
RESULTS

# RESULTS

## Isolation and characterization of VAM-fungi:

Healthy roots taken from onion bulbs grown in sterilized potted soil inoculated with the vesicular arbuscular mycorrhizal fungus *Glomus macrocarpum*, field grown broad bean plants, Swiss cheese plants (grown in outdoor pots) and maize seedlings grown aseptically (surfaced sterilized seeds in sterilized soil) *in vitro* were used for isolation trials. All fungi emerged from the used plant materials could grow and sporulate well on modified MS-agar medium producing white-grayish branched mycelium. Hyphae were branched, varied considerably in thickness, aseptate, hyaline, vacuolated and showed oil-like droplets. The hyphal branching pattern, particularly their terminal branches, resembles the VAM-arbuscular structure **(Fig., 1a and b)**.

All isolates (except VAM-M isolate) formed different sized sporangia borne individually at the terminal hyphal ends. VAM-S isolate formed *Mucor*-type sporangia while isolates of onion "VAM-O" and broad bean "VAM-B" produced deciduous sporangia **(Fig., 2a and b)**. Sporangia in all VAM-isolates contained rounded hyaline 1-celled sporangiospores **(Fig., 2b)** (Sp-spores). Oval shaped like-zygospore structures were observed in VAM-O isolate only. All isolates produced apical and intercalary round- and oval-shaped Chlamydospores (Ch-spores) singly and/or in chains **(Fig., 3a, b, c and d)**. The Chlamydospores showed double layered spore wall. Spore wall of the different VAM isolate was distinctly varied against aniline blue stain **(Fig. 4a and b)**. Growth and sporulation of the different VAM isolates on the modified barely-sand medium are

shown in **Fig. (5)**. The morphological features and dimensions of different fungal structures (in µm) are shown in **Table (6)**.

**Table (6):** Diameter (in µm) of different measured structures of the isolated Vesicular Arbuscular Mycorrhizal (VAM) fungi.

| | Vesicular Arbuscular Mycorrhizal (VAM) fungi | | | |
|---|---|---|---|---|
| Fungal structures | VAM-S | VAM-O | VAM-B | VAM-M |
| Hypha diam. (µm) | 2.5-17.5 | 3.2-30.0 | 3.3-24.0 | 2.5-35.0 |
| Sporangia (µm) | 25.0-37.5 | 30.0-57.5 | 40.0-45.0 | ND |
| Sp-spores (µm) | 2.5-3.0 | 2.5-3.0 | 2.5-3.0 | 2.5-3.0 |
| zygospores (µm) | ND | 32.5 x 42.5 | ND | ND |
| Ch-spores (round shaped) (µm) | 5.0- 25.0 (15.5) | 12.5-30.0 (24.2) | 20.0-30.0 (24.2) | 7.5-22.0 (15.5) |
| Ch-spores (oval shaped) (µm) | 12.5x33 (17.4x22.2) | 15.8x33.0 (20.3x25.2) | 15.8x33.0 (20.3x25.2) | 15.0x25 (15.0x22.5) |

**Screening efficiency of inoculation with isolated VAM-fungi for enhancing growth of maize seedlings:**

**1. Usage VAM-fungal cultures grown on modified barely-sand medium:**

Data in **Table (5a)** showed that most tested growth criteria of maize plants were significantly increased by some soil inoculation treatments. Compared with control, shoot length was increased by 11.5-36.6%, root length increased by 18.9-45.7%, stem diameter increased by 7.7-23.1%, shoot fresh weight increased by 67.4-115.1%, root fresh weight increased by 62.7-102.7%, shoot dry weight increased by 51.1-172.3%, and root dry weight was increased by 42.9-107.1%. Applying VAM-B at inoculm level 2g/Kg soil produced the highest increases in shoot length (36.6%), root length (45.7%) and stem diameter (23.1%). However, VAM-O (at inoculum level 1g/Kg soil) and VAM-S (at inoculum level 6g/Kg soil) came the next, respectively. Only VAM-B particularly at levels 2 and 4 g/Kg soil and VAM-O (at 0.1%) caused significant increase in fresh weights of both shoots and roots while VAM-O at 1 and 2g/Kg soil caused significant increase only in fresh weight of shoots. Swiss cheese isolate (VAM-S) at all tested inoculum

levels, however, had no significant effect on fresh weights of shoots and roots when compared with the control treatment.

Applying the different inoculum levels of the three tested isolates except VAM-B used at level of 6g/Kg soil significantly increased dry weight of shoot. However, VAM-O, VAM-B and VAM-O isolates at inoculum levels of 1, 2, 2g/Kg soil produced the highest increases in dry weight of shoot i.e. 172.3, 131.9 and 106.4%, respectively. Dry weight of roots showed significant increases by applying all inoculum levels of VAM-B, VAM-O at levels of 1, 2 and 4g/Kg soil and VAM-S isolate at 6g/Kg soil only. The highest increases in root dry weight of roots i.e. 107.1% and 75.0% were produced by VAM-B (at level 2g) and VAM-S (at level 6g), respectively. Among all treatments, VAM-B at 2g level only caused significant increase in number of leaves per plant (19.4%) compared control treatment. Also, VAM-B at inoculum level 2g/Kg soil produces the highest significant increase in stem diameter.

From these results it could concluded that, all growth criteria of maize plants have responded inversely with inoculum levels of VAM-O meanwhile, they were increased proportionally by increasing levels of inoculum of VAM-S. In this regard, VAM-B seems to be slightly varied since all growth criteria showed conspicuous increase, by increasing inoculum from 0.1% to 0.2% (w/w) then decreased significantly by using higher levels of inoculum (0.4% and 0.6% w/w).

**2. Usage VAM fungal sporangiospores:**

Data in **Table (5b)** show that all examined criteria of growth of maize seedlings were significantly increased when soil was inoculated with sporangiospore (Sp-spores) suspension of VAM-O at level of

**Table (5a):** Effect of soil inoculation with different inoculum levels of BS-cultures of three VA-mycorrhizal isolates (VAM-S, VAM-B and VAM-O), on some growth measurements of maize plants after 4 weeks from sowing.

| Treatments | | Shoot length (cm) *** | Root length (cm) | Stem diameter (cm) | No. of leaves /plant | Fresh weight of | | Dry weight of | |
|---|---|---|---|---|---|---|---|---|---|
| VAM Isolate | Inoculum level (g/Kg soil) | | | | | Shoot system (g/plant) | Root system (g/plant) | Shoot system (g/plant) | Root system (g/plant) |
| Control | | 64.5 * | 31.7 * | 0.39 * | 3.60 * | 2.58 * | 1.10 * | 0.47 * | 0.28 * |
| VAM-S | 1 | 71.9 (11.5) | 38.0 (19.9) | 0.38 * | 3.40 * | 3.40 * | 0.73 * | 0.81 (72.3) | 0.23 * |
| | 2 | 77.8 (20.6) | 38.0 (19.9) | 0.39 * | 3.60 * | 3.40 * | 1.03 * | 0.82 (74.5) | 0.30 * |
| | 4 | 78.2 (21.2) | 38.0 (19.9) | 0.40 * | 3.88 * | 3.23 * | 0.90 * | 0.82 (74.5) | 0.37 * |
| | 6 | 79.9 (23.9) | 41.0 (29.3) | 0.44 (12.7) | 4.00 * | 3.57 * | 1.15 * | 0.90 (91.5) | 0.49 (75.0) |
| VAM-B | 1 | 82.0 (27.1) | 38.3 (20.8) | 0.43 (10.2) | 3.60 * | 4.80 (86.0) | 1.73 (60.0) | 0.71 (51.1) | 0.46 (64.3) |
| | 2 | 88.1 (36.6) | 46.2 (45.7) | 0.48 (23.1) | 4.30 (19.4) | 5.55 (115.1) | 2.23 (102.7) | 1.09 (131.9) | 0.58 (107.1) |
| | 4 | 79.6 (23.4) | 38.3 (20.8) | 0.44 (12.8) | 4.00 * | 4.32 (67.4) | 1.79 (62.7) | 0.71 (51.1) | 0.47 (67.9) |
| | 6 | 68.1 * | 33.0 * | 0.39 * | 3.30 * | 2.75 * | 1.02 * | 0.52 * | 0.40 (42.9) |
| VAM-O | 1 | 83.3 (29.2) | 43.3 (36.6) | 0.45 (15.4) | 4.00 * | 4.79 (85.7) | 1.85 * | 1.28 (172.3) | 0.45 (60.7) |
| | 2 | 79.2 (22.8) | 37.7 (18..9) | 0.40 * | 3.70 * | 4.63 (79.5) | 1.65 * | 0.97 (106.4) | 0.44 (57.1) |
| | 4 | 77.1 * | 34.3 * | 0.42 (7.7) | 3.70 * | 3.32 * | 1.11 * | 0.90 (91.5) | 0.40 (42.9) |
| | 6 | 66.7 * | 31.0 * | 0.38 * | 3.17 * | 2.95 * | 1.06 * | 0.75 (59.6) | 0.30 * |
| L.S.D at 0.05 | | 6.657 | 4.546 | 0.024 | 0.673 | 1.553 | 0.631 | 0.203 | 0.095 |

* = Treatment has no significant difference compared with control.

*** = The values between brackets represent percentage of increase compared with control. It was calculated for treatments showing significant responses only.

**Table (5b):** Effect of inoculating soil with sporangiospore suspension (ml/kg soil) of three VA-mycorrhizal isolates (VAM-S, VAM-B and VAM-O), (grown on modified MS-medium), on some growth measurements of maize plants after 4 weeks from sowing.

| Treatments | | Shoot length (cm) *** | Root length (cm) | Stem diameter (cm) | No. of leaves/ plant | Fresh weight of | | Dry weight of | |
|---|---|---|---|---|---|---|---|---|---|
| VAM Isolate | Spore suspension (ml/Kg soil) | | | | | Shoot system (g/plant) | Root system (g/plant) | Shoot system (g/plant) | Root system (g/plant) |
| Control | | 64.5 * | 31.7* | 0.386* | 3.60* | 2.58* | 1.10 * | 0.47 * | 0.28* |
| VAM-S | 0.5 ml | 58.0 (-10.1) | 35.3* | 0.383* | 3.53 * | 2.90* | 1.45* | 0.47* | 0.33 * |
| | 1.0 ml | 63.9 * | 37.0 (16.7) | 0.413 (7.0) | 3.67 * | 3.37 * | 1.47 * | 0.53 * | 0.42 * |
| | 2.0 ml | 66.1 * | 41.0 (29.3) | 0.407 | 3.70 * | 3.43 * | 1.60 * | 0.61 * | 0.43 * |
| | 3.0 ml | 78.1 (21.1) | 44.3 (39.7) | 0.447 (15.8) | 4.10 (13.9) | 3.90 (51.2) | 1.97 (79.1) | 0.78 (66.0) | 0.43 * |
| VAM-B | 0.5 ml | 59.0 * | 33.7 * | 0.371 * | 3.13 (-13.1) | 3.30 * | 2.20 (100.0) | 0.57 * | 0.41 * |
| | 1.0 ml | 65.7 * | 36.3 * | 0.396 * | 3.27 (-9.2) | 3.64 * | 2.57 (133.6) | 0.60 * | 0.46 * |
| | 2.0 ml | 80.1 (24.2) | 47.7 (50.5) | 0.452 (17.1) | 3.90 * | 5.25 (103.5) | 2.80 (154.5) | 0.95 (102.1) | 0.51 * |
| | 3.0 ml | 72.8 (12.9) | 37.7 (18.9) | 0.420 (8.8) | 3.43 * | 3.90 (51.2) | 1.70 * | 0.73 (55.3) | 0.32 * |
| VAM-O | 0.5 ml | 81.0 (25.6) | 50.0 (57.7) | 0.447 (15.8) | 4.03 (11.9) | 4.76 (84.5) | 2.14 (94.5) | 0.92 (95.7) | 0.61 (117.9) |
| | 1.0 ml | 76.5 (18.6) | 42.0 (32.5) | 0.427 (10.6) | 3.75 * | 4.30 (66.7) | 1.97 (79.1) | 0.85 (80.9) | 0.59 (110.7) |
| | 2.0 ml | 65.1 * | 35.7 * | 0.400 * | 3.58 * | 3.27 * | 1.95 (77.3) | 0.59 * | 0.42 * |
| | 3.0 ml | 54.4 (-15.7) | 31.7 * | 0.370 * | 3.25 (-9.7) | 2.16 * | 1.12 * | 0.41 * | 0.24 * |
| L.S.D at 0.05 | | 5.393 | 5.215 | 0.021 | 0.318 | 1.138 | 0.848 | 0.231 | 0.247 |

* = Treatment has no significant difference compared with control.

