when plant were fertilized by 40 N unit.

Table (16) : Nitrogen content of Acacia plants inoculated by VAM fungi and *Bradyrhizobium* with two levels of nitrogen fertilizer.

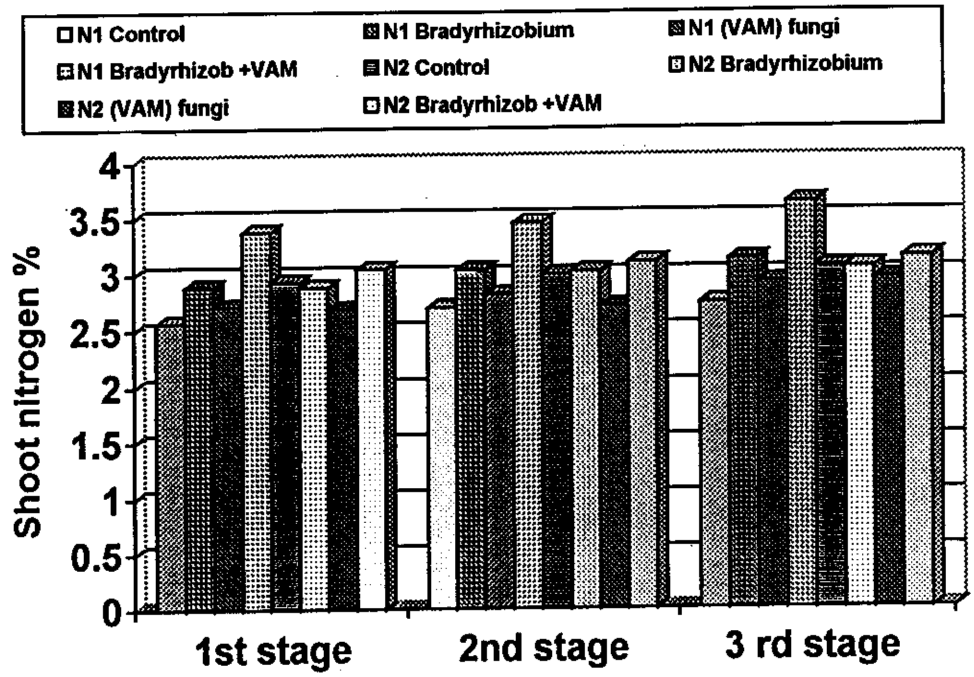
Treatments		Shoot N content* mg/shoot			Root N content* mg/root		
		1st stage	2nd stage	3rd stage	1st stage	2nd stage	3rd stage
N_1**	Control	3.351 ^{d}	5.414 ^{e}	5.738 ^{f}	0.8535 ^{a}	1.451 ^{c}	1.577 ^{e}
	Bradyrhizobium	7.203 ^{c}	10.36 ^{bc}	17.400 ^{b}	2.434 ^{ab}	4.044 ^{b}	6.229 ^{d}
	(VAM) fungi	8.807 ^{b}	10.96 ^{b}	18.540 ^{b}	2.593 ^{ab}	4.806 ^{b}	10.77 ^{b}
	Bradyrhizobium+VAM	12.530 ^{a}	16.50 ^{a}	33.840 ^{a}	3.501 ^{a}	7.586 ^{a}	17.39 ^{a}
N_2***	Control	4.065 ^{d}	7.205 ^{d}	8.602 ^{e}	2.127 ^{b}	4.739 ^{b}	7.484 ^{cd}
	Bradyrhizobium	7.085 ^{c}	10.110 ^{bc}	11.930 ^{cd}	2.798 ^{ab}	6.465 ^{a}	9.200 ^{bc}
	(VAM) fungi	6.753 ^{c}	10.640 ^{bc}	13.520 ^{c}	3.134 ^{ab}	7.089 ^{a}	8.718 ^{bcd}
	Bradyrhizobium+VAM	6.958 ^{c}	9.233 ^{b}	10.55 ^{d}	2.445 ^{ab}	3.875 ^{b}	7.331 ^{cd}
L.S.D. at 5% level							
	N	0.7843	0.6893	0.9416	N.S	0.6321	N.S.
	inoc	1.109	0.9749	1.332	0.7098	0.8939	1.7260
	Nx inoc	1.569	1.379	1.883	1.004	1.264	2.4410

* Values represent the mean of 4 replicates. Means in each column followed by the same letter are not significantly different according to Duncan's multiple range test .
** N_1 = 20 nitrogeN unit . ***N_2 = 40 nitrogeN unit .

4.2.9. Phosphorus concentration and content:

It is clear from the data given in Tables (17 and 18) and Fig. (10) that, non-inoculated Acacia have higher p% and contents when fertilized by 40 N unit than by 20 N unit . Biofertilization by VAM fungi and fertilization by rock phosphate, gave the higher shoot and root P-content. Than inoculation with Bradyrhizobium alone. Concerning the inoculation by *Bradyrhizobium* shoot and P% and contents increased with increasing plant growth particulary when fertilized by 40 N unit . As for the inoculation by VAM, application of high N rate led to decrease P% and content in both shoots and roots. Phosphorus % and content exhibited the highest values when plants were inoculated by both VAM and *Bradyrhizobium* and received 20 N unit , which are 0.360, 0.335 and 0.318 % for the shoots and 0.400, 0.368 and 0.355% for the roots. These values reveal, that p % decrease by time. While values obtained for P contents with time is correlated by dry weight production they are 1.329, 1.602 and 2.959 mg/shoot for the shoots and 0.511, 0.965 and 2.116 mg/root for the roots.

On the contrary values obtained for P contents increased with time due to the increase of dry weight production. The values are 1.329, 1.602 and 2.959 mg/shoot and 0.511 , 0.965 and 2.116 mg/root.



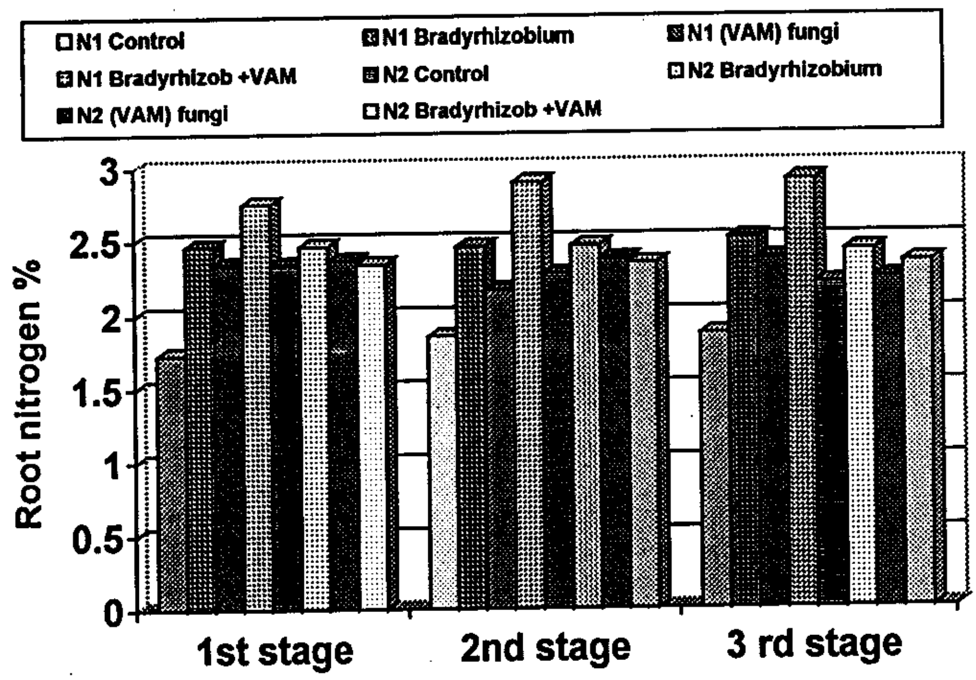


Fig (9): Concentration of Nitrogen in Acacia plants with two levels of nitrogen fertilizer as influenced by VAM and *Bradyrhizobium* inoculation

Table (17): Concentration of phosphorus in Acacia plants fertilized with two levels of nitrogen fertilizer as influenced by VAM fungi and *Bradyrhizobia* inoculation.

Treatments		Shoot phosphorus %*			Root phosphorus %*		
		1[st] stage	2[nd] stage	3[rd] stage	1[st] stage	2[nd] stage	3[rd] stage
N_1**	Control	0.1200 [d]	0.1300 [d]	0.1325 [e]	0.1000 [f]	0.1225 [d]	0.1125 [e]
	Bradyrhizobium	0.1725 [c]	0.1975 [c]	0.1800 [e]	0.1400 [e]	0.1375 [d]	0.1125 [e]
	(VAM) fungi	0.3100 [b]	0.2875 [b]	0.2700 [b]	0.3375 [b]	0.3225 [b]	0.2850 [b]
	Bradyrhizobium+VAM	0.3600 [a]	0.3350 [a]	0.3175 [a]	0.4000 [a]	0.3675 [a]	0.3550 [a]
N_2***	Control	0.1300 [d]	0.1150 [d]	0.3175 [ef]	0.1175 [ef]	0.1300 [d]	0.1375 [e]
	Bradyrhizobium	0.1800 [c]	0.2125 [c]	0.2175 [d]	0.1750 [d]	0.2200 [c]	0.1775 [d]
	(VAM) fungi	0.3300 [b]	0.305 [b]	0.2875 [c]	0.2650 [c]	0.2250 [c]	0.2175 [c]
	Bradyrhizobium+VAM	0.3300 [b]	0.3025 [b]	0.2800 [b]	0.3350 [b]	0.3125 [b]	0.2925 [b]
L.S.D. at 5% level							
	N	N.S	N.S	N.S	0.01273	0.01273	N.S
	inoc	0.02080	0.01471	0.01644	0.01801	0.01801	0.02080
	Nx inoc	0.02941	0.02080	0.02325	0.02547	0.02547	0.02941

* Values represent the mean of 4 replicates. Means in each column followed by the same letter are not significantly different according to Duncan's multiple range test .
** N_1 = 20 nitrogeN unit .. *** N_2 = 40 nitrogeN unit .

Table (18) : Phosphorus content of Acacia plants inoculated by VAM Fungi and *Bradyrhizobium* with two levels of nitrogen fertilizer.

Treatments		Shoot Phosphorus content mg/ shoot *			Root phosphorus content mg/root*		
		1st stage	2nd stage	3rd stage	1st stage	2nd stage	3rd stage
N_1**	Control	0.1604 e	0.2622 e	0.2771 e	0.049	0.09495 e	0.09385 f
	Bradyrhizobium	0.4342 d	0.6758 d	0.9942 d	0.138	0.2281 de	0.2795 ef
	(VAM) fungi	0.9990 b	1.1160 b	1.7110 b	0.385	0.7162 b	1.2910 b
	Bradyrhizobium+VAM	1.3290 a	1.602 a	2.959 a	0.511	0.9643 a	2.1160 a
N_2***	Control	0.1808 e	0.2776 e	0.3868 e	0.107	0.2765 d	0.4663 de
	Bradyrhizobium	0.4402 d	0.7097 d	0.8528 d	0.200	0.5755 bc	0.6711 cd
	(VAM) fungi	01.8294 c	1.197 b	1.318 c	0.348	0.6739 b	0.8459 c
	Bradyrhizobium+VAM	0.7532 c	0.8988 c	0.9388 d	0.351	0.5153 c	0.9096 c
L.S.D. at 5% level							
	N	0.06152	0.08054	0.1065	N.S	N.S	0.1414
	inoc	0.0870	0.1139	0.1507	0.1040	0.1040	0.2000
	Nx inoc	0.1230	0.1611	0.2131	N.S	0.1471	0.2829

* Values represent the mean of 4 replicates. Means in each column followed by the same letter are not significantly different according to Duncan's multiple range test .