*** = The values between brackets represent percentage of increase or decrease compared with control. It was calculated for treatments showing significant responses only.

0.5-ml/kg soil. This treatment showed the following significant increases compared with control: shoot length (25.6%), root length (57.7%), stem diameter (15.8%), number of leaves per plant (11.9%), fresh weight of shoot (84.5%) and root (94.5%), dry weight of shoot (95.7) and roots (117.9%). However, number of leaves and dry weight of roots only showed no significant variations by applying Sp-spores suspension of this isolate at level of 1.0ml/kg soil when compared with control. Increasing Sp-spores suspension of VAM-O up to 2.0ml/kg soil had no significant effects on all tested growth criteria but 3.0 ml/kg soil caused significant decreases in shoot length (-15.7%) and number of leaves per plant (-9.7%) only compared with control. VAM-B and VAM-S isolates produced significant increases in most tested growth criteria when their Sp-spores suspension was applied only at levels of 2.0 and 3.0ml/kg soil, respectively.

The above results concluded that, among all treatments the soil inoculated with Sp-spores suspension of VAM-O at level of 0.5 ml/kg soil (w/w) was best of all treatment for inducing the highest significant improvement in growth of maize plants.

### 3. Detection of VAM-infection structures formed by the isolated VAM-fungi:

Microscopic examination for squash's of root taken from maize seedlings grown in soils inoculated with different levels of fungal inocula (BS-cultures or suspensions of sporangiospores) showed typical VA-mycorrhizal infection structures. Squash's made in roots of maize seedlings inoculated with VAM-O showed VA-mycorrhizal infection structures i.e. Arbuscules, vesicles and aseptat hyphae grow mainly between and rarely across cells in root cortex. Roots of

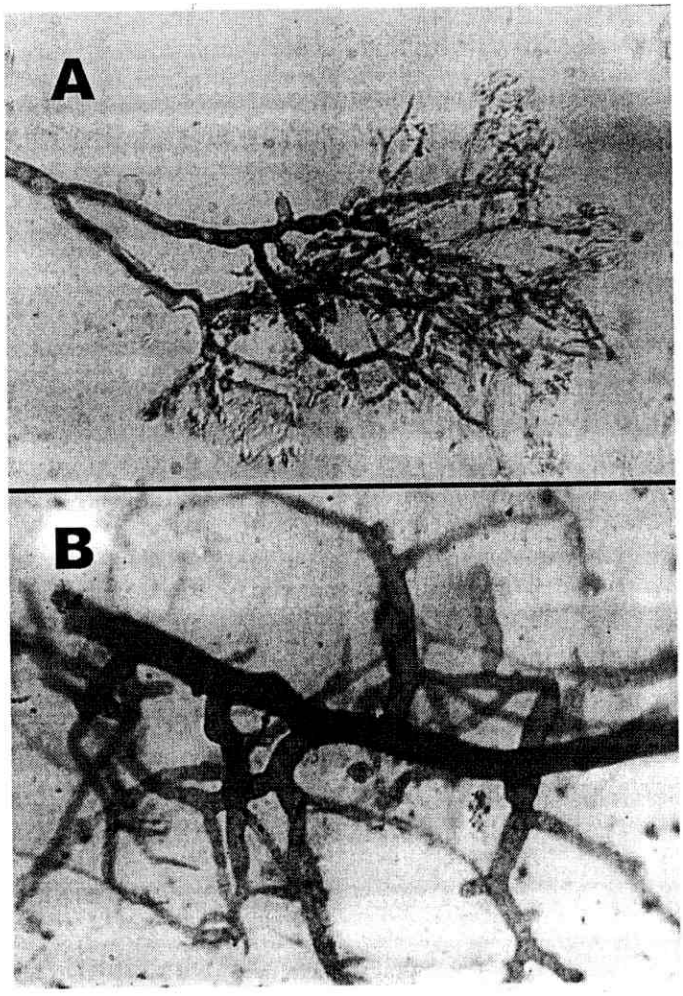



**Fig. (1):** *In vitro* mycelial growth and arbuscule-like structures formed by two VAM isolates. A- VAM-O isolate (100X). (B)-VAM-S isolate (X=400).

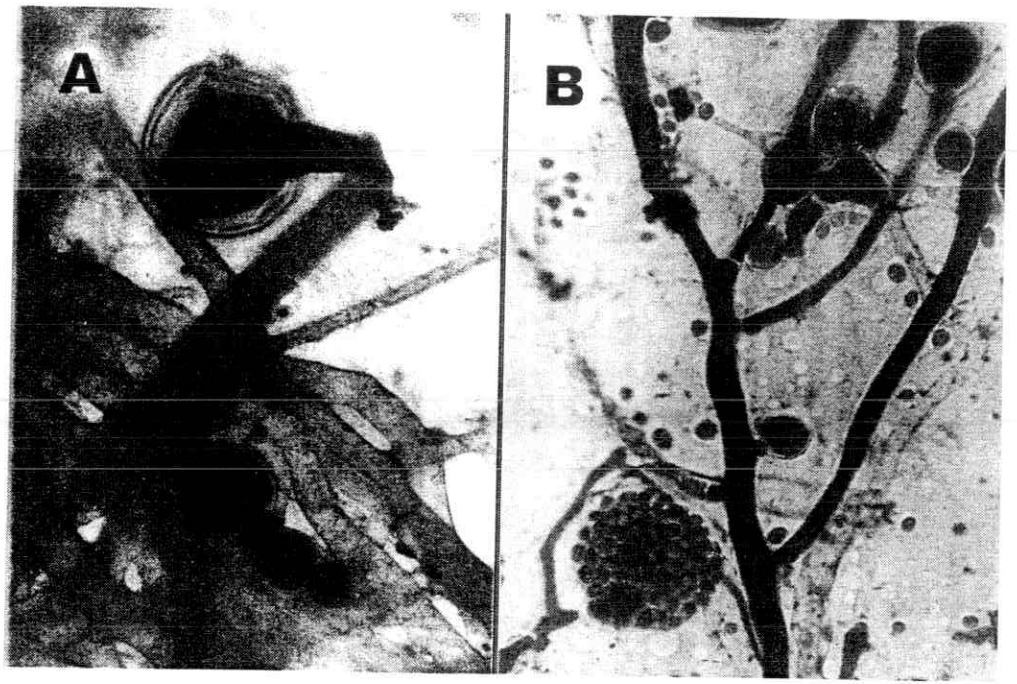



**Fig. (2):** Formation of sporangia *in vitro* for two VAM isolates. VAM-S isolate "a" (900X) and VAM-M "b" (600X). Noted sporangiospores formed inside sporangia of the later isolate.

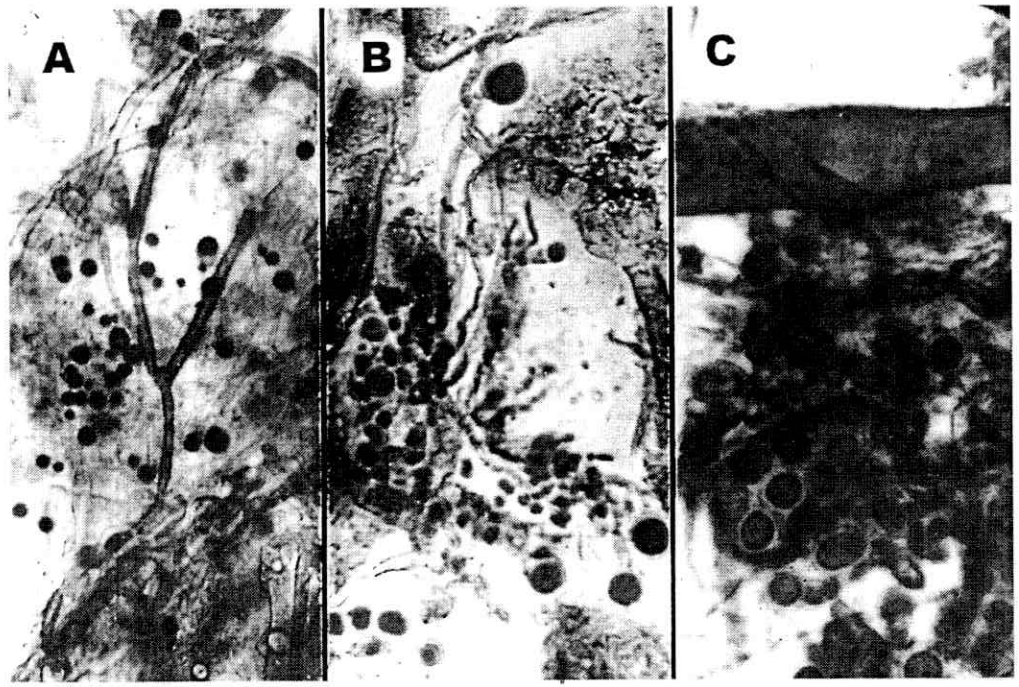



**Fig. (5):** Growth and sporulation of VAM isolates on the modified BS-medium. A-VAM-O (100X), B-VAM-S isolate (200X) and C-VAM-M isolate (400X).

inoculated seedlings showed no any detectable changes in their external morphology when compared with those of control treatment. However, arbuscules and vesicles were detected in the maize roots emerged from surfaced sterilized maize seeds in sterilized sand soil, while the H-shape structures were observed in the aerial roots of naturally grown Swiss cheese plants **(Fig. 6a and b)**.

**4. Usage the DNA technology to characterize the isolated VAM fungi either in the in vitro cultures or the mycorrhizal roots:**

Most detected (6-11) DNA bands or fragments have an average molecular weight between 300 and 1517 bp. The following important general aspects could be extracted from the data illustrated in **Table (7)** and **Fig. (7)**.

1- Several DNA bands that detected in the non-inoculated roots (control) were found also in both VAM-cultures and the VAM-inoculated roots including *Glomus* sp., for example, bands number 2, 4, 7, 8 and 9.

2- The DNA band number 9 (500 bp) was common in all investigated samples i.e. VAM cultures, VAM-inoculated and non-inoculated roots (control). On the contrary, band number 3 (1200 bp) was missed from the non-inoculated roots (control) while, detected in VAM cultures (mycelia) and VAM-inoculated roots.