** N_1 = 20 nitrogeN unit . ***N_2 = 40 nitrogeN unit .

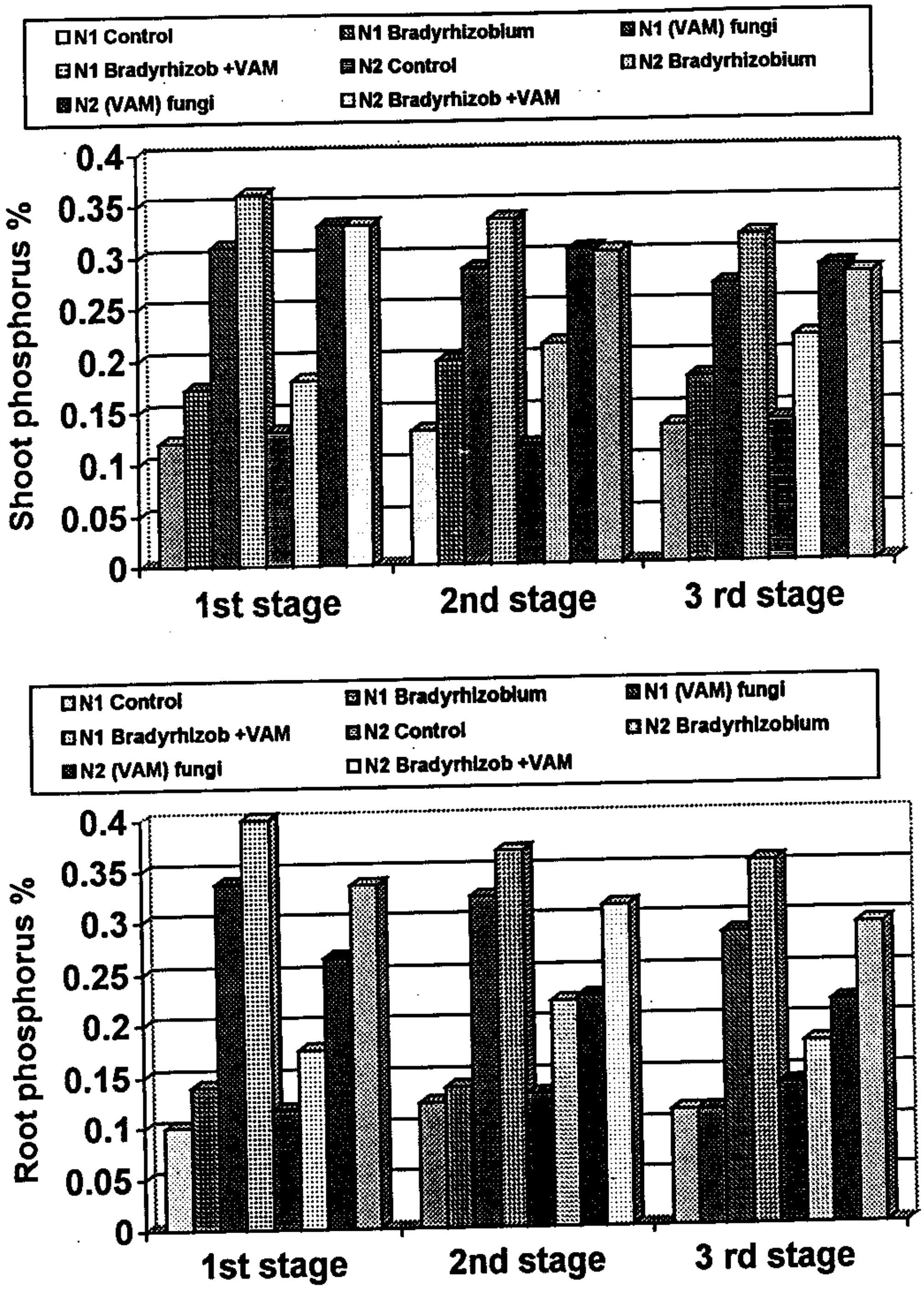


Fig (10): Concentration of phosphorus in Acacia plants fertilized by two levels of nitrogen fertilizer as influenced by (VAM) fungi and *Bradyrhizobium* inoculation.

4.2.10. Trace elements concentrations of Acacia plants

As for the results trace elements concentrations given in Tables (19 to 24) and Figs. (11 to 16) for Fe, Cu, Zn, Mn, Co and Mo, it is obvious that their shoot or root concentations are generally higher for the control soil supplied by high nitrogen fertilizer (N_2) than low rate of application (N_1). Moreover the inoculation by *Bradyrhizobium* or VAM seperately or in combination apparently increased the above mentioned elements in shoots and roots. Such response decreased by increasing the applied N fertilizer. It's intrestingly noticed that the variations for such nutrients among plant growth stages were not sound. However, they exhibited high values in the root system compared with those in the shoot system.

Averge Fe concentrations obtained among growth stages for Acacia shoots and roots were the highest; being 1422.7 and 3286.6 ppm, followed by Zn 99.3 and 181.4 ppm, Mn 68.7 and 82.4ppm , Co 68.2 and 81.1 ppm and Mo 64.9 and 77 ppm, for Acacia shoots and roots respectively while the values obtained for Cu were the least ones being 40.3 and 49 ppm. The values calculated for Fe and Zn concentrations in Acacia roots were, twice those calculated for the shoots.

As for the remaining four nutrient elements; Mn, Co, Mo and Cu it was astonishingly found that the ratios of the average values obtained for the shoot systems to those for the root systems were aproximatly equall to 83%. In the meantime, average N concentrations calculated among the three growth stages for the shoot systems, was 79% compared to that calculated for the root system being 2.355 % and 2.984 respectively. This ratio is in close proximity to those obtained for the four, mentioned

Table (19): Iron concentrations in Acacia plants inoculated by VAM Fungi and *Bradyrhizobium* with two levels of N fertilizer.

Treatments		Shoot Fe (ppm)*			Root Fe (ppm)*		
		1st stage	2nd stage	3rd stage	1st stage	2nd stage	3rd stage
N_1**	Control	1064^{d}	1089^{f}	1081^{f}	2448^{f}	2550^{f}	2425^{e}
	Bradyrhizobium	1406^{b}	1383^{d}	1441^{d}	3033^{d}	3189^{d}	3041^{c}
	(VAM) fungi	1608^{a}	1581^{a}	1649^{a}	3300^{c}	3486^{c}	3380^{b}
	Bradyrhizobium+VAM	1579^{a}	1593^{a}	1538^{b}	3858^{a}	3789^{a}	3760^{a}
N_2***	Control	1193^{c}	1206^{e}	1230^{e}	2856^{e}	2894^{d}	2819^{d}
	Bradyrhizobium	1394^{b}	1418^{c}	1498^{bc}	3298^{c}	3483^{b}	3436^{b}
	(VAM) fungi	1599^{a}	1583^{a}	1610^{a}	3408^{b}	3690^{b}	3513^{b}
	Bradyrhizobium+VAM	1448^{b}	1484^{b}	1470^{cd}	3796^{a}	3716^{ab}	3710^{a}
L.S.D. at 5% level							
	N	N.S	N.S	N.S	45.32	43.67	85.70
	inoc	37.83	22.15	36.71	64.09	61.75	121.2
	Nx inoc	53.50	31.33	51.92	90.63	87.33	171.4

* Values represent the mean of 4 replicates. Means in each column followed by the same letter are not significantly different according to Duncan's multiple range test.
** N_1 = 20 nitrogeN unit. *** N_2 = 40 nitrogeN unit.

Table (20): Copper concentrations in Acacia plants inoculated by VAM Fungi and *Bradyrhizobium* with two levels of N fertilizer.

Treatments		Shoot Cu (ppm)*			Root Cu (ppm)*		
		1st stage	2nd stage	3rd stage	1st stage	2nd stage	3rd stage
N_1**	Control	29.0 e	29.8	28.0 e	42.3 bc	19.8 e	20.5 e
	Bradyrhizobium	33.0 d	34.5	33.3 d	51.5 ab	51.8 c	52.0 c
	(VAM) fungi	42.5 c	43.8	45.3 c	53.8 ab	52.8 c	54.0 c
	Bradyrhizobium+VAM	59.5 a	54.3	61.5 a	71.3 a	72.5 a	73.3 a
N_2***	Control	31.8 de	28.8	29.8 de	23.0 c	21.3 e	21.8 e
	Bradyrhizobium	31.3 de	31.3	32.5 d	44.3 abc	44.8 d	42.5 d
	(VAM) fungi	42.0 c	42.0	43.5 c	61.3 ab	58.8 b	61.0 b
	Bradyrhizobium+VAM	52.0 b	52.0	54.8 b	60.5 ab	59.8 b	62.0 b
L.S.D. at 5% level							
	N	1.594	N.S	N.S	N.S	1.802	2.047
	inoc	2.255	3.073	2.887	N.S	2.548	2.895
	Nx inoc	3.189	N.S	4.083	25.35	3.604	4.094

* Values represent the mean of 4 replicates. Means in each column followed by the same letter are not significantly different according to Duncan's multiple range test.
** N_1 = 20 nitrogeN unit. ***N_2 = 40 nitrogeN unit.

Table (21): Zinc concentrations in Acacia plants inoculated by VAM Fungi and *Bradyrhizobium* combination with two levels of N fertilizer.

Treatments		Zn shoot (ppm) *			Zn root (ppm)*		
		1st stage	2nd stage	3rd stage	1st stage	2nd stage	3rd stage
N_1**	Control	67.50 f	68.00 f	64.00 g	169.0 f	164.0 e	170.0 f
	Bradyrhizobium	96.25 d	94.50 d	92.50 d	189.3 e	175.8 d	185.5 d
	(VAM) fungi	121.80 b	115.00 b	114.50 b	245.8 a	228.0 a	211.5 a
	Bradyrhizobium+VAM	143.50 a	134.80 a	130.5 a	220.5 c	205.8 b	202.5 b
N_2***	Control	89.50 e	78.50 e	79.75 f	194.5 d	186.5 c	173.0 f
	Bradyrhizobium	102.80 c	95.25 d	95.00 d	196.3 d	170.3 de	178.5 e
	(VAM) fungi	118.00 b	105.30 c	103.80 c	230.8 b	222.0 a	213.8 a
	Bradyrhizobium+VAM	100.3 cd	92.72 d	86.50 e	216.3 c	207.8 b	194.3 c
L.S.D. at 5% level							
	N	2.912	2.276	1.525	2.393	N.S	2.359
	inoc	4.118	3.219	2.157	3.384	6.176	3.336
	Nx inoc	5.824	4.552	3.051	4.786	8.734	4.778

* Values represent the mean of 4 replicates. Means in each column followed by the same letter are not significantly different according to Duncan's multiple range test .
** N_1 = 20 nitrogeN unit . ***N_2 = 40 nitrogeN unit .

Table (22): Manganese concentrations in Acacia plants inoculated by VAM Fungi and *Bradyrhizobium* with two levels of N fertilizer.

Treatments		Mn shoot (ppm) *			Mn Root (ppm)*		
		1^{st} stage	2^{nd} stage	3^{rd} stage	1^{st} stage	2^{nd} stage	3^{rd} stage
N_1**	Control	52.8^{f}	43.0^{g}	36.5^{g}	68.8^{h}	58.8^{g}	42.5^{g}
	Bradyrhizobium	87.5^{b}	76.0^{c}	67.3^{c}	116.0^{b}	97.0^{b}	86.8^{b}
	(VAM) fungi	81.3^{c}	70.0^{d}	60.5^{d}	102.3^{d}	92.5^{cb}	77.3^{c}
	Bradyrhizobium+VAM	102.8^{a}	89.8^{a}	76.8^{a}	119.5^{a}	105.5^{a}	94.3^{a}
N_2***	Control	62.5^{e}	51.5^{f}	43.8^{f}	71.5^{g}	63.5^{f}	49.5^{f}
	Bradyrhizobium	81.3^{c}	75.8^{c}	61.8^{d}	91.8^{e}	78.8^{d}	67.0^{d}
	(VAM) fungi	71.0^{d}	63.3^{e}	53.0^{e}	81.5^{f}	68.0^{e}	57.0^{e}
	Bradyrhizobium+VAM	90.0^{b}	82.0^{b}	70.8^{b}	109.0^{c}	94.0^{c}	85.0^{b}
L.S.D. at 5% level							
	N	1.913	1.292	1.226	1.375	1.336	1.318
	inoc	2.706	1.827	1.734	1.945	1.890	1.863
	Nx inoc	3.827	2.584	2.452	2.750	2.673	2.635

* Values represent the mean of 4 replicates. Means in each column followed by the same letter are not significantly different according to Duncan's multiple range test .
** N_1 = 20 nitrogeN unit .   *** N_2 = 40 nitrogeN unit .

Table (23): Cobalt concentrations in Acacia plants inoculated by VAM Fungi and *Bradyrhizobium* with two levels of N fertilizer.

Treatments		Co shoot (ppm) *			Co Root (ppm) *		
		1st stage	2nd stage	3rd stage	1st stage	2nd stage	3rd stage
N_1**	Control	42.7 h	38.8 g	33.2 g	66.0 g	58.9 g	51.3 g
	Bradyrhizobium	87.2 c	79.6 c	71.5 c	109.8 b	100.7 b	91.6 b
	(VAM) fungi	73.2 e	65.4 e	55.7 f	90.1 e	82.0 e	77.8 d
	Bradyrhizobium+VAM	105.0 aa	93.6 a	84.1 a	120.6 a	112.4 a	100.2 a
N_2***	Control	46.9 g	39.6 g	34.3 g	72.0 f	64.7 f	55.2 f
	Bradyrhizobium	84.2 d	76.4 d	67.7 d	94.1 d	85.2 d	79.0 d
	(VAM) fungi	69.8 f	63.8 f	60.0 e	88.3 e	80.3 e	73.7 e
	Bradyrhizobium+VAM	94.3 b	88.9 b	82.0 b	97.6 c	91.1 c	83.3 c
L.S.D. at 5% level							
	N	0.9296	0.7474	N.S	0.9020	0.8964	0.8584
	inoc	1.315	1.057	1.126	1.276	1.268	1.214
	Nx inoc	1.859	1.495	1.592	1.804	1.793	1.717

* Values represent the mean of 4 replicates. Means in each column followed by the same letter are not significantly different according to Duncan's multiple range test .

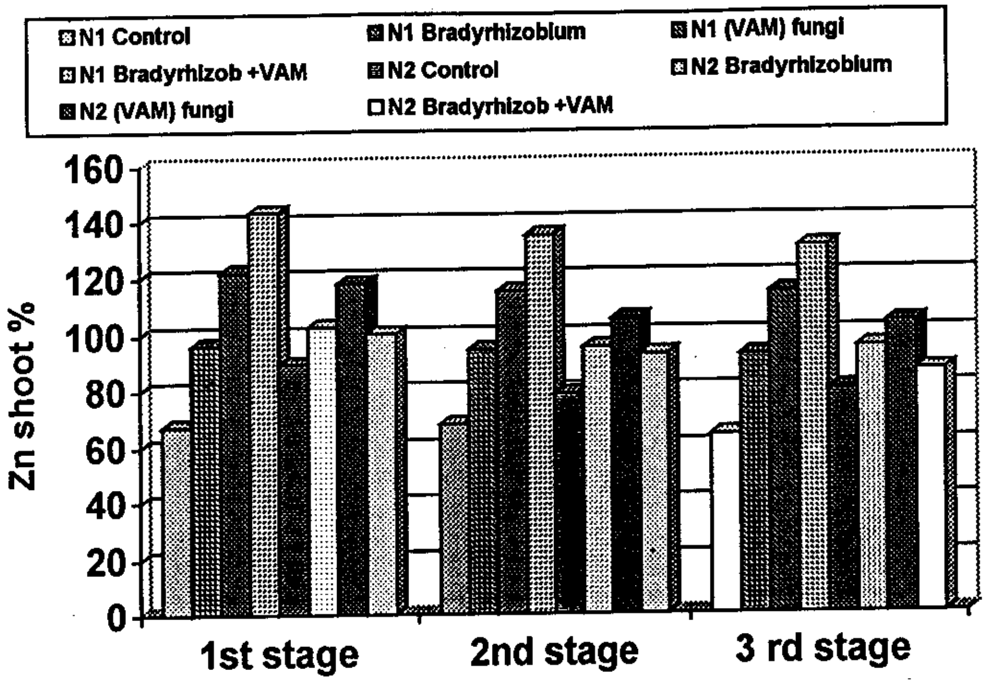
** N_1 = 20 nitrogeN unit . *** N_2 = 40 nitrogeN unit .

Table (24): Molybdenum concentrations in Acacia plants inoculated by VAM Fungi and *Bradyrhizobium* with two levels of N fertilizer.

Treatments		Mo shoot (ppm) *			Mo Root (ppm)*		
		1[st] stage	2[nd] stage	3[rd] stage	1[st] stage	2[nd] stage	3[rd] stage
N_1**	Control	32.8	28.0[h]	22.3[g]	37.5[f]	31.3[g]	23.0[f]
	Bradyrhizobium	83.0	91.8[b]	88.3[a]	115.5[b]	103.5[b]	92.0[b]
	(VAM) fungi	75.8	67.3[e]	60.3[e]	83.3[d]	75.5[e]	62.0[d]
	Bradyrhizobium+VAM	111.3	98.0[a]	85.8[b]	131.3[a]	119.3[a]	107.8[a]
N_2***	Control	42.8	36.8[g]	29.3[g]	45.8[e]	32.3[g]	21.5[f]
	Bradyrhizobium	84.0	78.3[d]	71.8[d]	95.3[c]	81.5[d]	72.5[c]
	(VAM) fungi	70.8	64.3[f]	56.3[f]	80.0[d]	70.5[f]	59.3[e]
	Bradyrhizobium+VAM	101.0	88.8[c]	78.8[c]	114.8[b]	100.3[c]	91.8[b]
L.S.D. at 5% level							
	N	N.S	0.9480	0.9879	1.657	1.307	1.013
	inoc	10.08	1.341	1.397	2.343	1.848	1.433
	Nx inoc	N.S	1.896	1.976	3.314	2.614	2.026

* Values represent the mean of 4 replicates. Means in each column followed by the same letter are not significantly different according to Duncan's multiple range test .

** N_1 = 20 nitrogeN unit . ***N_2 = 40 nitrogeN unit .



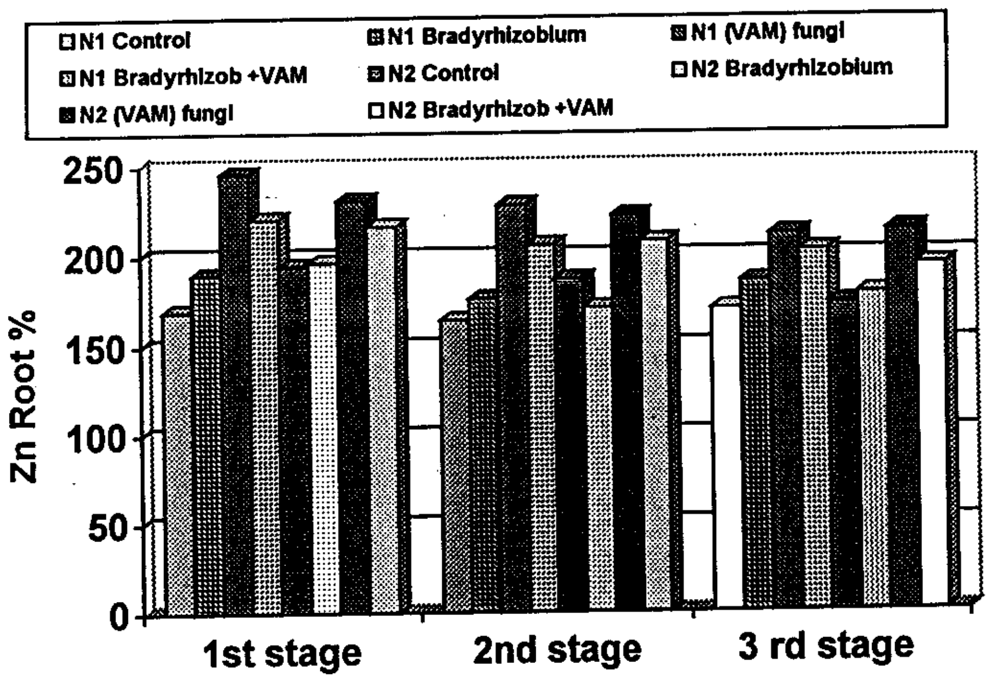
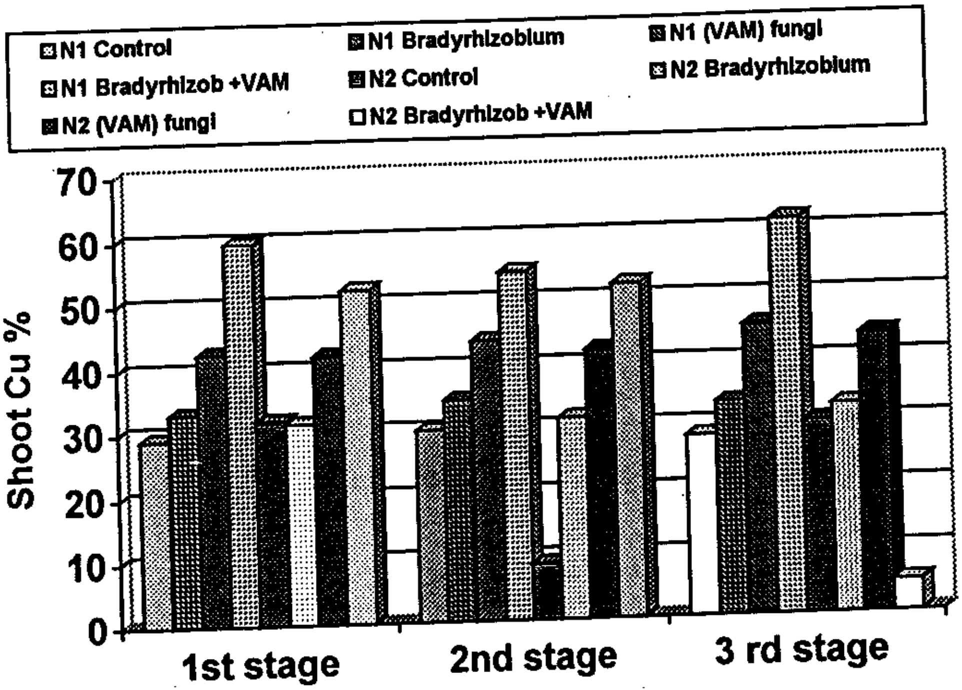


Fig (11): Zinc concentrations in Acacia plants inoculated by VAM fungi and *Bradyrhizobium* with two levels of N fertilizer.



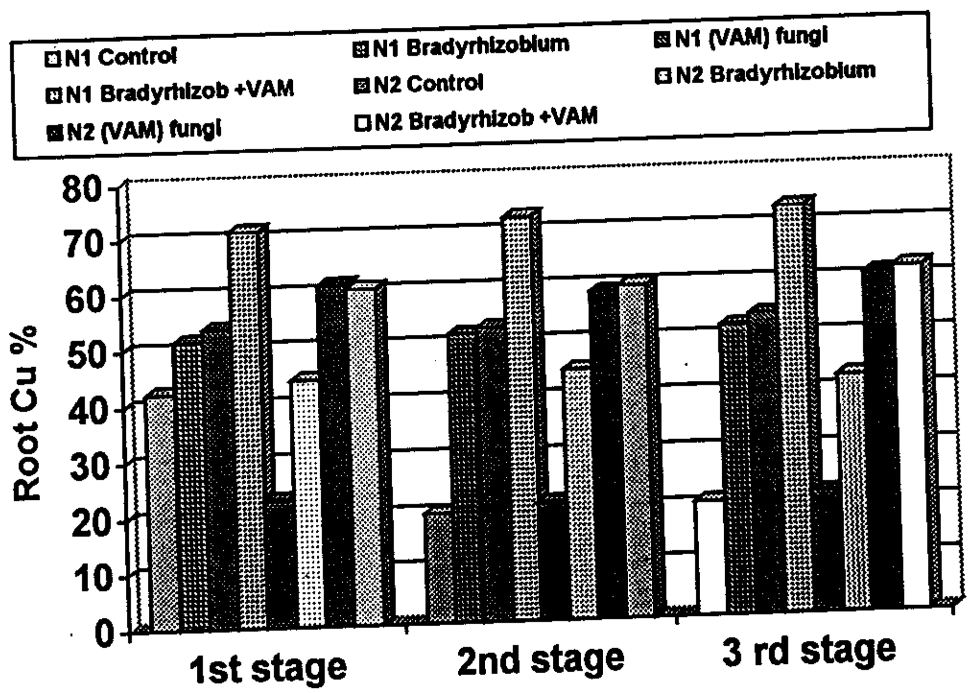
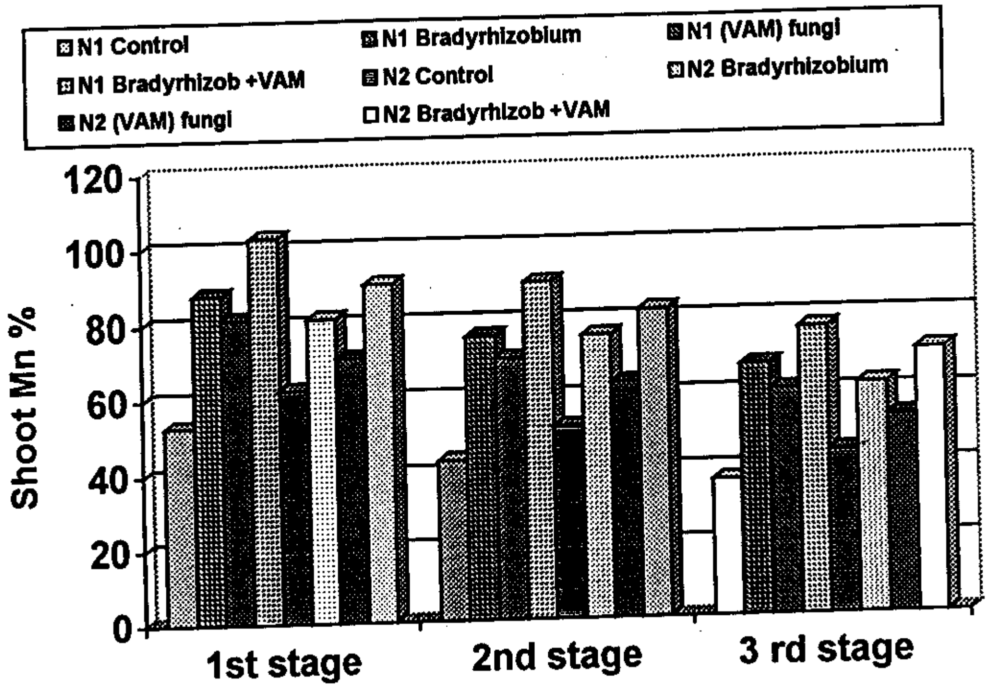


Fig (12): Copper concentrations in Acacia plants inoculated by VAM fungi and *Bradyrhizobium* with two levels of N fertilizer.