3- The DNA bands number 3, 5, 10, 11 and 12 characterized VAM-M, isolated from maize, (mycelia and inoculated roots) as they missed from the non-inoculated roots (control).

4- The DNA bands number 10 and 12 characterized roots inoculated with VAM-O isolate and *Glomus* spp. Both bands were missed from the non-inoculated roots (control).

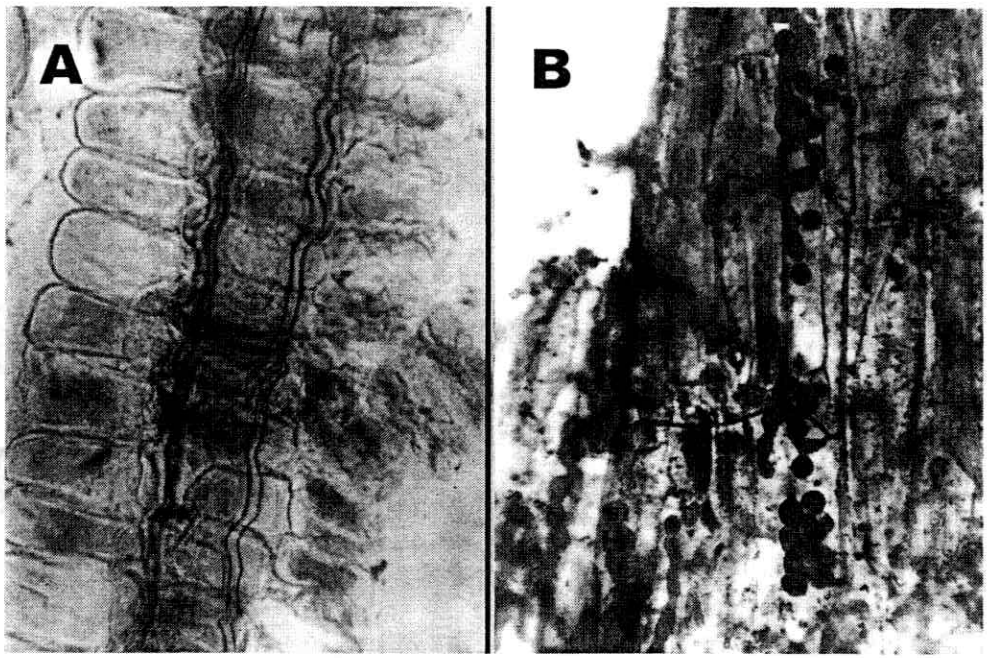



**Fig. (6):** Natural micorrhyzation showing H-shaped structure in roots of Swiss cheese plant "a" (300X) and spores and arbuscules in roots of maize seedlings "b" (200X).

5- The DNA bands number 11 and 12 characterized VAM-B in both culture (mycelia) and infected roots. Both bands were missed from the non-inoculated roots (control).

The correlation coefficient distance and single linkage method were used for cluster analysis of 4 isolates of VAM fungi (V1-V4 in cultures "C") and in mycorrhizal roots (V1-V4 in roots "R"), roots inoculated with *Glomus* sp. in addition to the non-mycorrhizal roots (control). The cluster analysis and similarity percentages between each pair of the investigated samples are illustrated in **Fig. (8)**. The dendrogram reveal that the investigated 10 samples were arranged in single main cluster with two sub-clusters. The first sub-cluster included both VAM-B and VAM-S in inoculated roots with 77.39% similarity in between. The first sub-cluster shows the same similarity (77.39%) with the second sub-cluster. On the other hand, the percentages of similarities between samples located in the second sub-cluster could be described as following: Similarity percentage between VAM-B, VAM-S and VAM-M isolates (in cultures) was 92.43% but it was maximized to 100% between cultures of the first two isolates. However, VAM-M (in culture) and in inoculated roots showed 91.29% similarity. The similarity between VAM-O (in culture) and each of VAM-M and *Glomus* sp. (in inoculated roots) were 87.27 and 85.03%, respectively. Moreover, the control treatment (non-inoculated roots) recorded 82.27% similarity with each of VAM-O and *Glomus* sp. (in inoculated roots).

**Table (7):** Molecular weights (bp) of the fractionated DNA bands for the *in vitro* (VAM-mycelia) and *in vivo* (VAM-roots) as well as with *Glomus* sp. Non-inoculated roots were used as control.

| Ref Band Number | Marker | Numerical DNA bands detected in mycelia | | | | Numerical DNA bands detected in inoculated roots | | | | Control | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 VAM-O | 2 VAM-B | 3 VAM-S | 4 VAM-M | 5 VAM-O | 6 VAM-B | 7 VAM-S | 8 VAM-M | * 9 *Glomus* | ** 10 Non. |
| 1 | | - | - | - | - | - | 1889.46 | 1870.11 | - | - | - |
| 2 | 1517 | 1444.03 | 1474.35 | 1444.03 | 1414.31 | - | 1342.54 | 1569.02 | 1328.61 | 1370.82 | 1328.61 |
| 3 | 1200 | 1287.65 | 1261.01 | 1234.9 | 1234.9 | 1222.03 | 1147.49 | 1222.03 | 1209.3 | 1159.6 | |
| 4 | 1000 | 1088.68 | 1077.26 | 1065.96 | 1065.96 | 989.93 | 1011.11 | - | 1000.47 | 1011.11 | 1043.7 |
| 5 | 900 | 890.1 | 909.28 | 909.28 | 871.3 | - | - | - | 909.28 | - | - |
| 6 | 800 | - | - | - | - | 817.1 | 843.79 | 834.81 | 782.72 | 834.81 | 834.81 |
| 7 | 700 | 757.82 | 733.65 | 733.65 | 717.93 | - | 717.93 | 694.94 | 679.99 | 679.99 | 717.93 |
| 8 | 600 | 636.88 | 650.96 | 658.11 | 665.33 | - | 643.89 | - | 623.07 | 609.54 | 629.94 |
| 9 | 500 | 527.84 | 482.57 | 499.12 | 493.55 | 466.5 | 461.25 | 445.81 | 440.77 | 456.06 | 440.77 |
| 10 | 400 | - | - | - | 402.17 | 375.17 | - | - | 370.83 | 383.99 | - |
| 11 | | - | 349.74 | 353.87 | 341.6 | - | 358.05 | - | 337.58 | - | - |
| 12 | 300 | - | 303.22 | 299.58 | 285.41 | 265.19 | 285.41 | - | 265.19 | 265.19 | - |
| 13 | 200 | - | - | - | - | - | - | - | - | - | - |
| 14 | 100 | - | - | - | - | - | - | - | - | - | - |
| | 12 | 7 | 9 | 9 | 10 | 6 | 10 | 6 | 11 | 9 | 6 |

* Roots of plants inoculated with *Glomus* sp.

** Roots of non-inoculated plants.

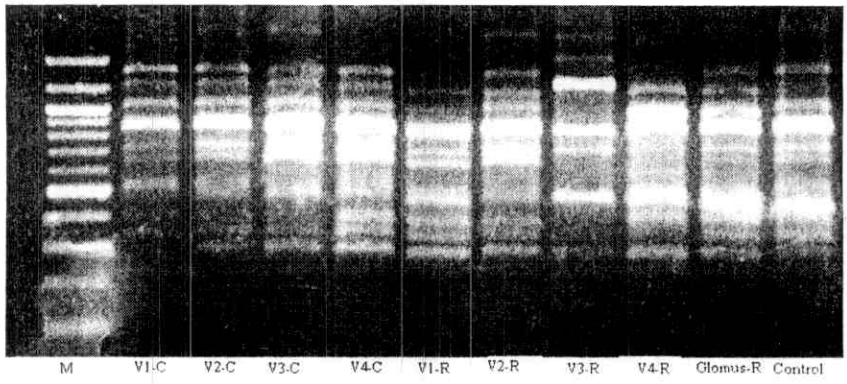



**Fig. (7):** DNA fractionated bands for the *in vitro* cultures of VAM fungal isolates (V1-C – V4-C) and inoculated roots (V1-R – V4-R). *Glomus* sp. (Gl-R)- inoculated roots and non-inoculated roots (Control) were also included.

**Physiological studies "*in vitro*":**

**1. Effect of different media on growth and sporulation of VAM-fungi utilizing solidified and liquid media:**

**1.1. Effect on the linear growth:**

Data in **Table (8a)** reveal that, the tested nutritive agar media significantly varied in their effect on the linear growth of VAM fungal isolates tested. The highest linear growth, however, was recorded on the Bushnell's medium (70.0mm) followed by PDA (68.27mm), CDA (66.5mm), Haskin's (65.24mm) and MS7 (63.85mm), respectively. While, rice-extract medium recorded the lowest linear growth (30.96mm) followed by Czapek's (34.33mm) and soil extract (47.05mm), respectively.

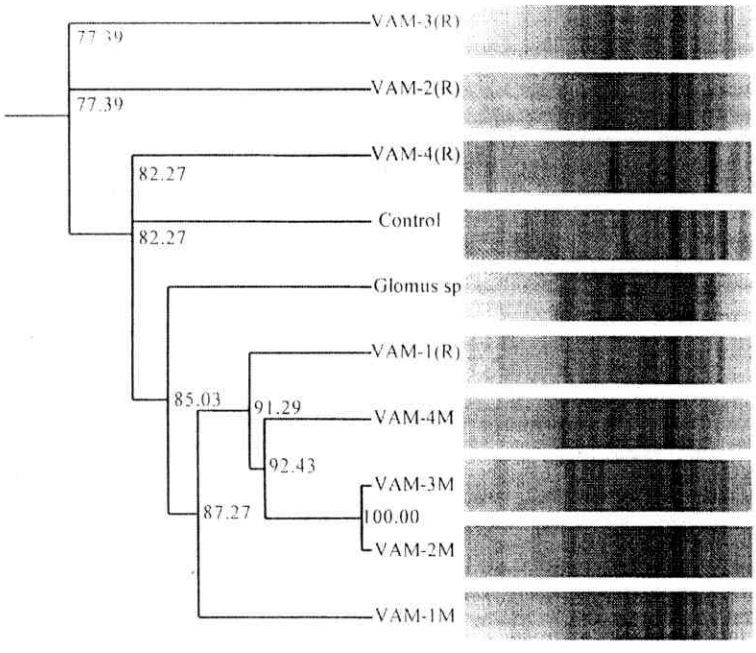



**Fig. (8)**: Dendrogram shows cluster analysis and similarity (%) between DNA bands of 4 VAM isolates in cultures (sign "(C", roots (sign "(R" inoculated with the same 4 VAM isolates or *Glomus* spp. and the non- inoculated (control) roots.