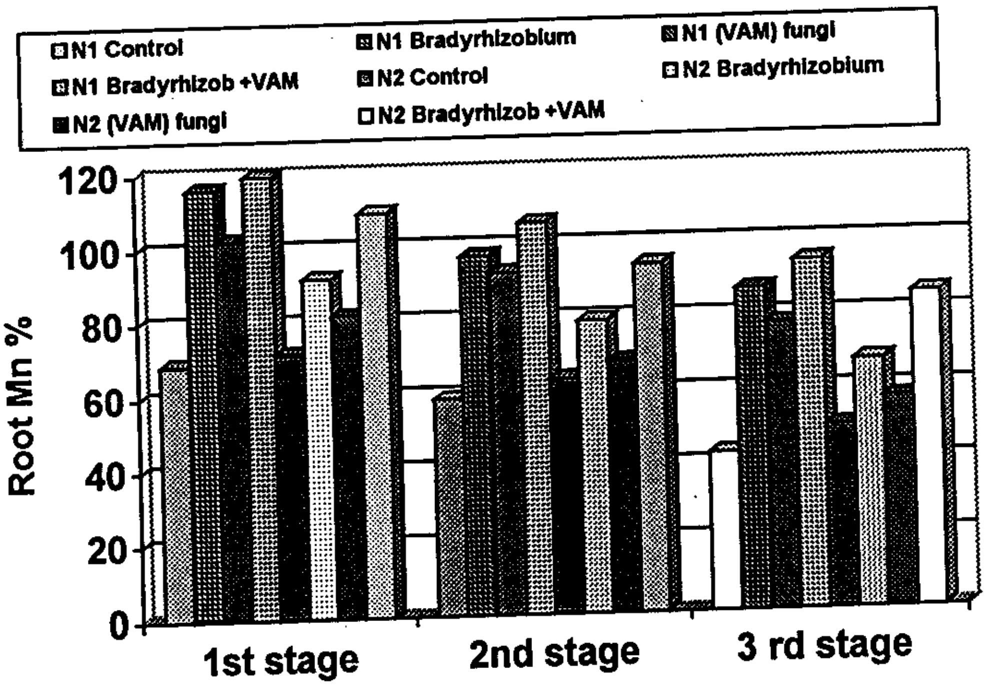
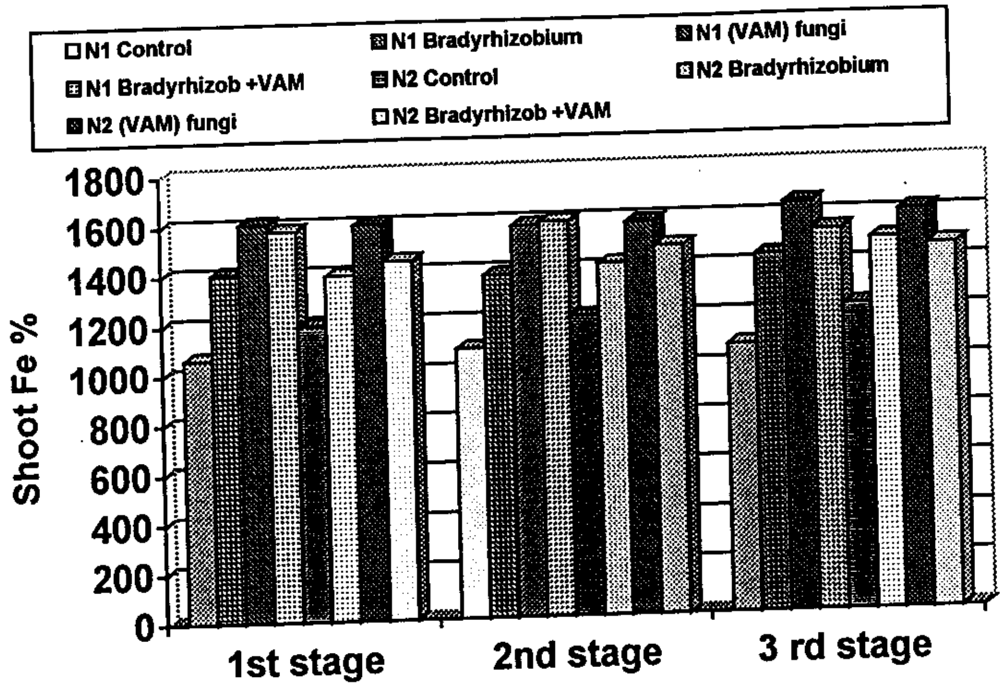


Fig (13): Manganese concentrations in Acacia plants inoculated by VAM fungi and *Bradyrhizobium* with two levels of N fertilizer.



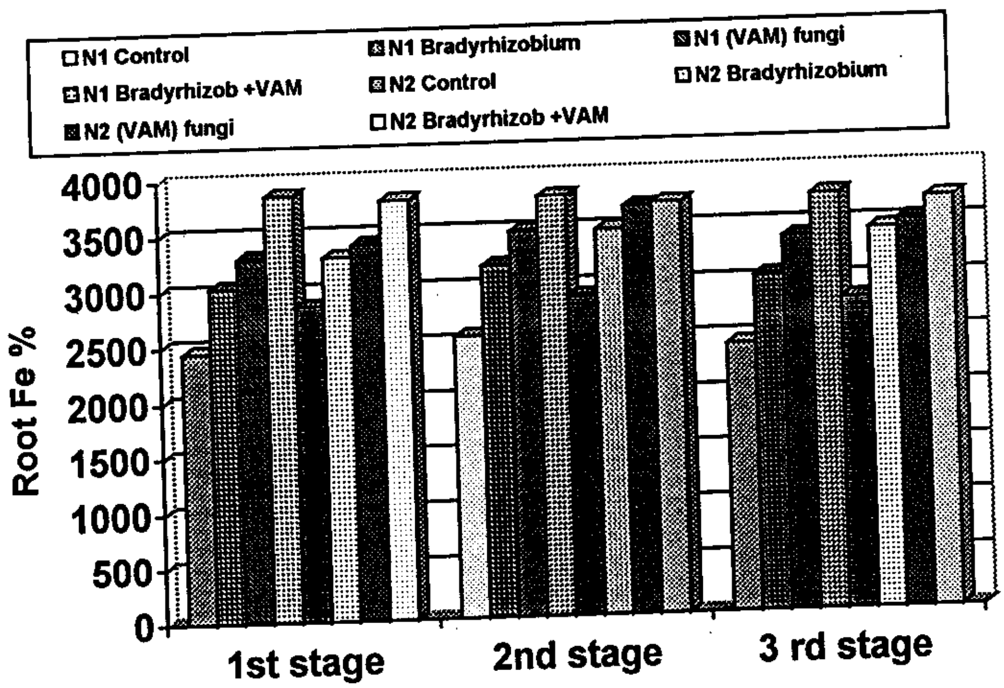
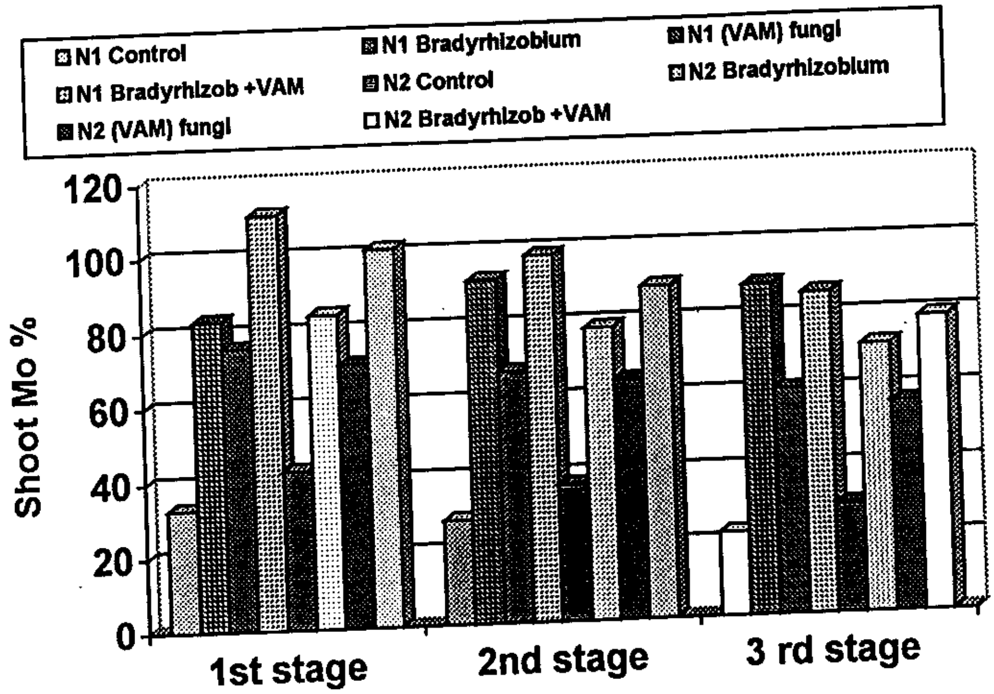


Fig (14): Iron concentrations in Acacia plants inoculated by VAM fungi and *Bradyrhizobium* wih two levels of N fertilizer.



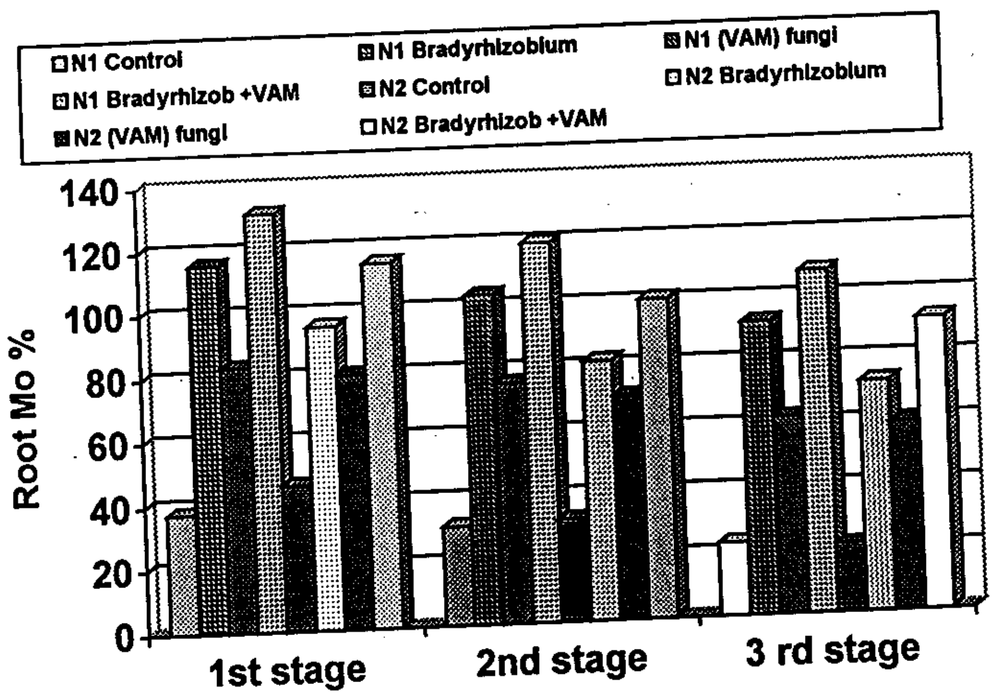
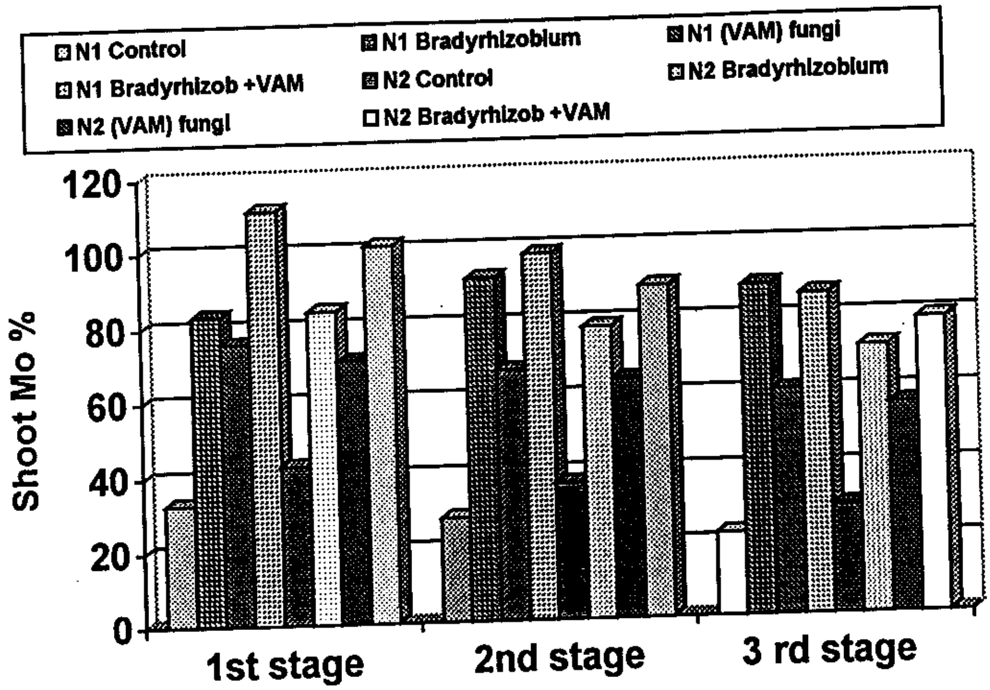


Fig (15): Molybdenum concentrations in Acacia plants inoculated by VAM fungi and *Bradyrhizobium* with two levels of N fertilizer.



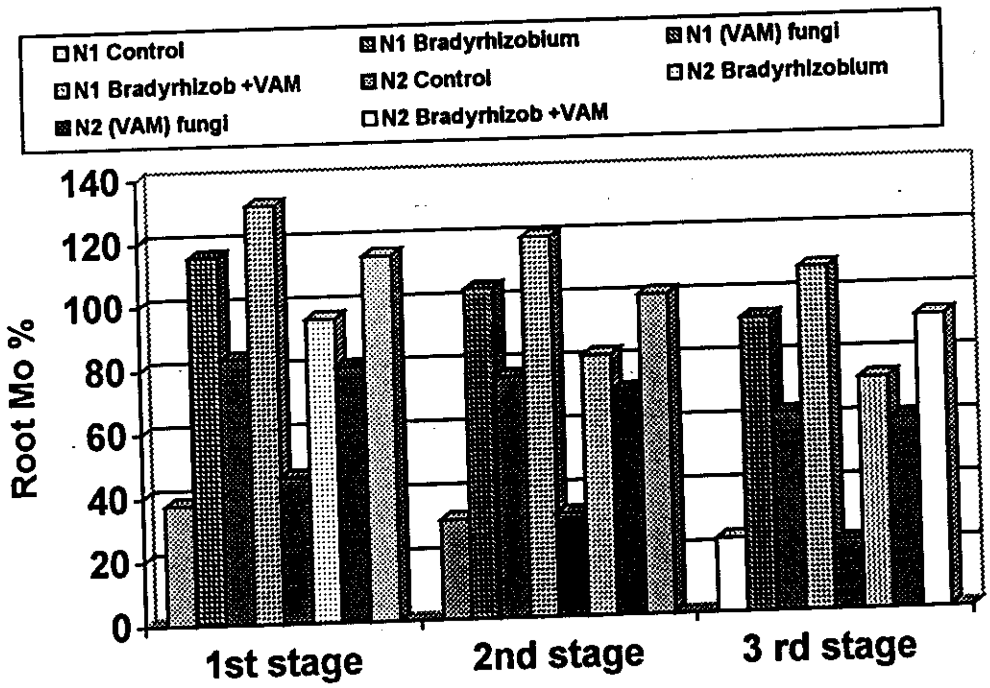


Fig (15): Molybdenum concentrations in Acacia plants inoculated by VAM fungi and *Bradyrhizobium* with two levels of N fertilizer.

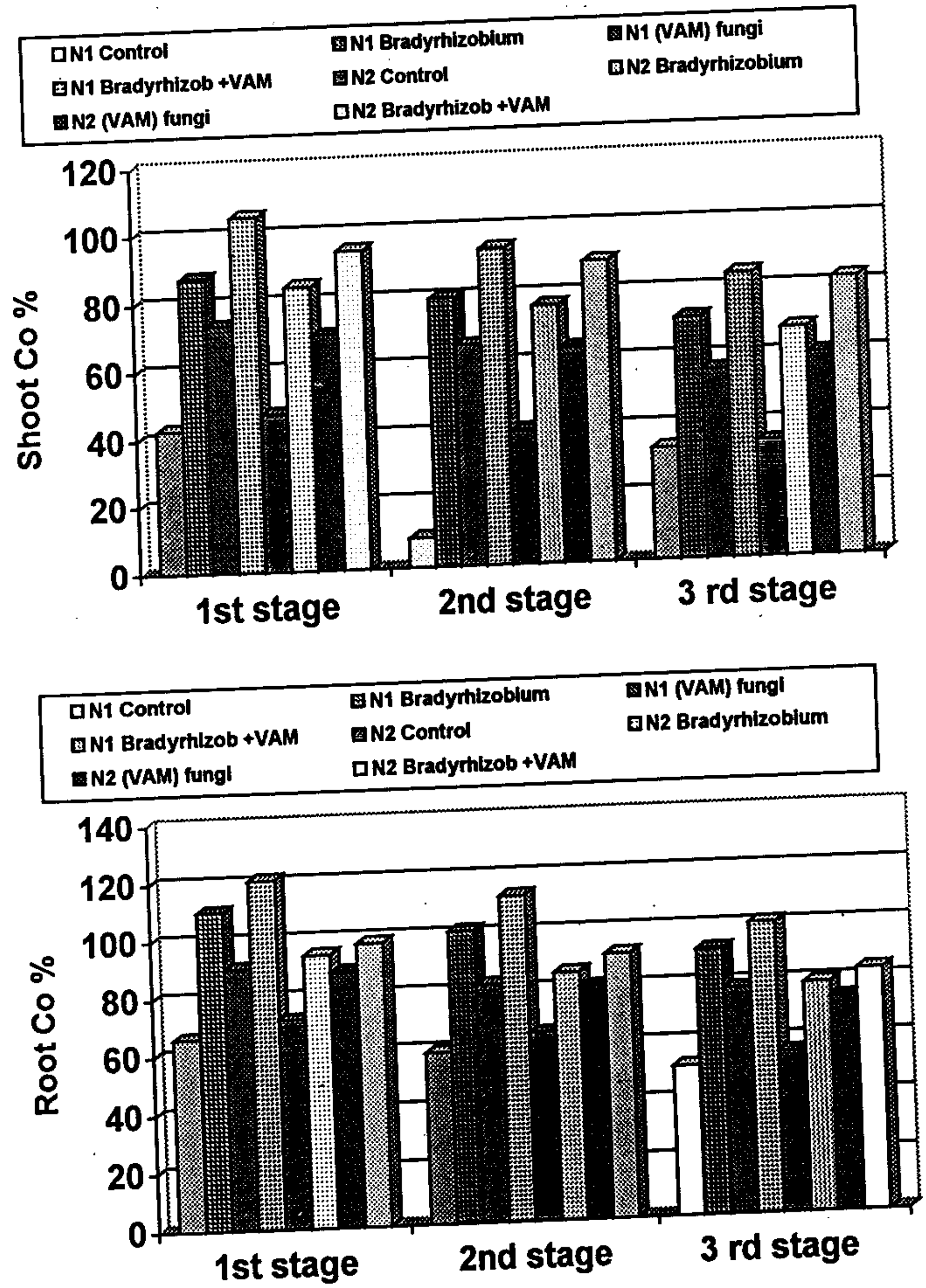


Fig (16): Cobalt concentrations in Acacia plants inoculated by VAM fungi and *Bradyrhizobium* with two levels of N fertilizer.

nutrients consquently, these nutrients probably play important roles in N assimilation by plants.

4.2.11. Micronutrients contents of shoots and roots

The contents of Fe, Zn, Mn, Co, Mo and Cu in the shoots and roots of Acacia plants are presented in tables (25 to 30). The trends of the abtained results closely match the obtained trends for dry matter contents. The magnitudes of the obtained values are increased as the growth stages increased. More over uninoculated plants fertilized only by high N fertilizer (40 unit) exhibited higher values for such nutrients compared to those obtained for plants fertilized by 20 unit. Inoculation by either *Bradyrhizobium*, VAM or in combination have led to increase all investigated nutrient elements in plant shoots and roots. The magnitude of increasing Fe and Zn contents in the shoot system during all growth stages are apparently associated with double inoculating Acacia plants fertilized by 20 N unit (Table 25 and 26). The avarge values among the growth stages were 9247.7and 796.2 ppm respectively. In the root system, both nutrients show the highest contents during the second growth stages when plants were inoculated by VA and fertilized by 40 N unit . However during the third growth stage both nutrients show the hightest contents when plants inoculating by *Bradyrhizobium* and VAM and fertilized by 20 N unit . During the first growth stage, the obtained results for both nutrients didn't show a constant trend.

Concerning Mn, CO, Mo and Cu contents in Acacia plant shoots and roots, the results given in Tables (27 to 30) show that their contents noninoculated plants (control) increased during growth stages when Acacia plants fertilized by 40 N unit compared to 20N unit .

Inoculation by either VAM or *bradyrhizobium* stimulated their contents for all growth stages. It was interstingly found that their highest values were obtained for plants inoculated by *bradyrhizobium* and VAM and fertilized by 20 N unit.

Table (25): Iron contents in the shoot and roots of Acacia plants fertilized with rock phosphate and two levels of N fertilizer and inoculated by VAM fungi and *Bradyrhizobium*.

Treatments		shoot Fe content (ppm)*			Root Fe content (ppm)*		
		1st stage	2nd stage	3rd stage	1st stage	2nd stage	3rd stage
N_1**	Control	14.11^{c}	2178^{e}	2265^{g}	1205^{d}	1993^{f}	2059^{f}
	Bradyrhizobium	3500^{b}	4716^{c}	8001^{c}	2998^{bc}	5220^{e}	7536^{e}
	(VAM) fungi	5194^{ab}	6141^{b}	10460^{b}	3712^{abc}	7732^{cd}	15310^{b}
	Bradyrhizobium+VAM	5846^{a}	7597^{a}	14300^{a}	4899^{a}	9933^{ab}	22420^{a}
N_2***	Control	1653^{c}	2905^{d}	3455^{f}	2601^{cd}	6044de	9575^{be}
	Bradyrhizobium	4319^{b}	4728^{c}	3419^{d}	3736^{abc}	9146^{bc}	12950^{bc}
	(VAM) fungi	4016^{b}	6203^{b}	7359^{c}	4511^{ab}	11010^{a}	13680^{bc}
	Bradyrhizobium+VAM	3312^{b}	4405^{c}	4929^{e}	3969^{abc}	6143de	11570^{cd}
L.S.D. at 5% level							
	N	370.03	300.8	401.8	718.8	853.8	N.S
	inoc	523.7	425.3	568.3	1017	1207	2145
	Nx inoc	740.6	601.5	803.6	1438	1708	3034

* Values represent the mean of 4 replicates. Means in each column followed by the same letter are not significantly different according to Duncan's multiple range test .
** N_1 = 20 nitrogeN unit . *** N_2 = 40 nitrogeN unit .

Table (26) : Zinc contents in the shoots and roots of Acacia plants fertilized with rock phosphate and two levels of N fertilizer and inoculated by VAM fungi and *Bradyrhizobium*.

Treatments		Shoot Zn content (ppm)*			Root Zn content (ppm) *		
		1st stage	2nd stage	3rd stage	1st stage	2nd stage	3rd stage
N_1**	Control	88.3 e	137.0 e	133.9 f	83.2	128.5 e	144.3 f
	Bradyrhizobium	240.6 cd	322.7 c	514.9 c	186.8	288.2 d	459.5 e
	(VAM) fungi	393.3 b	447.0 b	726.4 b	274.1	505.2 b	957.6 b
	Bradyrhizobium+VAM	531.3 a	642.2 a	1215 a	280.8	538.2 b	1206.0 a
N_2***	Control	124.3 e	189.0 d	224.3 e	176.9	388.8 cd	588.5 de
	Bradyrhizobium	251.8 cd	318.1 c	371.3 d	222.0	447.1 bc	676.6 cd
	(VAM) fungi	296.3 c	412.3 b	474.4 c	304.6	661.4 a	833.0 bc
	Bradyrhizobium+VAM	228.1 d	275.5 c	290.0 e	226.3	343.5 d	605.9 de
L.S.D. at 5% level							
	N	27.22	22.63	33.30	N.S	48.91	N.S
	inoc	38.49	32.00	47.09	66.90	69.16	122.6
	Nx inoc	54.44	45.26	66.60	N.S	97.81	173.4

* Values represent the mean of 4 replicates. Means in each column followed by the same letter are not significantly different according to Duncan's multiple range test.

** N_1 = 20 nitrogeN unit. *** N_2 = 40 nitrogeN unit.

Table (27): Manganese contents in the shoot and roots of Acacia plants fertilized with rock phosphate and two levels of N fertilizer and inoculation by VAM fungi and *Bradyrhizobium*.

Treatments		Mn shoot content (ppm)*			Mn root content (ppm)*		
		1st stage	2nd stage	3rd stage	1st stage	2nd stage	3rd stage
N_1**	Control	68.7 d	86.1 d	76.4 e	33.8	45.67 d	36.0 e
	Bradyrhizobium	218.5 bc	259.1 b	347.1 b	114.4	159.2 c	214.8 cd
	(VAM) fungi	262.6 b	272.5 b	384.2 b	113.6	205.1 b	350.1 b
	Bradyrhizobium+VAM	380.5 a	428.0 a	714.7 a	151.9	276.2 a	562.4 a
N_2***	Control	86.8 d	123.8 c	122.7 d	65.0	132.8 c	168.4 d
	Bradyrhizobium	199.3 c	253.0 b	240.9 c	104.4	206.4 b	253.8 c
	(VAM) fungi	178.3 c	248.1 b	242.2 c	107.3	203.3 b	222.1 cd
	Bradyrhizobium+VAM	206.4 c	243.5 b	237.2 c	113.7	155.1 c	264.9 c
L.S.D. at 5% level							
	N	24.30	6.16	21.08	N.S	N.S	37.21
	inoc	34.37	22.85	29.81	30.04	26.69	52.62
	Nx inoc	48.60	32.31	42.16	N.S	37.75	74.42

* Values represent the mean of 4 replicates. Means in each column followed by the same letter are not significantly different according to Duncan's multiple range test.
** N_1 = 20 nitrogeN unit. *** N_2 = 40 nitrogeN unit.

4.2.12. Elemental uptake of Acacia plants.

The total amount of absorbed nutrients (N, P, Fe, Zn, Mo, Co, Cu, Mn) are shown in Tables (31-34) and illustrate by Figs (17-20). It could be stated that fertilization by high level of N fertilizer give higher total elemental content than those receive low level of N fertilizer in noninoculated plants (control). Also, biofertilization by VAM fungi and or Bradyrhizobium increased macro and micronutrients uptake in Acacia plants. However VAM fungi has greater effect on total nutrients uptake than *Bradyrhizobium* especially in case of total P uptake when received 20 N unit of ammonium sulphate. So the presence of VAM fungi can reduce the nutrient stress in environments limited in availability of elements such as N, P, Fe, Zn , Cu, Mn, Mo and Co. Phosphorus and nitrogen absorption are significantly increased in all harvests being 1.840, 2.57 and 5.06 mg/plants for phosphorus and 16.03, 24.09 and 51.23 mg/plant for nitrogen respectively when plants inoculated by VAM fungi and *Bradyrhizobium* and received 20 N unit of ammonium sulphate.