**Table (8a):** Effect of different liquid media on linear growth (mm) of the four VAM isolates tested.

| Media | VAM isolates | | | | Mean |
|---|---|---|---|---|---|
| | VAM-O | VAM-B | VAM-S | VAM-M | |
| MS-7 | 70.00 | 70.00 | 54.50 | 60.90 | 63.85 |
| PDA | 70.00 | 67.13 | 70.00 | 65.95 | 68.27 |
| Czapek's | 65.73 | 54.30 | 9.30 | 8.00 | 34.33 |
| CDA | 70.00 | 70.00 | 70.00 | 56.00 | 66.50 |
| Bushnell's | 70.00 | 70.00 | 70.00 | 70.00 | 70.00 |
| Haskin's | 54.60 | 66.35 | 70.00 | 70.00 | 65.24 |
| Soil-extract | 30.65 | 31.23 | 66.30 | 60.00 | 47.05 |
| Rice-extract | 48.55 | 57.30 | 11.00 | 7.00 | 30.96 |
| Mean | 59.94 | 60.79 | 52.64 | 49.73 | |

| LSD at 5% for: | Media | Isolates | Interaction |
|---|---|---|---|
| | 0.013 | 0.027 | 0.106 |

The linear growth of tested VAM isolates, for example VAM-S isolate **(Fig., 9a)**, was responded differently against tested nutritive media. The VAM-B isolate shows the highest value (60.79mm) followed by VAM-O (59.94mm), VAM-S (52.64mm) and VAM-M (49.73mm), respectively. Nevertheless, Bushnell's medium for all tested VAM isolates, CDA medium for VAM-O, VAM-B and VAM-S, MS7 medium for VAM-O and VAM-B, PDA medium for VAM-O and VAM-S and Haskin's medium for VAM-S and VAM-M recorded the maximum linear growth (70.0mm). Among all interactions, however, the Czapek's and rice-extract media recorded the lowest linear growths i.e 8.0 and 7.0mm (VAM-M) and 9.3 and 11.0mm (VAM-S), respectively.

### 1.2. Effect on the dry weight of growth:

Data in **Table (8b)** reveal the dry weight of mycelial growth (DWM-growth) of tested VAM isolates was affected by different tested media. The Bushnell's medium recorded the highest average of DWM-

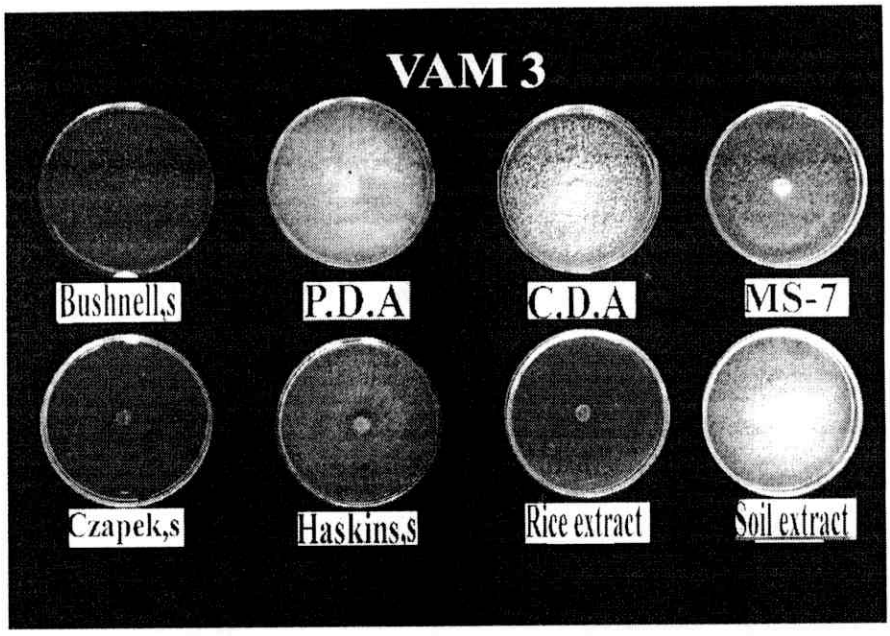



**Fig. (9a):** Effect of different tested solid media on linear growth of isolate VAM-S.

growth (466.88mg) followed by CDA medium (370.63mg), PDA medium (328.13mg), Haskin's medium (253.13mg), MS7 medium (205.63mg), soil-extract medium (179.38mg), rice-extract medium (126.88mg) and Czapek's medium (95.63mg), respectively. As for VAM isolates, VAM-O recorded the highest DWM-growth (average 268.13mg) followed by VAM-B (251.88mg), VAM-M (241.88mg) and VAM-S (241.25mg), respectively. The DWM-growth was significantly affected also by the interactions between media and VAM isolates. In this respect the highest value was recorded by VAM-S **(Fig., 9b)** on the Bushnell's medium (510.0mg) while the lowest value was recorded by VAM-M on Czapek's medium (22.5mg).

**Table (8b):** Effect of different liquid media on weight of growth (in mg) of the four VAM isolates tested.

| Media | VAM isolates | | | | Mean |
|---|---|---|---|---|---|
| | VAM-O | VAM-B | VAM-S | VAM-M | |
| MS-7 | 197.50 | 165.00 | 202.50 | 257.50 | 205.63 |
| PDA | 430.00 | 370.00 | 280.00 | 232.50 | 328.13 |
| Czapek's | 190.00 | 102.50 | 67.50 | 22.50 | 95.63 |
| CDA | 292.50 | 347.50 | 407.50 | 435.00 | 370.63 |
| Bushnell's | 430.00 | 392.50 | 510.00 | 455.00 | 446.88 |
| Haskin's | 242.50 | 197.50 | 325.00 | 247.50 | 253.13 |
| Soil-extract | 195.00 | 310.00 | 92.50 | 120.00 | 179.38 |
| Rice-extract | 167.50 | 130.00 | 45.00 | 165.00 | 126.88 |
| Mean | 268.13 | 251.88 | 241.25 | 241.88 | |
| LSD at 5% for: | Media | Isolates | Interaction | | |
| | 2.791 | 5.581 | 22.325 | | |

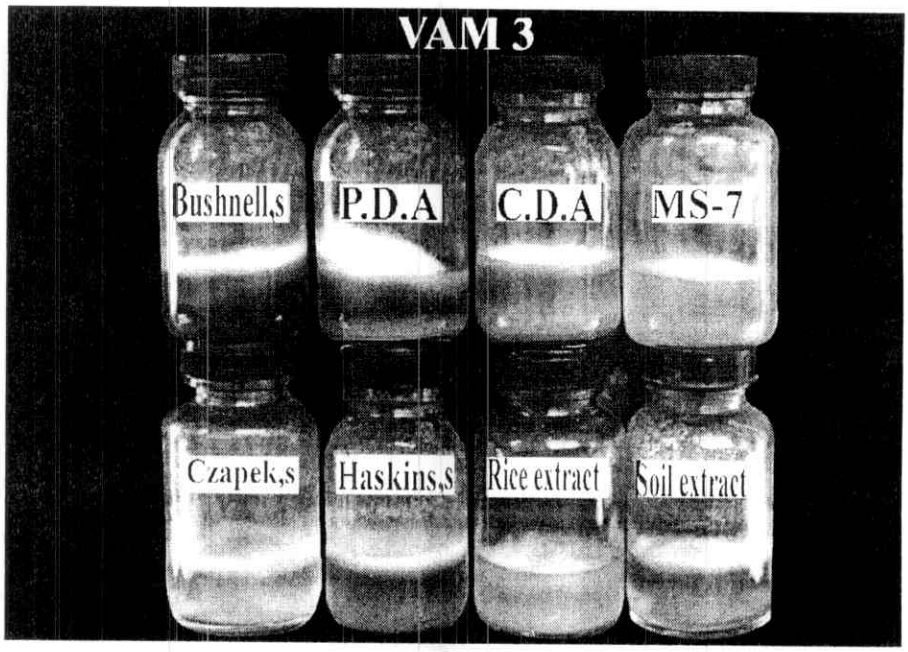



**Fig. (9b):** Effect of different tested liquid media on amount of growth of isolate VAM-S.

### 1.3. Effect on VAM-sporangiospores production:

Production of sporangiospores (Sp-spores) in term of number of spores per microscopic field (300X) was significantly affected by tested nutritive media, source of VAM isolates and the interaction between them **(Table, 8c)**.

**Table (8c):** Effect of different media on sporangiospores production (spore no./microscopic field "300X") of the four VAM isolates tested.

| Media | VAM isolates | | | | Mean |
|---|---|---|---|---|---|
| | VAM-O | VAM-B | VAM-S | VAM-M | |
| MS-7 | 21.1 | 9.3 | 47.9 | 29.2 | 26.9 |
| PDA | 28.4 | 58.1 | 80.7 | 30.8 | 49.5 |
| Czapek`s | 11.4 | 2.4 | 7.2 | 2.7 | 6.0 |
| CDA | 14.0 | 14.0 | 41.3 | 26.2 | 23.9 |
| Bushnell's | 180.9 | 78.3 | 195.4 | 75.7 | 132.5 |
| Haskin's | 14.2 | 16.0 | 67.2 | 36.4 | 33.5 |
| Soil-extract | 44.9 | 11.2 | 52.2 | 13.6 | 30.4 |
| Rice-extract | 7.2 | 3.0 | 8.5 | 22.3 | 10.3 |
| Mean | 40.3 | 24.0 | 62.5 | 29.6 | |

| LSD at 5% for: | Media | Isolates | Interaction |
|---|---|---|---|
| | 0.340 | 0.679 | 2.718 |

As for media, Bushnell's medium was the best of all, produced the maximum number of Sp-spores (132.5) followed by PDA (49.5), Haskin`s (33.5), soil-extract (30.4), MS7 (26.9), CDA (23.9), rice-extract (10.3) and Czapek's (6.0), respectively. Concerning with VAM isolates, VAM-S recorded the highest number of Sp-spores (62.5) followed by VAM-O (40.3), VAM-M (29.6) and VAM-B (24.0), respectively. In general, Bushnell's medium was the best for production of Sp-spores by all VAM isolates particularly VAM-S (195.4) while, Czapek's and rice-extract media were the inferiors in this respect particularly with VAM-B.

### 1.4. Effect on VAM-chlamydospores production:

The number of chlamydospores (Ch-spores) per microscopic field (300X) produced by different tested VAM isolates as affected by the tested media was significantly varied **(Table, 8d)**.

The Bushnell's medium produced the maximum number (8.69) followed by Haskin's (6.03), MS7 (5.83), PDA (5.81), soil-extract (3.41), CDA (2.82), rice-extract (2.29) and Czapek's (1.64), respectively. Concerning with VAM isolates, VAM-S recorded the highest number of Ch-spores (6.1) followed by VAM-O (4.61), VAM-M (4.46) and VAM-B (3.1), respectively. In general, Bushnell's medium was the superior for Ch-spores production by all VAM isolates (6.47-10.65) while, Czapek's medium for VAM-B, VAM-S and VAM-M (1.18-1.72) and rice-extract medium for VAM-O, VAM-B and VAM-S (1.33-1.73) were the inferior media in this respect.

**Table (8d):** Effect of different media on chlamydospores production (spore no./microscopic field "300X") of the four VAM isolates tested.

| Media | VAM isolates | | | | Mean |
|---|---|---|---|---|---|
| | VAM-O | VAM-B | VAM-S | VAM-M | |
| MS-7 | 9.33 | 1.49 | 7.56 | 4.93 | 5.83 |
| PDA | 4.50 | 4.81 | 9.00 | 4.95 | 5.81 |
| Czapek's | 2.44 | 1.18 | 1.72 | 1.22 | 1.64 |
| CDA | 2.50 | 2.00 | 3.65 | 3.12 | 2.82 |
| Bushnell's | 10.65 | 7.26 | 10.39 | 6.47 | 8.69 |
| Haskin's | 3.11 | 5.35 | 9.83 | 5.83 | 6.03 |
| Soil-extract | 2.87 | 1.39 | 4.89 | 4.50 | 3.41 |
| Rice-extract | 1.44 | 1.33 | 1.73 | 4.67 | 2.29 |
| Mean | 4.61 | 3.10 | 6.10 | 4.46 | |
| LSD at 5% for: | Media | Isolates | Interaction | | |
| | 0.052 | 0.104 | 0.418 | | |

## 2. Effect of different temperatures on growth and sporulation of VAM-fungi utilizing solidified and liquid media:

### 2.1. Effect on the linear growth:

Data in **Table (9a)** and **Fig. (10a)** prove that, the mycelial linear growth (ML-growth) of tested VAM isolates at different tested temperatures was significantly varied. The ML-growth was sharply increased as temperature increased from 5°C (10.96mm) to 28°C (63.51mm) then appreciably decreased by elevating it up to 33°C (59.49mm).