Table (28): Cobalt contents in the shoots and roots of Acacia plants fertilized with rock phosphate and two levels of N fertilizer and inoculated by VAM fungi and *Bradyrhizobium*.

Treatments		Co shoot content (ppm)*			Co shoot content (ppm)*		
		1st stage	2nd stage	3rd stage	1st stage	2nd stage	3rd stage
N_1**	Control	55.8 d	77.6 c	69.5 e	32.5 d	45.9 e	43.5 e
	Bradyrhizobium	216.7 bc	271.2 b	397.1 b	108.9 bc	165.2 cd	226.9 cd
	(VAM) fungi	236.8 b	254.4 b	352.3 c	100.1 bc	181.7 c	352.2 b
	Bradyrhizobium+VAM	388.3 a	446.4 a	782.5 a	153.5 a	294.0 a	598.7 a
N_2***	Control	65.1 d	95.4 c	96.3 e	65.5 cd	134.9 d	188.0 d
	Bradyrhizobium	206.4 bc	255.1 b	264.0 d	106.7 bc	223.5 b	299.0 bc
	(VAM) fungi	175.4 c	250.1 b	274.2 d	116.7 ab	239.7 b	287.2 bc
	Bradyrhizobium+VAM	215.6 bc	264.0 b	274.9 d	102.1 bc	150.4 cd	259.5 cd
L.S.D. at 5% level							
	N	22.11	16.12	16.31	N.S	N.S	40.94
	inoc	31.27	22.80	23.07	29.40	27.21	57.94
	Nx inoc	44.22	32.24	32.63	41.58	38.47	81.94

* Values represent the mean of 4 replicates. Means in each column followed by the same letter are not significantly different according to Duncan's multiple range test.

** N_1 = 20 nitrogeN unit. *** N_2 = 40 nitrogeN unit.

Table (29): Molybdenum Contents in the shoots and roots of Acacia plants fertilized with rock phosphate and two levels of N fertilizer and inoculated by VAM fungi and *Bradyrhizobium*.

Treatments		Mo Shoot content (ppm) *			Mo Root content (ppm) *		
		1st stage	2nd stage	3rd stage	1st stage	2nd stage	3rd stage
N_1**	Control	42.6 c	56.1 d	46.6 e	18.5 c	24.3 e	19.4 c
	Bradyrhizobium	212.4 b	312.6 b	490.3 b	114.1 b	170.2 c	227.6 b
	(VAM) fungi	245.4 b	261.3 c	382.2 c	93.8 b	167.3 c	281.5 b
	Bradyrhizobium+VAM	411.7 a	468.0 a	798.0 a	166.9 a	311.7 a	643.6 a
N_2***	Control	59.40 c	88.7 d	82.0 e	41.6 c	67.7 d	73.0 c
	Bradyrhizobium	205.9 b	261.2 c	279.8 d	1058.2 b	213.6 b	108.2 b
	(VAM) fungi	177.7 b	252.0 c	257.0 d	105.7 b	210.8 b	230.8 b
	Bradyrhizobium+VAM	231.0 b	263.6 c	264.0 d	119.7 d	165.4 c	286.0 b
L.S.D. at 5% level							
	N	31.50	17.13	18.85	N.S	N.S	41.32
	inoc	44.54	24.23	26.66	30.03	24.99	58.43
	Nx inoc	62.99	34.27	37.71	42.48	35.34	82.63

* Values represent the mean of 4 replicates. Means in each column followed by the same letter are not significantly different according to Duncan's multiple range test .
** N_1 = 20 nitrogeN unit . ***N_2 = 40 nitrogeN unit .

Table (30) : Copper contents in the shoots and roots of Acacia plants fertilized with rock phosphate and two levels of N fertilizer as and inoculation by VAM fungi and *Bradyrhizobium*.

Treatments		shoot Cu content (ppm)*			Root Cu content (ppm) *		
		1st stage	2nd stage	3rd stage	1st stage	2nd stage	3rd stage
N_1**	Control	38.2 f	60.0 d	58.7 e	21.2	15.2 e	17.6 e
	Bradyrhizobium	82.5 de	117.7 c	184.6 c	51.0	84.7 c	129.5 cd
	(VAM) fungi	138.0 b	169.9 b	285.6 b	59.3	117.4 b	243.5 b
	Bradyrhizobium+VAM	220.5 a	258.8 a	572.3 a	90.4	189.8 a	439.7 a
N_2***	Control	43.9 f	69.3 d	83.3 e	20.9	44.4 d	73.8 de
	Bradyrhizobium	76.9 e	103.8 c	126.6 c	49.5	117.5 b	161.1 c
	(VAM) fungi	105.5 cd	163.9 b	198.7 b	81.6	175.3 a	237.3 b
	Bradyrhizobium+VAM	118.9 bc	54.4 b	183.7 a	63.3	98.6 bc	193.4 bc
L.S.D. at 5% level							
	N	12.44	10.05	13.78	N.S	N.S	32.74
	inoc	17.60	14.21	19.48	17.69	17.97	46.30
	Nx inoc	24.88	20.10	27.55	N.S	25.41	65.48

* Values represent the mean of 4 replicates. Means in each column followed by the same letter are not significantly different according to Duncan's multiple range test .

** N_1 = 20 nitrogeN unit . *** N_2 = 40 nitrogeN unit .

Table (31) : Elemental phosphorus and Nitrogen uptake of Acacia Plants fertilized with rock phosphate and two levels of nitrogen influenced by VAM fungi and *Bradyrhizobium* inoculation.

Treatments		Total N uptake (mg/plant) *			Total phosphorus uptake (mgplant) *		
		1st stage	2nd stage	3rd stage	1st stage	2nd stage	3rd stage
N_1**	Control	4.205 e	6.866 f	7.315 f	0.2097 e	0.3572 e	0.3710 g
	Bradyrhizobium	9.641 bc	14.40 cd	23.63 c	0.5726 d	0.9039 d	1.274 ef
	(VAM) fungi	11.40 b	15.77 bc	27.31 b	1.384 b	1.832 b	3.002 b
	Bradyrhizobium+VAM	16.03 a	24.09 a	51.23 a	1.840 a	2.567 a	5.075 a
N_2***	Control	6.193 d	11.94 e	16.09 e	0.2879 e	0.5541 e	0.8531 f
	Bradyrhizobium	9.883 bc	16.58 bc	21.13 cd	0.6398 d	1.285 c	1.524 de
	(VAM) fungi	9.887 bc	17.73 b	22.24 c	1.177 c	1.871 b	2.163 c
	Bradyrhizobium+VAM	9.403 c	13.11 de	17.88 de	1.104 c	1.414 c	1.848 cd
L.S.D. at 5% level							
	N	0.8783	N.S	1.984	0.9005	0.1273	0.2371
	inoc	1.242	1.511	2.806	0.1273	1.1801	0.3353
	Nx inoc	1.757	2.137	3.968	0.1801	0.2547	0.4742

* Values represent the mean of 4 replicates. Means in each column followed by the same letter are not significantly different according to Duncan's multiple range test .

** N_1 = 20 nitrogeN unit . ***N_2 = 40 nitrogeN unit .

Table (32): Total manganese and cobalt uptake of Acacia plants fertilized with rock phosphate and two levels of N fertilizer influenced by (VAM) fungi and *Bradyrhizobium* inoculation.

Treatments		Total Mn content *			Total Co content *		
		1st stage	2nd stage	3rd stage	1st stage	2nd stage	3rd stage
N_1**	Control	102.5 d	131.8 e	112.4 f	88.24 c	123.5 e	113.0 e
	Bradyrhizobium	332.9 bc	418.2 bc	588.9 c	325.1 b	436.4 bc	624.0 bc
	(VAM) fungi	376.1 b	477.6 b	734.3 b	336.9 b	436.1 bc	704.5 b
	Bradyrhizobium+VAM	532.4 a	704.3 a	1277.0 a	541.8 a	740.4 a	1381.0 a
N_2***	Control	151.9 d	256.6 d	291.1 e	130.6 c	230.3 d	284.3 d
	Bradyrhizobium	303.7 bc	459.4 bc	494.7 cd	313.2 b	478.6 b	563.0 c
	(VAM) fungi	285.7 c	451.5 bc	464.2 c	292.1 b	489.7 b	561.4 c
	Bradyrhizobium+VAM	320.1 bc	398.6 c	502.2 cd	317.8 b	414.4 c	534.4 c
L.S.D. at 5% level							
	N	35.62	28.14	51.89	32.79	29.16	52.02
	inoc	50.37	39.80	73.39	46.37	41.24	73.57
	Nx inoc	71.23	56.28	103.8	65.57	58.32	104.0

* Values represent the mean of 4 replicates. Means in each column followed by the same letter are not significantly different according to Duncan's multiple range test.
** N_1 = 20 nitrogeN unit . *** N_2 = 40 nitrogeN unit .

Table (33): Total Molebdenum and Zinc uptake of Acacia plants fertilized with rock phosphate and two levels of N fertilizer influenced by (VAM) fungi and *Bradyrhizobium* inoculation.

Treatments		Total Mo content (ppm)			Total Zn content (ppm)		
		1st stage	2nd stage	3rd stage	1st stage	2nd stage	3rd stage
N_1**	Control	61.09 c	80.40 d	66.02 d	171.5 e	265.5 e	278.2 f
	Bradyrhizobium	326.5 b	482.8 b	717.9 b	427.4 c	610.9 d	974.4 de
	(VAM) fungi	339.2 b	428.5 b	663.7 b	667.4 b	952.2 b	1684.0 b
	Bradyrhizobium+VAM	578.6 a	779.7 a	1442.0 a	812.2 a	1180.0 a	2421.0 a
N_2***	Control	101.0 c	156.4 c	155.0 d	301.2 d	577.8 d	812.9 e
	Bradyrhizobium	314.1 b	474.9 b	554.7 c	473.8 c	765.2 c	1048 d
	(VAM) fungi	283.5 b	462.8 b	487.8 c	600.9 b	1075.0 a	1307 c
	Bradyrhizobium+VAM	350.7 b	429.0 b	550.0 c	454.4 c	619.0 d	895.9 de
L.S.D. at 5% level							
	N	40.22	27.51	53.91	61.68	N.S	105.3
	inoc	56.88	38.91	76.25	87.23	80.06	148.9
	Nx inoc	80.44	55.03	107.8	123.4	113.2	210.6

* Values represent the mean of 4 replicates. Means in each column followed by the same letter are not significantly different according to Duncan's multiple range test.

** N_1 = 20 nitrogeN unit. *** N_2 = 40 nitrogeN unit.

Table (34): Total Cu and Fe uptake of Acacia plants fertilized with rock phosphate and two levels of N fertilizer influenced by (VAM) fungi and *Bradyrhizobium* inoculation.

Treatments		Total Cu content *			Total Fe content *		
		1st stage	2nd stage	3rd stage	1st stage	2nd stage	3rd stage
N_1**	Control	59.38 d	75.16 g	76.26 g	2617 d	4171 d	4323 f
	Bradyrhizobium	133.5 c	202.4 e	314.1 de	6497 c	9936 c	15540 de
	(VAM) fungi	197.2 b	287.3 c	529.4 b	8906 b	13870 b	25770 b
	Bradyrhizobium+VAM	310.9 a	448.6 a	1012.0 a	10.750 a	17530 a	36720 a
N_2***	Control	64.71 d	113.6 f	157.1 f	4254 d	8950 c	13030 e
	Bradyrhizobium	126.3 c	221.2 be	287.6 e	7155 bc	13870 b	18800 cd
	(VAM) fungi	187.1 b	339.2 b	436.0 c	8527 b	17210 a	21040 c
	Bradyrhizobium+VAM	182.2 b	253.0 cd	377.1 cd	7281 bc	10550 c	16500 de
L.S.D. at 5% level							
N		20.30	17.39	39.06	N.S	955.2	1682
inoc		28.71	24.59	55.24	1262	1351	2379
Nx inoc		40.61	34.77	78.13	1785	1911	3364

* Values represent the mean of 4 replicates. Means in each column followed by the same letter are not significantly different according to Duncan's multiple range test.
** N_1 = 20 nitrogeN unit. *** N_2 = 40 nitrogeN unit.

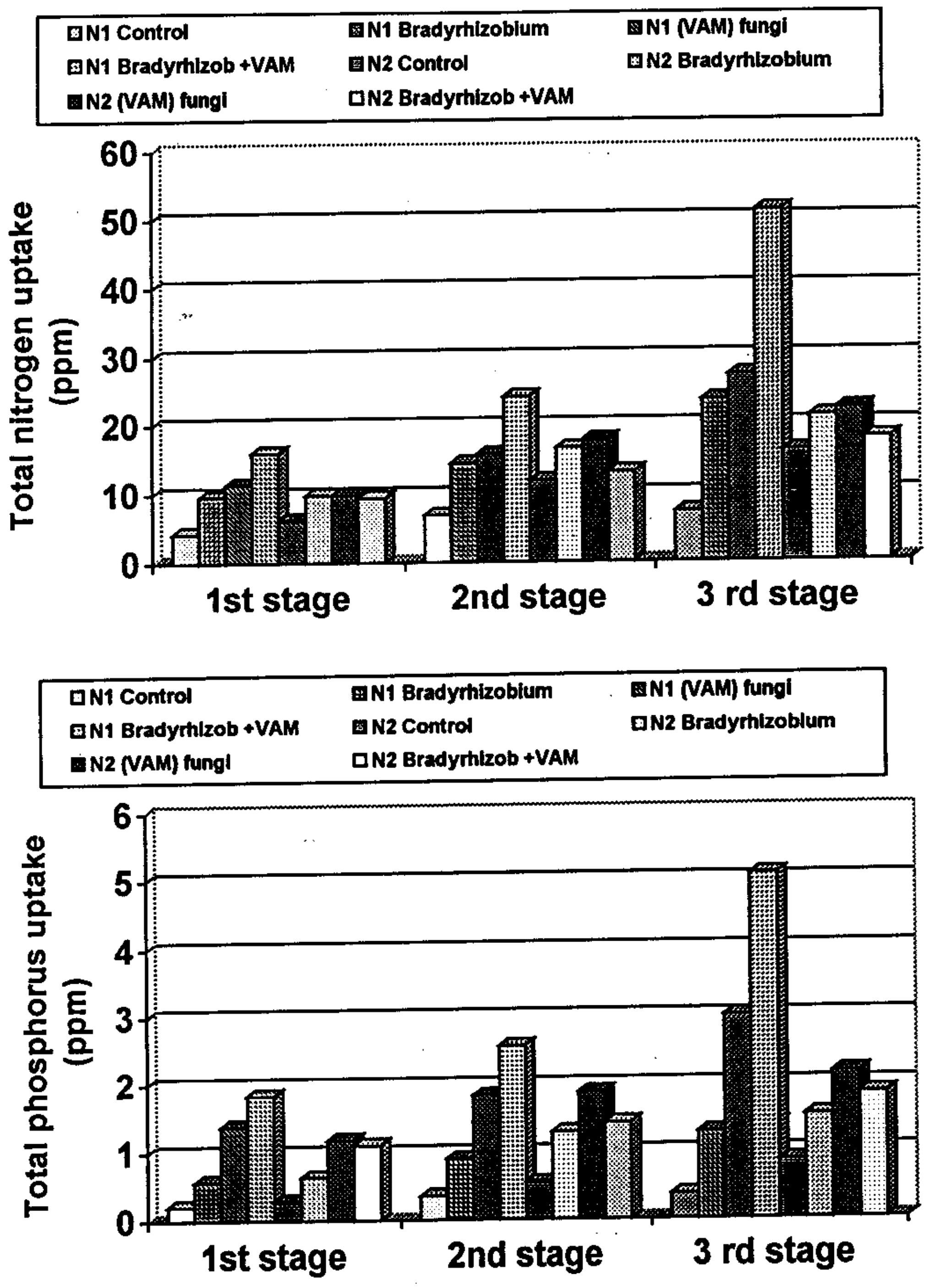
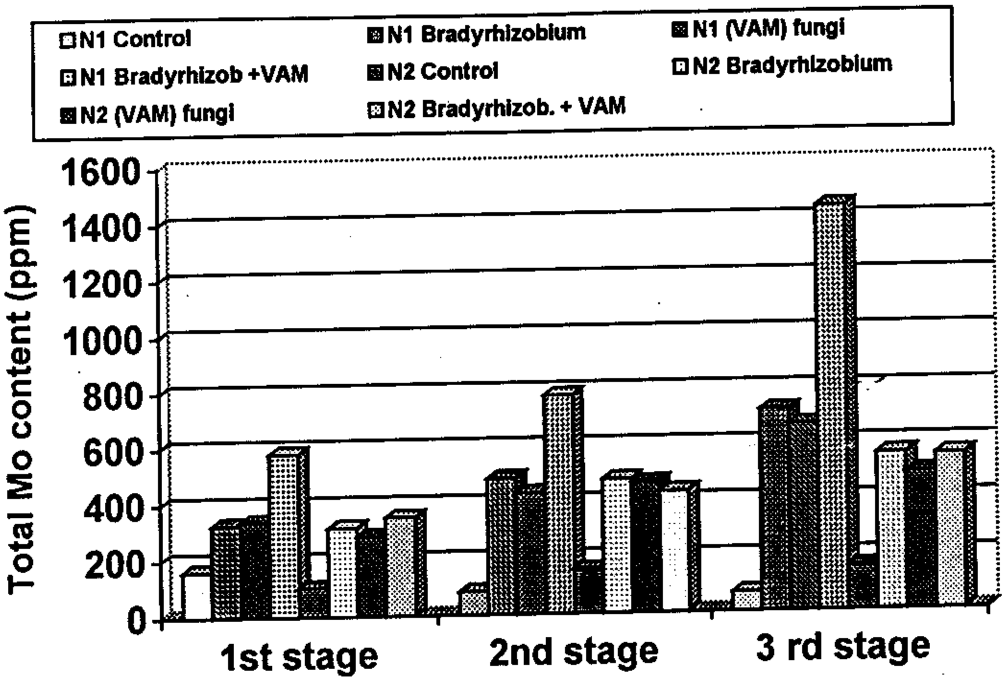


Fig (17): Elemental phosphorus and nitrogen uptake of Acacia (plants fertilized with rock phosphate and two levels of nitrogen) influenced by (VAM) fungi and *Bradyrhizobium* inoculation.



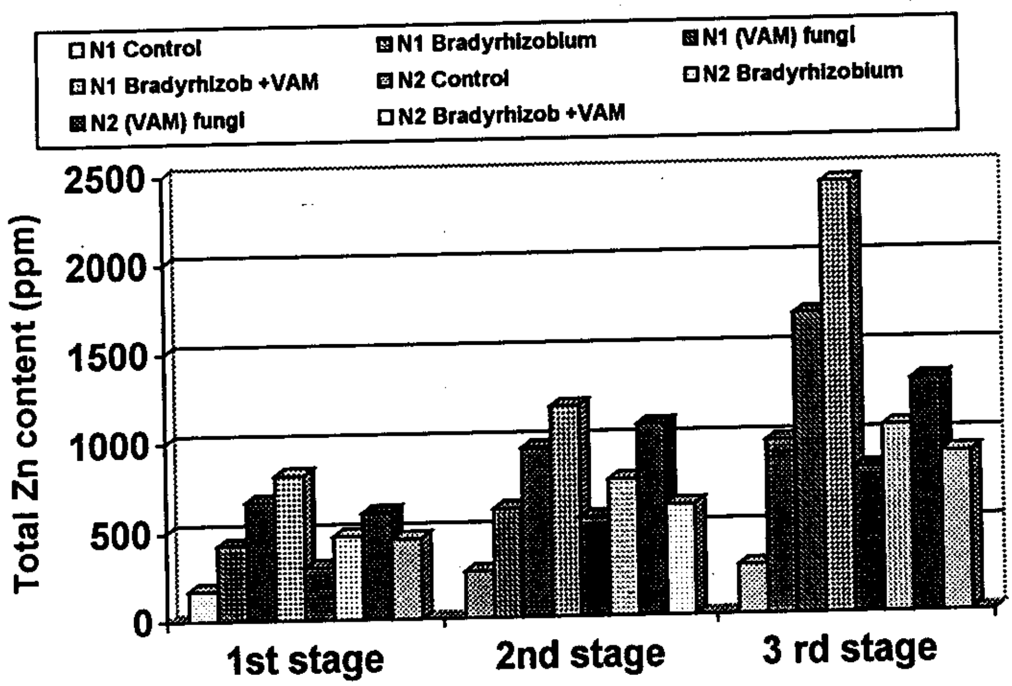
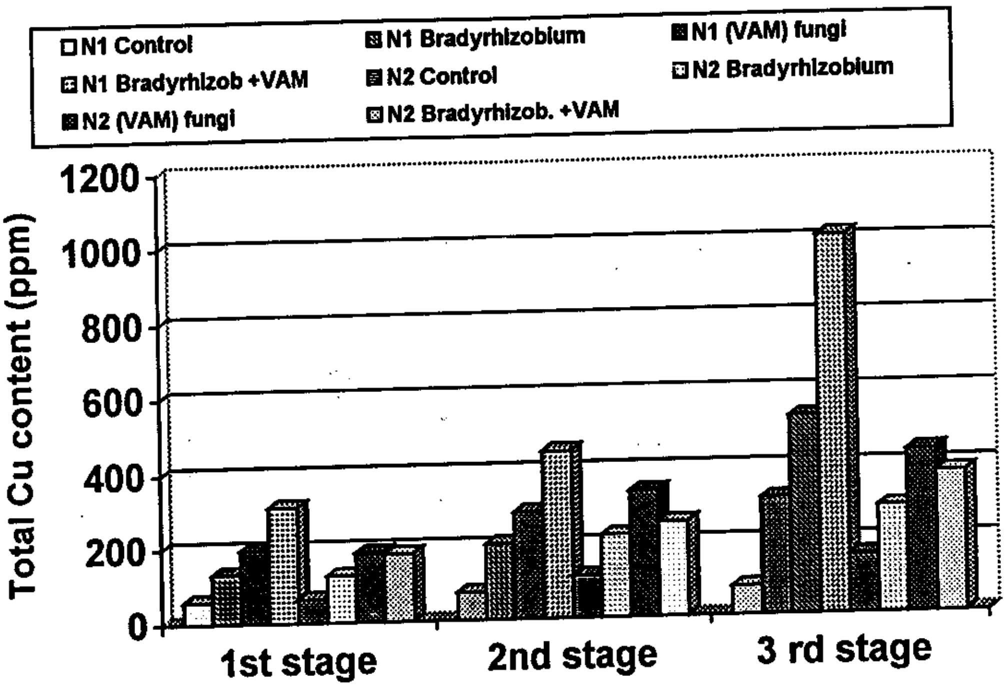


Fig (18): Total zinc and molybdenem uptake of Acacia plants fertilized with rock phosphate and two levels of N fertilizer influenced by (VAM) fungi and *Bradyrhizobium* inoculation.



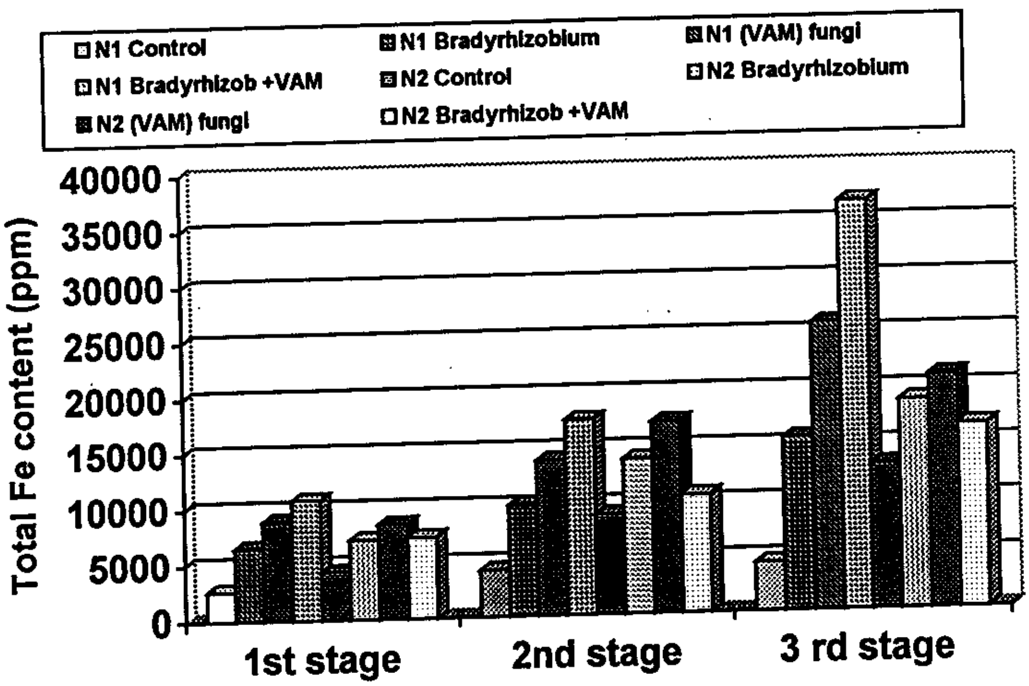


Fig (19): Total copper and Iron uptake of Acacia plants fertilized with rock phosphate and two levels of N fertilizer influenced by (VAM) fungi and *Bradyrhizobium* inoculation.