**Table (9a):** Effect of different temperature degrees on linear growth (in mm) of the tested VAM isolates.

| Temperature °C | VAM isolates | | | | Mean |
|---|---|---|---|---|---|
| | VAM-O | VAM-B | VAM-S | VAM-M | |
| | 12.1 | 10.7 | 6.9 | 14.2 | 10.96 |
| | 26.7 | 19.5 | 14.8 | 23.4 | 21.10 |
| | 39.9 | 40.1 | 37.3 | 27.1 | 36.08 |
| | 47.8 | 45.7 | 38.0 | 49.1 | 45.14 |
| | 60.5 | 60.0 | 47.5 | 57.3 | 56.31 |
| | 61.2 | 62.4 | 57.5 | 63.6 | 61.16 |
| | 62.1 | 62.6 | 58.1 | 63.7 | 61.62 |
| | 62.1 | 64.6 | 63.5 | 63.9 | 63.51 |
| | 59.0 | 64.2 | 63.7 | 63.9 | 62.69 |
| | 56.3 | 63.0 | 61.4 | 57.3 | 59.49 |
| Mean | 48.76 | 49.27 | 44.86 | 48.34 | |
| LSD at 5% for: | Temp. | Isolates | Interaction | | |
| | 0.018 | 0.044 | 0.178 | | |

Whatever, the optimal temperature range for ML-growth was wider in VAM-M isolate (23-31°C) than VAM-O (26-28°C) or VAM-B and VAM-S (28-31°C). In this regard, VAM-B exhibits the highest average ML-growth (49.27mm) followed by VAM-O (48.76), VAM-M (48.34mm) and VAM-S (44.86mm), respectively. In general, VAM-B at 28°C and VAM-S at 5°C recorded the highest and lowest values of ML-growth i.e. 64.6 and 6.9mm, respectively. Effect of exposing to some tested temperature treatments on the linear of growth of the four

VAM isolates (solid Bushnell's medium) were selected and photographed **(Fig., 10a)**.

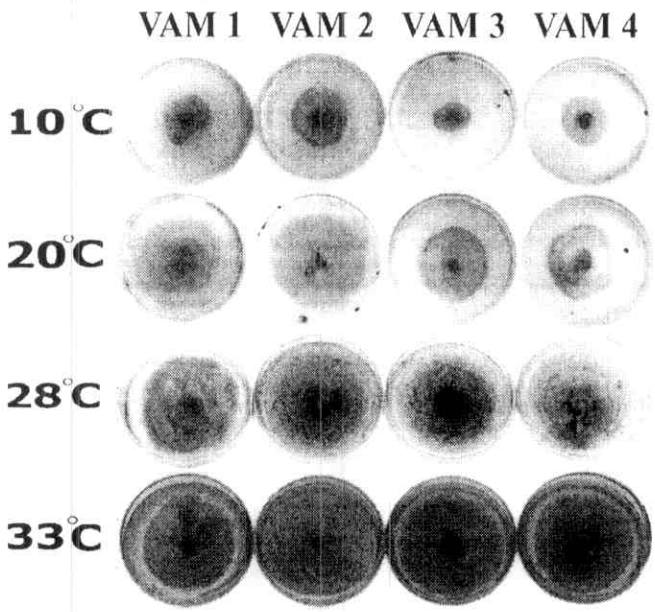



**Fig. (10a):** Effect of some selected temperature degrees on linear growth of the four VAM isolates on solid Bushnell's medium.

**2.2. Effect on the dry weight of growth:**

Data in **Table (9b)** prove that, different tested temperatures significantly affected the DWM-growth (mg) of tested VAM isolates in similar way as above described for ML-growth **(Table, 9a)**. The DWM-growth was sharply increased as temperature increased from 5°C (74.38mg) to 31°C (470.63mg) then appreciably decreased by elevating it up to 33°C (433.75mg). This trend was true for isolates VAM-O, VAM-S and VAM-M which recorded their highest DWM-growth i.e. 465.0, 537.5 and 522.5mg, respectively at 31°C. while DWM-growth of VAM-B was significantly better at 28°C (467.5mg). The comparison between VAM isolates reveal that VAM-M produces the highest

significant increase in DWM-growth (335.75mg) followed by VAM-S (314.25mg), VAM-O (286.25mg) and VAM-B (280.75mg), respectively. Effect of exposing to some tested temperature treatments on the amount of growth (liquid medium) were selected and photographed **(Fig., 10b)**.

**Table (9b):** Effect of different temperatures on dry weight of growth (in mg) of tested VAM isolates.

| Temperature °C | VAM isolates | | | | Mean |
|---|---|---|---|---|---|
| | VAM-O | VAM-B | VAM-S | VAM-M | |
| 5 | 67.5 | 67.5 | 80.0 | 82.5 | 74.38 |
| 10 | 90.0 | 110.0 | 120.0 | 127.5 | 111.88 |
| 15 | 105.0 | 115.0 | 157.5 | 142.5 | 130.00 |
| 17 | 127.5 | 165.0 | 115.0 | 162.5 | 142.50 |
| 20 | 347.5 | 377.5 | 370.0 | 402.5 | 374.38 |
| 23 | 397.5 | 412.5 | 370.0 | 490.0 | 417.50 |
| 26 | 422.5 | 417.5 | 437.5 | 455.0 | 433.13 |
| 28 | 427.5 | 467.5 | 452.5 | 470.0 | 454.38 |
| 31 | 465.0 | 357.5 | 537.5 | 522.5 | 470.63 |
| 33 | 412.5 | 317.5 | 502.5 | 502.5 | 433.75 |
| Mean | 286.25 | 280.75 | 314.25 | 335.75 | |
| LSD at 5% for: | Temp. | Isolates | Interaction | | |
| | 1.243 | 3.109 | 12.435 | | |

### 2.3. Effect on VAM-sporangiospores production:

Data in **Table (9c)** prove that, the ability of tested VAM isolates to produce sporangiospores (Sp-spores) in term of number per microscopic field (300X) was significantly varied at different tested temperatures. Number of Sp-spores was sharply increased as temperature increased from 5°C (27.56) up to 31°C (133.35) then partially decreased by elevating temperature to 33°C (126.98). This trend was true for isolates VAM-O, VAM-S and VAM-M while, isolate VAM-B produced the highest number of Sp-spores at 28C (93.5). Nevertheless, the tested VAM isolates seemed to be significantly varied in their abilities for Sp-spores production. In this respect, VAM-S

produces the highest significant increase in number of Sp-spores (136.21) followed by VAM-O (131.25), VAM-B (66.78) and VAM-M (54.51), respectively.

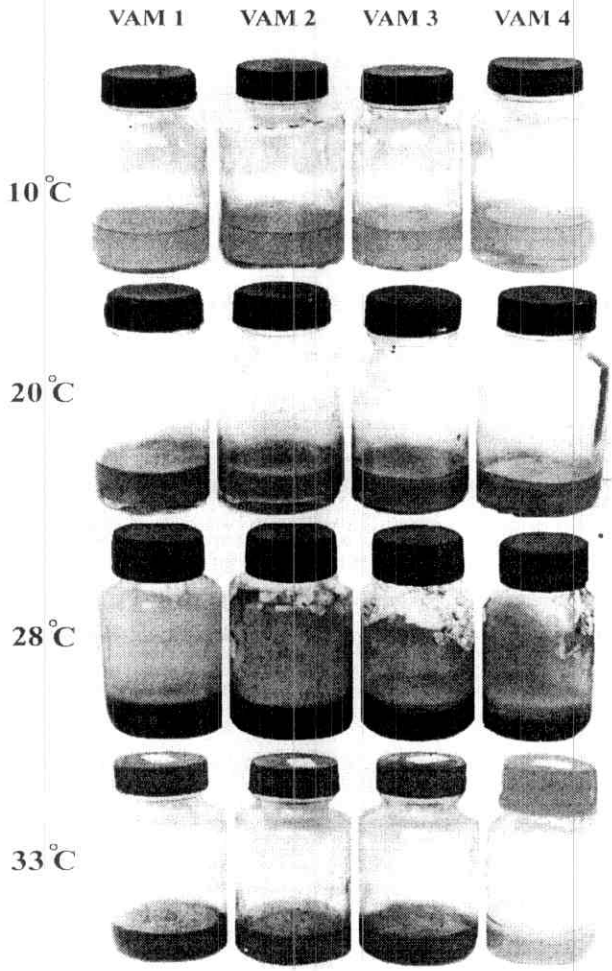



**Fig. (10b):** Effect of some selected temperature degrees on amount of growth of the four VAM isolates on liquid Bushnell's medium.

**Table (9c):** Effect of different temperatures on sporangiospores production (spores no./microscopic field "X300") by tested VAM isolates.

| Temperature °C | VAM isolates | | | | Mean |
|---|---|---|---|---|---|
| | VAM-O | VAM-B | VAM-S | VAM-M | |
| 5 | 35.9 | 20.4 | 39.0 | 14.9 | 27.56 |
| 10 | 66.2 | 37.6 | 72.8 | 28.5 | 51.27 |
| 15 | 93.9 | 50.5 | 105.1 | 41.0 | 72.62 |
| 17 | 99.5 | 56.8 | 94.5 | 39.1 | 72.48 |
| 20 | 153.2 | 81.8 | 157.5 | 62.9 | 113.86 |
| 23 | 165.5 | 86.4 | 157.5 | 71.2 | 120.15 |
| 26 | 171.7 | 87.3 | 171.9 | 68.1 | 124.75 |
| 28 | 174.8 | 93.5 | 178.0 | 69.1 | 128.85 |
| 31 | 181.7 | 79.1 | 196.2 | 76.5 | 133.35 |
| 33 | 170.2 | 74.4 | 189.6 | 73.7 | 126.98 |
| Mean | 131.25 | 66.78 | 136.21 | 54.51 | |
| LSD at 5% for: | Temp. | Isolates | Interaction | | |
| | 0.496 | 1.239 | 4.957 | | |

## 2.4. Effect on VAM-chlamydospores production:

Data in **Table (9d)** prove that, the ability of tested VAM isolates to produce Ch-spores was significantly varied at different tested temperatures. Average number of Ch-spores per microscopic field (300X) was sharply increased as temperature increased from 5°C (1.92) up to 31°C (9.36) then decreased by elevating temperature to 33°C (8.7).

Comparing with Ch-spores production at 5°C (1.4-2.3), VAM-O, VAM-S and VAM-M produced the highest number of Ch-spores i.e. 11.6, 11.2 and 7.3, respectively at 31°C while 28°C was the best for Ch-spores production by VAM-B (8.7). Regardless temperature, VAM-O produced the highest average number of Ch-spores (8.35) followed by VAM-S (7.29), VAM-B (6.21) and VAM-M (5.18), respectively.