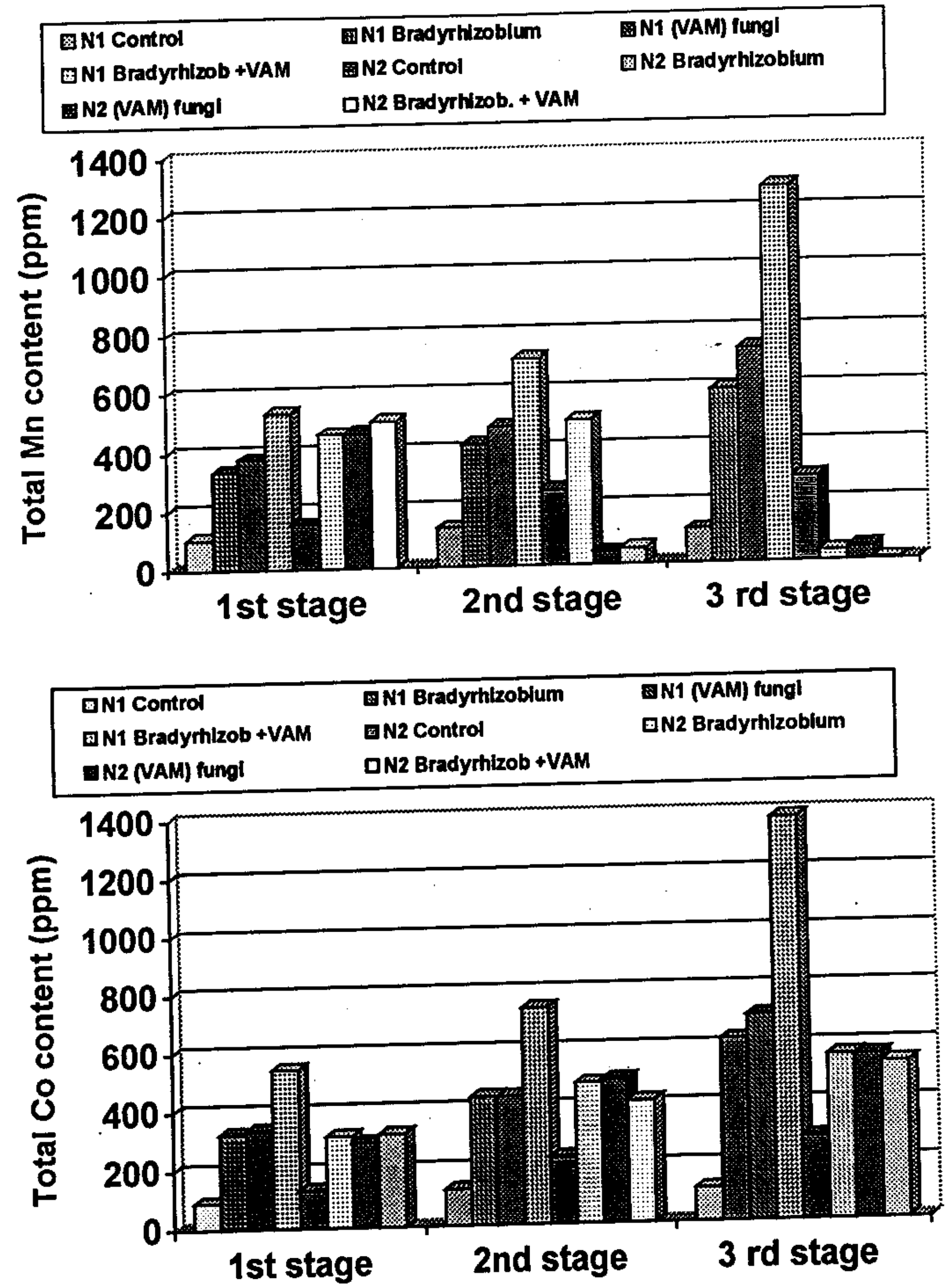


Fig (20): Total manganese and cobalt uptake of Acacia plants fertilized with rock phosphate and two levels of N fertilizer influenced by (VAM) fungi and *Bradyrhizobium* inoculation.

4.2.13.Growth promoting substances produced by Acacia plants;

The results obtained for phytohormones produced by Acacia shoots are shown in Tables (35 and 36) and Figs. (21 and 22). The data reveals that gibbrelic acid concentration for control treatment fertilized by 40 N unit are higher than those fertilzed by 20 N unit. The highest production occurred during the first growth stage (350.1 mg/100g). Concerning the single inoculation by VAM or *bradyrhizobium*, the results reveal that treatments inoculated by *bradyrhizobium*, produced higher values when fertilized by 40 than by 20 N unit. On the other hand, inoculation by VAM gave opposite results to those obtained from plants inoculated by *bradyrhizobium*. The highest values for both inoculums occurred during the second growth stage. Double inoculation proved that, when plants were fertilized by low rate of N, the response of inoculation by VAM in producing gibbrelic acid was stimulated by *bradyrhizobium* inoculation. However, when Acacia plants were fertilized by 40 N unit, the stimulation by VAM incoulation to *bradyrhizobium* inoculation was minimum. The reasons for such results are related to the fact that increasing nitrogen fertilizer with in the recomended dose, probably stimulate the formation of active nodules. But in case of VAM inoculation, increasing available N and P in the soil will result in decreasing the colonization of plant roots by VAM hyphae.

Production of IAA. always increased by time (table 35). For the control treatments N_2 fertilized plants were better than N_1 treatment. The response to single or double inoculation by *bradyrhizobium* or VAM on IAA production have the same trend like that observed for gibberlic acid production.

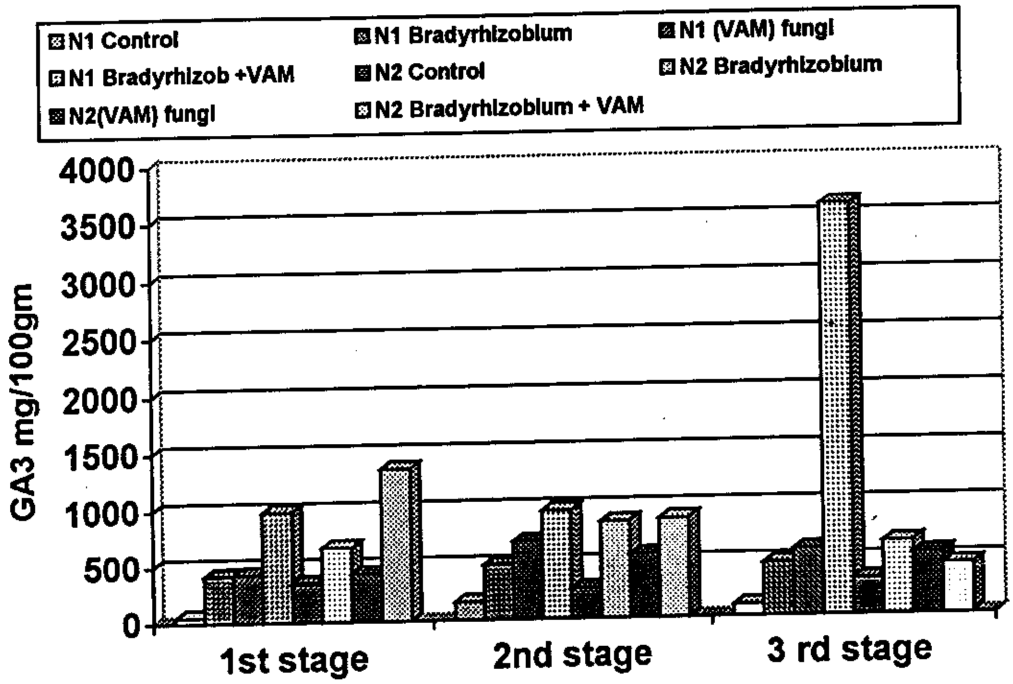
Production of cytokinine (zeation riboside) Table (36) by Acacia shoots show the highest values during the second growth stage and was affected by the type of inoculation and the level of N fertilization. The combination of *Bradyrhizobium* and VAM fungi inoculation recorded the highest values followed by single inoculation of VAM fungi and then by only *bradyrhizobium.* Under the previous inoculation treatments the contents of cytokinine for plants fertilized by 40 N unit were less than those fertilized by 20 N level.

Table (35): GA_3 and IAA production influenced by (VAM) fungi and Bradyrhizobia under two levels of N-fertilizer.

Treatments		GA_3 mg/100 gm			IAA mg/100 gm		
		1st stage	2nd stage	3rd stage	1st stage	2nd stage	3rd stage
N_1**	Control	48.680	159.170	98.882	0.4070	0.6153	0.8593
	Bradyrhizobium	415.830	487.479	469.643	3.1816	3.5921	4.8055
	(VAM) fungi	422.877	697.492	595.64	3.9594	3.6824	4.6929
	Bradyrhizobium+VAM	982.979	963.160	3605.860	5.6139	5.8489	6.2427
N_2***	Control	350.093	268.089	318.180	1.7061	1.6487	2.2501
	Bradyrhizobium	663.888	861.079	654.301	4.3481	3.8397	5.1420
	(VAM) fungi	424.578	564.692	547.330	3.2101	2.9591	4.3151
	Bradyrhizobium+VAM	1351.195	880.371	943.152	4.9318	3.2739	5.0091

Table (36): Zeation riboside production influenced by (VAM) fungi and Bradyrhizobia.

Treatments		ABA mg/ 100g			Zeation riboside Ug/100g		
		1st stage	2nd stage	3rd stage	1st stage	2nd stage	3rd stage
N_1**	Control	0.570176	1.82539	2.273135	291.165	383.571	179.365
	Bradyrhizobium	0.940166	0.746712	4.16868	449.317	1818.117	851.457
	(VAM) fungi	4.264206	1.273731	0.943698	1102.534	2422.006	1686.055
	Bradyrhizobium+VAM	0.340591	2.480567	3.978235	3747.5833	3977.831	3346.666
N_2***	Control	3.877653	2.632190	3.921383	444.763	722.115	533.047
	Bradyrhizobium	3.256255	2.031123	0.607394	1515.337	2351.510	2734.642
	(VAM) fungi	1.921367	3.637383	3.497116	515.34	1462.323	1239.855
	Bradyrhizobium+VAM	1.817483	3.8632	1.341104	1749.353	3046.169	2981.197



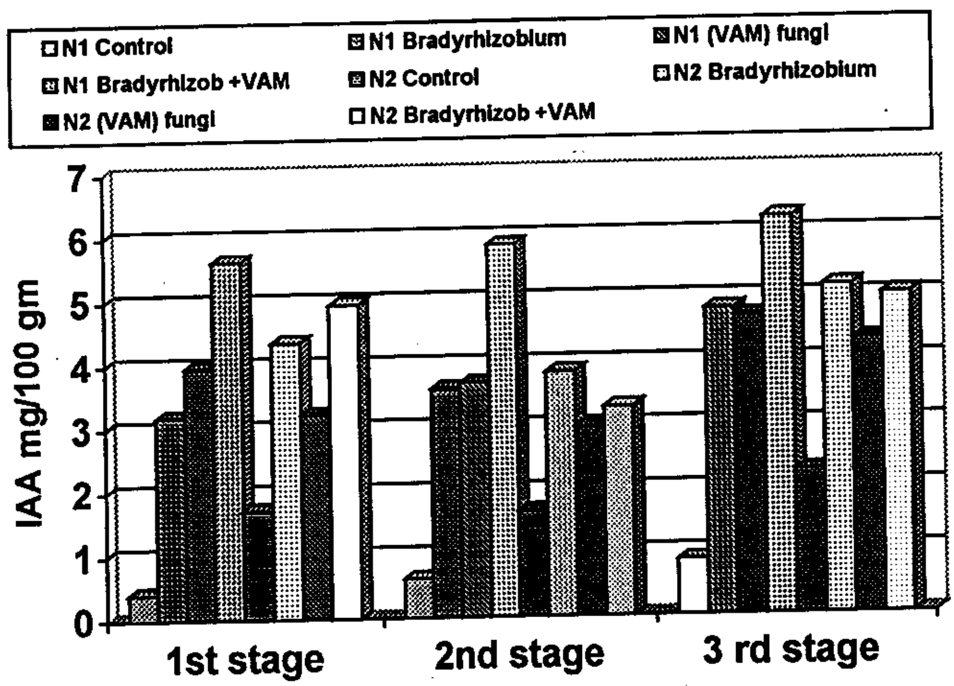


Fig (21): Phytohormones production by Acacia plants which inoculated by (VAM) fungi and Bradyrhizobium.

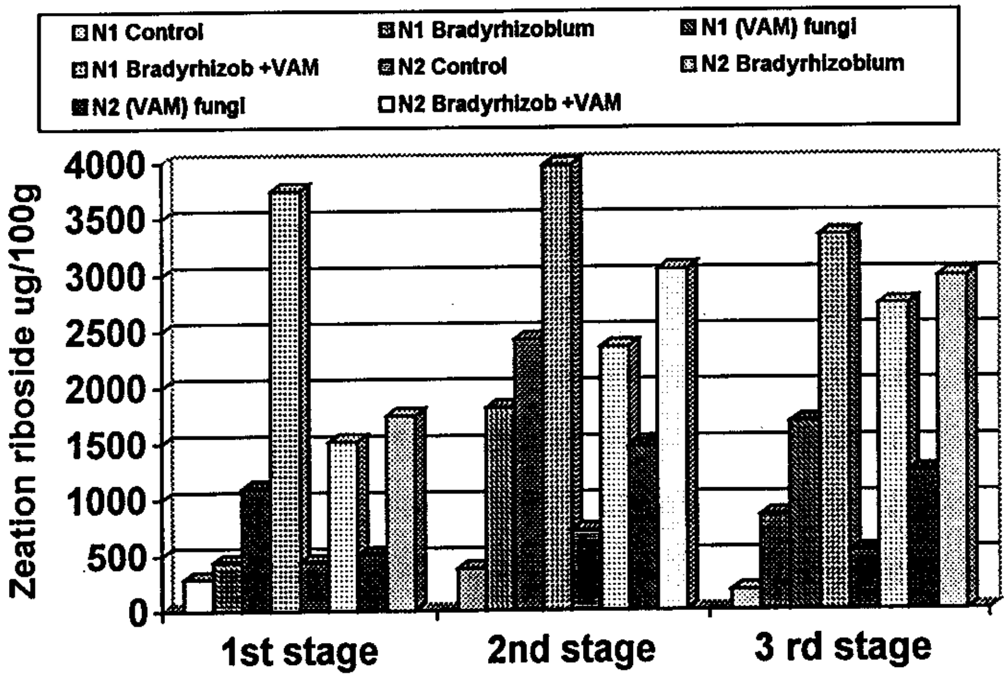


Fig (22): Phytohormones production by Acacia plants which inoculated by (VAM) fungi and Bradyrhizobium.