**Table (9d):** Effect of different temperatures on chlamydospores production (spores no./microscopic field "X300") by tested VAM isolates.

| Temperature °C | VAM isolates | | | | Mean |
|---|---|---|---|---|---|
| | VAM-O | VAM-B | VAM-S | VAM-M | |
| 5 | 2.3 | 1.9 | 2.1 | 1.4 | 1.92 |
| 10 | 4.2 | 3.5 | 3.8 | 2.7 | 3.56 |
| 15 | 6.0 | 4.7 | 5.6 | 3.9 | 5.02 |
| 17 | 6.3 | 5.3 | 5.0 | 3.7 | 5.08 |
| 20 | 9.7 | 7.6 | 8.3 | 6.0 | 7.92 |
| 23 | 10.5 | 8.0 | 8.3 | 6.8 | 8.41 |
| 26 | 10.9 | 8.1 | 9.1 | 6.5 | 8.65 |
| 28 | 11.1 | 8.7 | 9.4 | 6.6 | 8.94 |
| 31 | 11.6 | 7.4 | 11.2 | 7.3 | 9.36 |
| 33 | 10.8 | 6.9 | 10.0 | 7.0 | 8.70 |
| Mean | 8.35 | 6.21 | 7.29 | 5.18 | |
| LSD at 5% for: | Temp. | Isolates | Interaction | | |
| | 0.040 | 0.099 | 0.396 | | |

### 3. Effect of different percentages of relative humidity on growth and sporulation of VAM-fungi utilizing solidified media:

#### 3.1. Effect on the linear growth:

Data in **Table (10a)** prove that, the ML-growth of tested VAM isolates, for example VAM-M **(Fig., 11)**, was significantly affected by the surrounded relative humidity (R.H.%). Comparing with (69.83mm) in the control treatment (un-controlled humidity conditions), the ML-growth was gradually and significantly decreased as R.H.% increased from 14% (68.0mm) to 100% (52.95mm). The average of ML-growth of VAM-S was the most negatively affected by R.H.% (58.29mm) followed by VAM-M (59.06mm), VAM-B (63.08mm) and VAM-O (65.24mm), respectively. Among all interactions, the highest ML-growth was recorded by VAM-O and VAM-B grown at R.H. 14 and 50% (70mm) while, VAM-S recorded the lowest ML-growth at R.H. 100% (47.0mm).

**Table (10a):** Effect of relative humidity on linear growth (in mm) of tested VAM isolates.

| R.H % | VAM isolates | | | | Mean |
|---|---|---|---|---|---|
| | VAM-O | VAM-B | VAM-S | VAM-M | |
| Control * | 70.0 | 70.0 | 70.0 | 69.3 | 69.83 |
| 14% | 70.0 | 70.0 | 67.0 | 65.0 | 68.00 |
| 50% | 70.0 | 70.0 | 65.0 | 62.7 | 66.93 |
| 70% | 69.5 | 64.2 | 60.0 | 60.0 | 63.41 |
| 74% | 66.9 | 62.1 | 60.0 | 60.0 | 62.24 |
| 80% | 64.0 | 61.4 | 59.8 | 58.0 | 60.78 |
| 85% | 62.0 | 59.2 | 54.9 | 56.0 | 58.01 |
| 90% | 61.3 | 59.0 | 50.3 | 55.3 | 56.46 |
| 95% | 61.2 | 57.8 | 49.0 | 54.3 | 55.57 |
| 100% | 57.7 | 57.2 | 47.0 | 50.0 | 52.95 |
| Mean | 65.24 | 63.08 | 58.29 | 59.06 | |

| LSD at 5% for: | R.H | Isolates | Interaction |
|---|---|---|---|
| | 0.025 | 0.063 | 0.254 |

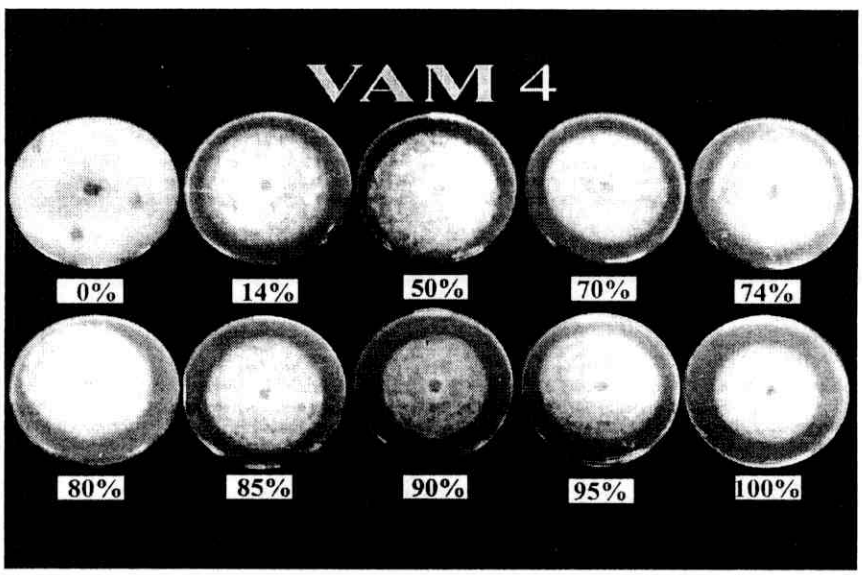



**Fig. (11):** Effect of different percentages of relative humidity on the linear growth of the isolate VAM-M.

### 3.2. Effect on VAM-sporangiospores production:

Data in **Table (10b)** prove that, the number of Sp-spores (per microscopic field "300X") of tested VAM isolates was significantly affected by relative humidity (R.H.%). Compared with the control treatment (527.17) Sp-spores number was dramatically decreased as R.H.% increased from 14% (453.36) to 100% (6.9). This trend was true in all tested VAM isolates.

Regardless R.H.%, VAM-O, however, produced the highest significant increase in the average number of Sp-spores (242.09) followed by VAM-S (177.38), VAM-B (164.57) and VAM-M (139.88), respectively. The number of Sp-spores was significantly affected by the interaction between R.H.% and VAM isolates. The produced number was ranged between 705.3 (in control of VAM-O) and 5.7 (in case of VAM-M grown at 100% R.H.

**Table (10b):** Effect of relative humidity on sporangiospores production (spore no./microscopic field "300X") of tested VAM isolates.

| R.H % | VAM isolates | | | | Mean |
|---|---|---|---|---|---|
| | VAM-O | VAM-B | VAM-S | VAM-M | |
| Control * | 705.3 | 479.3 | 516.7 | 407.3 | 527.17 |
| 14% | 606.6 | 412.2 | 444.3 | 350.3 | 453.36 |
| 50% | 352.7 | 239.7 | 258.3 | 203.7 | 263.58 |
| 70% | 211.6 | 143.8 | 155.0 | 122.2 | 158.15 |
| 74% | 183.4 | 124.6 | 134.3 | 105.9 | 137.06 |
| 80% | 141.1 | 95.9 | 103.3 | 81.5 | 105.43 |
| 85% | 105.8 | 71.9 | 77.5 | 61.1 | 79.08 |
| 90% | 70.5 | 47.9 | 51.7 | 40.7 | 52.72 |
| 95% | 35.3 | 24.0 | 25.8 | 20.4 | 26.36 |
| 100% | 8.7 | 6.4 | 6.8 | 5.7 | 6.90 |
| Mean | 242.09 | 164.57 | 177.38 | 139.88 | |
| LSD at 5% for: | R.H | Isolates | Interaction | | |
| | 0.519 | 1.298 | 5.192 | | |

### 3.3. Effect on VAM-chlamydospores production:

Data in **Table (10c)** prove that, the ability of tested VAM isolates to produce Ch-spores was significantly affected by the surrounded relative humidity (R.H.%). Compared with the control, number of Ch-spores (average 9.19) was significantly decreased as R.H.% increased from 14% (7.88) to 100% (1.0). Regardless R.H.%, VAM-S produced the lowest number of Ch-spores (2.43) followed by VAM-M (2.49), VAM-B (2.7) and VAM-O (5.67), respectively.

**Table (10c):** Effect of relative humidity on chlamydospores production (spore no./microscopic field "300X") of tested VAM isolates.

| R.H % | VAM isolates | | | | Mean |
|---|---|---|---|---|---|
| | VAM-O | VAM-B | VAM-S | VAM-M | |
| Control * | 16.3 | 7.3 | 6.5 | 6.7 | 9.19 |
| 14% | 13.9 | 6.3 | 5.6 | 5.7 | 7.88 |
| 50% | 8.1 | 3.7 | 3.3 | 3.3 | 4.58 |
| 70% | 4.9 | 2.2 | 2.0 | 2.0 | 2.75 |
| 74% | 4.2 | 1.9 | 1.7 | 1.7 | 2.38 |
| 80% | 3.2 | 1.5 | 1.3 | 1.3 | 1.83 |
| 85% | 2.4 | 1.1 | 1.0 | 1.1 | 1.40 |
| 90% | 1.7 | 1.0 | 1.0 | 1.0 | 1.18 |
| 95% | 1.0 | 1.0 | 1.0 | 1.0 | 1.00 |
| 100% | 1.0 | 1.0 | 1.0 | 1.0 | 1.00 |
| Mean | 5.67 | 2.70 | 2.43 | 2.49 | |

| LSD at 5% for: | R.H | Isolates | Interaction |
|---|---|---|---|
| | 0.027 | 0.069 | 0.275 |

The number of produced Ch-spores seems to be significantly affected by the interaction between R.H.% and VAM isolate. Under controlled R.H.%, VAM-O produces the highest number of Ch-spores at 14% R.H. (13.9) while the lowest number (1.0) was produced by VAM-B, VAM-S and VAM-M at 85 and 90% R.H. and all VAM isolates at 95 and 100% R.H.

**Table (11a):** Effect of nitrogen sources on linear growth (in mm) of tested VAM isolates.

| N source | VAM isolates | | | | Mean |
|---|---|---|---|---|---|
| | VAM-O | VAM-B | VAM-S | VAM-M | |
| Control * | 70.0 | 70.0 | 70.0 | 70.0 | 70.0 |
| $NaNO_3$ | 70.0 | 70.0 | 70.0 | 70.0 | 70.0 |
| $KNO_3$ | 70.0 | 70.0 | 70.0 | 70.0 | 70.0 |
| NH4N $O_3$ | 70.0 | 70.0 | 70.0 | 70.0 | 70.0 |
| (NH4)2SO4 | 48.4 | 48.4 | 48.4 | 48.4 | 48.4 |
| Urea | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| Aspragin | 70.0 | 70.0 | 70.0 | 70.0 | 70.0 |
| Yeast extract | 70.0 | 70.0 | 70.0 | 70.0 | 70.0 |
| Beef extract | 70.0 | 70.0 | 70.0 | 70.0 | 70.0 |
| $NaNO_2$ | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| Mean | 54.8 | 54.8 | 54.8 | 54.8 | |

| LSD. At 5% for: | N-sources | Isolates | Interaction |
|---|---|---|---|
| | 0.001 | 0.003 | 0.012 |

* (Sodium nitrate + Peptone + Casein hydrolysate)

## 4. Effect of different nitrogen sources:

### 4.1. Effect on the linear growth of tested VAM isolates:

Data in **Table (11a)** illustrate that the ML-growth of tested VAM isolates was significantly affected by the tested nitrogen (N) sources. The N-sources $NaNO_3$, $KNO_3$, NH4N $O_3$, aspragine, yeast extract and beef extract were significantly better for ML-growth of all tested VAM isolates (70.0mm) than $(NH_4)_2$ $SO_4$ (48.4mm). However, urea and $NaNO_2$ as N-sources seemed to be unfavorable for ML-growth of all tested VAM isolates (5.0mm).

### 4.2. Effect on the dry weight of growth:

Data in **Table (11b)** indicate that the dry weight of growth (DWM-growth) of VAM isolates was significantly varied on media supplemented with the tested nitrogen sources. The highest DWM-growth was produced by the yeast extract (596.25mg) followed by beef extract (561.88mg), aspragine (485.63mg), $NH_4NO_3$ (474.38mg), $(NH_4)_2$ $SO_4$ (250.0mg), $KNO_3$ (218.13mg), $NaNO_3$ (127.5mg), urea

(43.13mg) and $NaNO_2$ (27.5mg), respectively. As for VAM isolates, VAM-S produces the highest DWM-growth (387.75mg) followed by VAM-O (348.75mg), VAM-B (303.0mg) and VAM-M (258.75mg), respectively. The interaction between VAM isolates and N-sources significantly affected the DWM-growth. VAM-B grown on medium with yeast extract yielded the highest value (660.0mg), while VAM-M grown on media provided with $NaNO_2$ recorded the lowest value (15.0mg).

**Table (11b):** Effect of nitrogen sources on dry weight of growth (in mg) of tested VAM isolates.

| N source | VAM isolates | | | | Mean |
|---|---|---|---|---|---|
| | VAM-O | VAM-B | VAM-S | VAM-M | |
| Control * | 430.0 | 442.5 | 510.0 | 462.5 | 461.25 |
| $NaNO_3$ | 130.0 | 90.0 | 227.5 | 62.5 | 127.50 |
| $KN\ O_3$ | 275.0 | 42.5 | 440.0 | 115.0 | 218.13 |
| $NH4N\ O_3$ | 540.0 | 420.0 | 475.0 | 462.5 | 474.38 |
| (NH4)2SO4 | 322.5 | 287.5 | 352.5 | 37.5 | 250.00 |
| Urea | 40.0 | 45.0 | 62.5 | 25.0 | 43.13 |
| Aspragin | 525.0 | 467.5 | 502.5 | 447.5 | 485.63 |
| Yeast extract | 600.0 | 660.0 | 640.0 | 485.0 | 596.25 |
| Beef extract | 592.5 | 547.5 | 632.5 | 475.0 | 561.88 |
| $NaNO_2$ | 32.5 | 27.5 | 35.0 | 15.0 | 27.50 |
| Mean | 348.75 | 303.00 | 387.75 | 258.75 | |

| LSD. At 5% for: | N-sources | Isolates | Interaction |
|---|---|---|---|
| | 3.625 | 9.064 | 36.254 |

* (Sodium nitrate + Peptone + Casein hydrolysate)

### 4.3. Effect on VAM-sporangiospores production:

Production of VAM- Sp-spores **(Table, 11c)** was significantly varied on media supplemented with the tested nitrogen sources. The highest average spore number of Sp-spores (per microscopic field "300X") was produced by the yeast extract (168.5) followed by beef extract (153.4), aspragine (146.41), $NH_4NO_3$ (139.18), $KNO_3$ (122.83), $NaNO_3$ (109.36) and $(NH_4)_2SO_4$ (32.28) while, no Sp-spores were detected on media containing urea or $NaNO_2$.

Regardless N-source, VAM-S produces the highest number of Sp-spores (130.51) compared with VAM-M (45.46). However, VAM-O (119.2) and VAM-B (117.34) were intermediate without significant difference in between. Among all interactions, VAM-S on beef extract produces the highest Sp-spore number (207.7) while, VAM-M on $NaNO_3$ produces the lowest number (16.0). However, all VAM isolates failed to produce Sp-spores on media containing urea or $NaNO_2$.

**Table (11c):** Effect of nitrogen sources on sporangiospores production (spores no./microscopic field "300X") of tested VAM isolates.

| N source | VAM isolates | | | | Mean |
|---|---|---|---|---|---|
| | VAM-O | VAM-B | VAM-S | VAM-M | |
| Control * | 171.9 | 190.1 | 202.2 | 74.0 | 159.56 |
| $NaNO_3$ | 132.1 | 133.8 | 155.4 | 16.0 | 109.36 |
| KN $O_3$ | 150.1 | 142.4 | 165.8 | 33.0 | 122.83 |
| NH4N $O_3$ | 157.1 | 157.9 | 170.0 | 71.8 | 139.18 |
| (NH4)2SO4 | 45.9 | 23.3 | 28.4 | 31.6 | 32.28 |
| Urea | 0.0 | 0.0 | 0.0 | 0.0 | 0.00 |
| Aspragin | 190.1 | 153.1 | 172.0 | 70.4 | 146.41 |
| Yeast extract | 194.2 | 192.4 | 203.6 | 83.8 | 168.51 |
| Beef extract | 150.6 | 180.3 | 207.7 | 74.1 | 153.14 |
| $NaNO_2$ | 0.0 | 0.0 | 0.0 | 0.0 | 0.00 |
| Mean | 119.20 | 117.34 | 130.51 | 45.46 | |

| LSD. At 5% for: | N-sources | Isolates | Interaction |
|---|---|---|---|
| | 1.016 | 2.539 | 10.158 |

* (Sodium nitrate + Peptone + Casein hydrolysate)

### 4.4. Effect on VAM-chlamydospores production:

Data in **Table (11d)** reveal that the production of Ch-spores of the VAM isolates tested was significantly varied on media containing a known N-source. The number of Ch-spores was significantly increased from 10.23 spores (per microscopic field "300X") in the control Bushnell-medium (contained mixture of N-sources) to 16.06, 13.77 and 10.9 Ch-spores on media supplemented with yeast extract, beef extract and aspragine, respectively while it was significantly decreased on

media contained $NH_4NO_3$ (10.0), $KNO_3$ (6.78), $NaNO_3$ (5.54) and $(NH_4)_2SO_4$ (2.94). Number of Ch-spores significantly unchanged by using aspragine (10.9), as sole N-sources, respectively compared with the control medium. However, no Ch-spores were detected on media containing urea or $NaNO_2$. As for VAM isolates, VAM-O produces the highest number of Ch-spores (10.1) followed by VAM-S (9.47), VAM-B (6.97) and VAM-M (3.95), respectively with significant differences between them. Among all interactions, the yeast extract was the best N-source for producing the highest number of Ch-spores in VAM-O (21.1) and VAM-B (20.0) while, the lowest number of Ch-spores was produced by VAM-B on $(NH_4)_2SO_4$ (1.2) and VAM-M on $NaNO_3$ (1.4). All VAM isolates, however, failed to produce Ch-spores on media containing urea or $NaNO_2$.

**Table (11d):** Effect of nitrogen source on chlamydospores production (spores no./microscopic field "300X") of tested VAM isolates.

| N source | VAM isolates | | | | Mean |
|---|---|---|---|---|---|
| | VAM-O | VAM-B | VAM-S | VAM-M | |
| Control * | 18.8 | 8.0 | 7.7 | 6.4 | 10.23 |
| $NaNO_3$ | 6.8 | 4.8 | 9.1 | 1.4 | 5.54 |
| KN $O_3$ | 6.9 | 5.5 | 11.8 | 2.9 | 6.78 |
| NH4N $O_3$ | 13.2 | 7.0 | 13.6 | 6.2 | 10.00 |
| (NH4)2SO4 | 3.6 | 1.2 | 4.2 | 2.7 | 2.94 |
| Urea | 0.0 | 0.0 | 0.0 | 0.0 | 0.00 |
| Aspragin | 15.9 | 9.0 | 12.6 | 6.1 | 10.90 |
| Yeast extract | 21.1 | 20.0 | 15.9 | 7.3 | 16.06 |
| Beef extract | 14.8 | 14.1 | 19.7 | 6.4 | 13.77 |
| $NaNO_2$ | 0.0 | 0.0 | 0.0 | 0.0 | 0.00 |
| Mean | 10.10 | 6.97 | 9.47 | 3.95 | |

| LSD. At 5% for: | N-sources | Isolates | Interaction |
|---|---|---|---|
| | 0.062 | 0.155 | 0.618 |

* (Sodium nitrate + Peptone + Casein hydrolysate)

## 5. Effect of different carbon sources:

### 5.1. Effect on the linear growth of tested VAM isolates:

Data in **Table (12a)** illustrated that all tested VAM isolates could not grow on media containing citric acid as sole carbon source. While, all VAM isolates were grown successfully on most tested carbon sources producing the maximum ML-growth (70mm). The ML-growth of VAM isolates, for example VAM-B **(Fig., 12a)**, was significantly varied on media containing inositol as sole carbon source. In this respect, VAM-S and VAM-M successfully utilized inositol (70.0mm) followed by VAM-B (52.5mm) while, VAM-O completely failed (0mm). In general, the highest average of ML-growth was produced by VAM-S and VAM-M (63.0mm) followed by VAM-B (61.3mm) and VAM-O (56.0mm) with significant differences in between.

**Table (12a):** Effect of carbon sources on linear growth (in mm) of tested VAM isolates.

| C-source | VAM isolates | | | | Mean |
|---|---|---|---|---|---|
| | VAM-O | VAM-B | VAM-S | VAM-M | |
| Sucrose | 70.0 | 70.0 | 70.0 | 70.0 | 70.0 |
| Glucose | 70.0 | 70.0 | 70.0 | 70.0 | 70.0 |
| Galactose | 70.0 | 70.0 | 70.0 | 70.0 | 70.0 |
| Fructose | 70.0 | 70.0 | 70.0 | 70.0 | 70.0 |
| Maltose | 70.0 | 70.0 | 70.0 | 70.0 | 70.0 |
| Lactose | 70.0 | 70.0 | 70.0 | 70.0 | 70.0 |
| Starch | 70.0 | 70.0 | 70.0 | 70.0 | 70.0 |
| Arabinose | 70.0 | 70.0 | 70.0 | 70.0 | 70.0 |
| Inositol | 0.0 | 52.5 | 70.0 | 70.0 | 48.1 |
| Citric acid | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Mean | 56.0 | 61.3 | 63.0 | 63.0 | |
| LSD. At 5% for: | C-sources | Isolates | Interaction | | |
| | 0.39 | 0.97 | 3.87 | | |

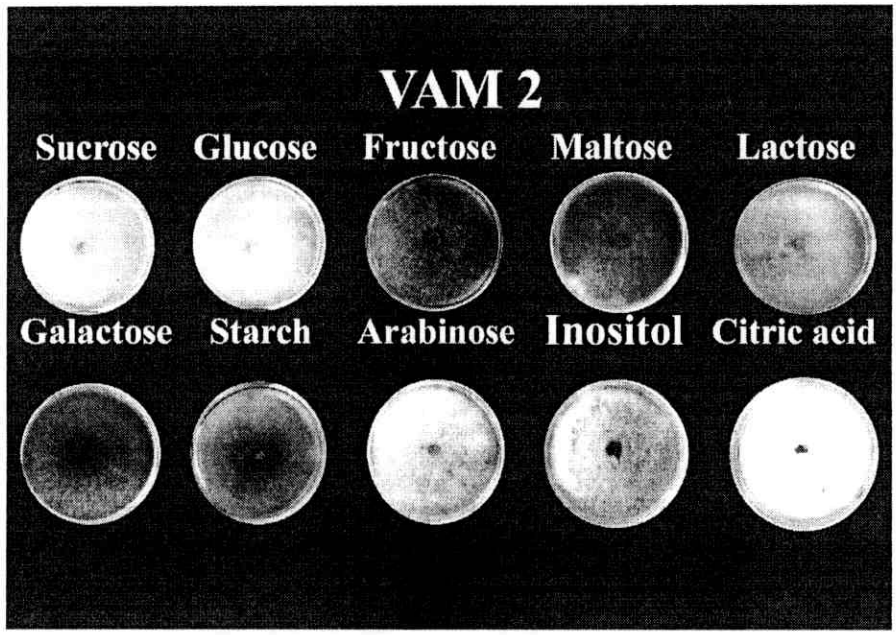



**Fig. (12a):** Effect of different carbon sources on the linear growth of the isolate VAM-B.

**5.2. Effect on the dry weight of growth:**

Data in **Table (12b)** indicate that the dry weight of growth (DWM-growth) of VAM isolates, for example VAM-B **(Fig., 12b)**, was significantly varied on media supplemented with the tested carbon sources. In this regard, glucose produces the highest DWM-growth (430.3mg) followed by galactose (414.7mg), fructose (414.4mg), starch (413.4mg), maltose (402.5mg), arabinose (392.5mg), sucrose (381.6mg), lactose (368.1mg) and inositol (265.0mg), respectively.

All VAM isolates never grown on citric acid. As for VAM isolates, VAM-M produces the highest DWM-growth (367.6mg) followed by VAM-B (355.8mg), VAM-S (341.9mg) and VAM-O (327.8mg), respectively. Concern interaction, VAM-O grown on

medium with glucose or fructose yielded the highest DWM-growth. (450.0-451.3mg), while its growth was completely stopped on medium with inositol.

**Table (12b):** Effect of carbon sources on dry weight of growth (in mg) of tested VAM isolates.

| C-source | VAM isolates | | | | Mean |
|---|---|---|---|---|---|
| | VAM-O | VAM-B | VAM-S | VAM-M | |
| Sucrose | 403.8 | 376.3 | 356.3 | 390.0 | 381.6 |
| Glucose | 450.0 | 412.5 | 412.5 | 446.3 | 430.3 |
| Galactose | 451.3 | 391.3 | 376.3 | 440.0 | 414.7 |
| Fructose | 415.0 | 430.0 | 405.0 | 407.5 | 414.4 |
| Maltose | 412.5 | 422.5 | 386.3 | 388.8 | 402.5 |
| Lactose | 362.5 | 370.0 | 356.3 | 383.8 | 368.1 |
| Starch | 410.0 | 400.0 | 400.0 | 443.8 | 413.4 |
| Arabinose | 372.5 | 407.5 | 390.0 | 400.0 | 392.5 |
| Inositol | 0.0 | 347.5 | 336.3 | 376.3 | 265.0 |
| Citric acid | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Mean | 327.8 | 355.8 | 341.9 | 367.6 | |
| LSD. At 5% for: | C-sources | Isolates | Interaction | | |
| | 1.80 | 4.49 | 17.96 | | |

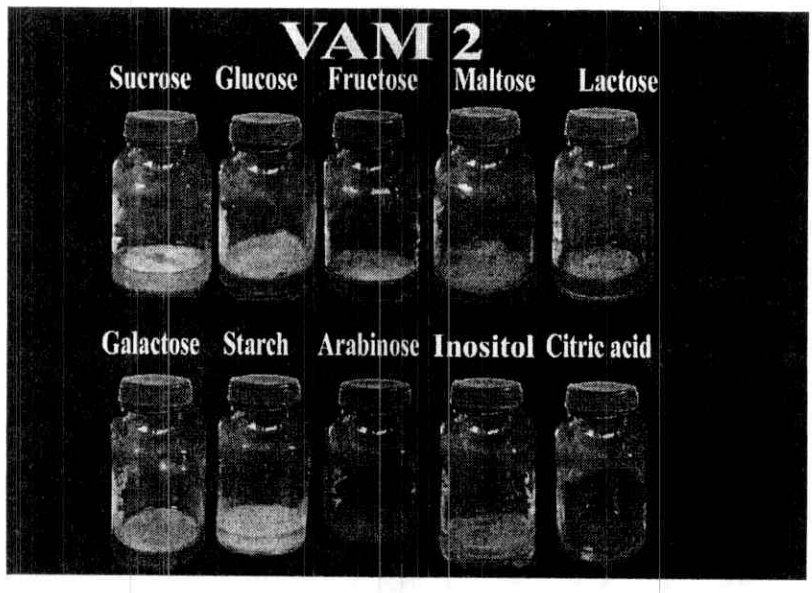



**Fig. (12b):** Effect of different carbon sources on the growth amount of the isolate VAM-B.

### 5.3. Effect on VAM-sporangiospores production:

Data in **Table (12c)** showed number of Sp-spores per microscopic field "300X" produced by different VAM isolates as affected by tested carbon sources. Sucrose was the best in this respect (205.8) followed by galactose and fructose (198.6) while inositol was the least favorable one (117.0). S-spore production by all VAM isolates was completely failed on citric acid and VAM-O only on inositol. In general, VAM-S produces the highest average spore number (216.9) followed by VAM-O (190.2), VAM-B (154.9) and VAM-M (106.1), respectively with clear significant difference in between. As for interaction, the highest S-spore number was produced by VAM-O on sucrose (260.6) while the lowest number was produced by VAM-M (107.7) on inositol.

**Table (12c):** Effect of carbon sources on sporangiospores production (spores no./microscopic field "300X") of tested VAM isolates.

| C-source | VAM isolates | | | | Mean |
|---|---|---|---|---|---|
| | VAM-O | VAM-B | VAM-S | VAM-M | |
| Sucrose | 260.6 | 177.6 | 256.6 | 128.3 | 205.8 |
| Glucose | 258.7 | 168.0 | 233.7 | 127.5 | 197.0 |
| Galactose | 241.3 | 184.2 | 252.2 | 117.0 | 198.6 |
| Fructose | 241.3 | 184.2 | 252.2 | 117.0 | 198.6 |
| Maltose | 236.5 | 180.3 | 241.6 | 110.6 | 192.2 |
| Lactose | 209.2 | 159.0 | 225.6 | 110.3 | 176.0 |
| Starch | 237.9 | 172.1 | 251.2 | 127.8 | 197.2 |
| Arabinose | 216.3 | 174.5 | 244.9 | 114.6 | 187.6 |
| Inositol | 0.0 | 149.4 | 210.9 | 107.7 | 117.0 |
| Citric acid | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Mean | 190.2 | 154.9 | 216.9 | 106.1 | |

| LSD. At 5% for: | C-sources | Isolates | Interaction |
|---|---|---|---|
| | 0.60 | 1.49 | 5.97 |

### 5.4. Effect on VAM-chlamydospores production:

Data in **Table (12d)** reveal that the production of Ch-spores of the VAM isolates tested was significantly varied on media containing different carbon sources. Based on number of Ch-spores per microscopic field "300X", sucrose was the best (10.8) followed by glucose, galactose and fructose (10.4), starch (10.3), maltose (10.0), arabinose (9.7), lactose (9.2) and inositol (5.6), respectively. All VAM isolates, however, failed to produce Ch-spores on media containing citric acid while VAM-O only did that on medium containing inositol. The highest number of Ch-spores, however, was produced by VAM-O on media containing sucrose or glucose (16.1-16.2) while the lowest number (6.6) was produced by VAM-M on medium containing inositol as sole source of carbon.

**Table (12d):** Effect of carbon source on chlamydospores production (spores no./microscopic field "300X") of tested VAM isolates.

| C-source | VAM isolates | | | | Mean |
|---|---|---|---|---|---|
| | VAM-O | VAM-B | VAM-S | VAM-M | |
| Sucrose | 16.2 | 9.0 | 10.2 | 7.9 | 10.8 |
| Glucose | 16.1 | 8.5 | 9.2 | 7.8 | 10.4 |
| Galactose | 15.0 | 9.3 | 10.0 | 7.2 | 10.4 |
| Fructose | 15.0 | 9.3 | 10.0 | 7.2 | 10.4 |
| Maltose | 14.7 | 9.1 | 9.6 | 6.8 | 10.0 |
| Lactose | 13.0 | 8.0 | 9.0 | 6.7 | 9.2 |
| Starch | 14.8 | 8.7 | 10.0 | 7.8 | 10.3 |
| Arabinose | 13.4 | 8.8 | 9.7 | 7.0 | 9.7 |
| Inositol | 0.0 | 7.5 | 8.4 | 6.6 | 5.6 |
| Citric acid | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Mean | 11.8 | 7.8 | 8.6 | 6.5 | |
| LSD. At 5% for: | C-sources | Isolates | Interaction | | |
| | 0.04 | 0.11 | 0.45 | | |

**6. Effect of different pH values:**

**6.1. Effect on the linear growth:**

Data in **Table (13a)** illustrated that, the ML-growth of tested VAM isolates, for example isolate VAM-M **(Fig., 13.a)**, was significantly affected by the pH values of the growth media. Gradual significant increase in the ML-growth was observed as pH increased from pH 5.0 (52.13mm) to pH 7.0 (69.75mm) then gradually decreased by elevating pH value up to 7.6 (69.0mm), 8.0 (68.81mm), 8.6 (68.31mm) or 9.0 (67.38mm), respectively.

**Table (13a):** Effect of pH values on ML-growth (in mm) of tested VAM isolates.

| pH values | VAM isolates | | | | Mean |
|---|---|---|---|---|---|
| | VAM-O | VAM-B | VAM-S | VAM-M | |
| 5.0 | 51.75 | 51.75 | 51.75 | 53.25 | 52.13 |
| 5.6 | 52.50 | 52.50 | 52.50 | 54.50 | 53.00 |
| 6.0 | 53.25 | 53.75 | 53.25 | 54.75 | 53.75 |
| 6.6 | 54.25 | 56.25 | 54.25 | 56.25 | 55.25 |
| 7.0 | 70.00 | 70.00 | 70.00 | 69.00 | 69.75 |
| 7.6 | 70.00 | 66.00 | 70.00 | 70.00 | 69.00 |
| 8.0 | 70.00 | 65.25 | 70.00 | 70.00 | 68.81 |
| 8.6 | 70.00 | 65.25 | 70.00 | 68.00 | 68.31 |
| 9.0 | 70.00 | 62.50 | 70.00 | 67.00 | 67.38 |
| Mean | 62.42 | 60.36 | 62.42 | 62.53 | |

| LSD. At 5% for: | pH | Isolates | Interaction |
|---|---|---|---|
| Treatments | 0.048 | 0.108 | 0.434 |

These results concluded that, the ML-growth of VAM-fungi seemed to be enhanced at the higher pH values more than the lower ones. The average ML-growth recorded on media with pH 5.0-6.6 was ranged between 52.13-55.25mm while at pH 7.6-9.0 it was ranged between 69.0-67.38mm. Regardless pH value, the ML-growth of VAM-B was significantly low (60.36mm) compared with VAM-O (62.42mm), VAM-S (62.42mm) or VAM-M (62.53mm). Among all interactions, VAM-O and VAM-S at pHs 7.0-9.0 and VAM-M at pHs

7.6-8.0 recorded the same highest ML-growth (70.0mm). Moreover, VAM-B recorded the lowest ML-growth at pH 9.0 (62.5mm) in comparison with the former isolates.

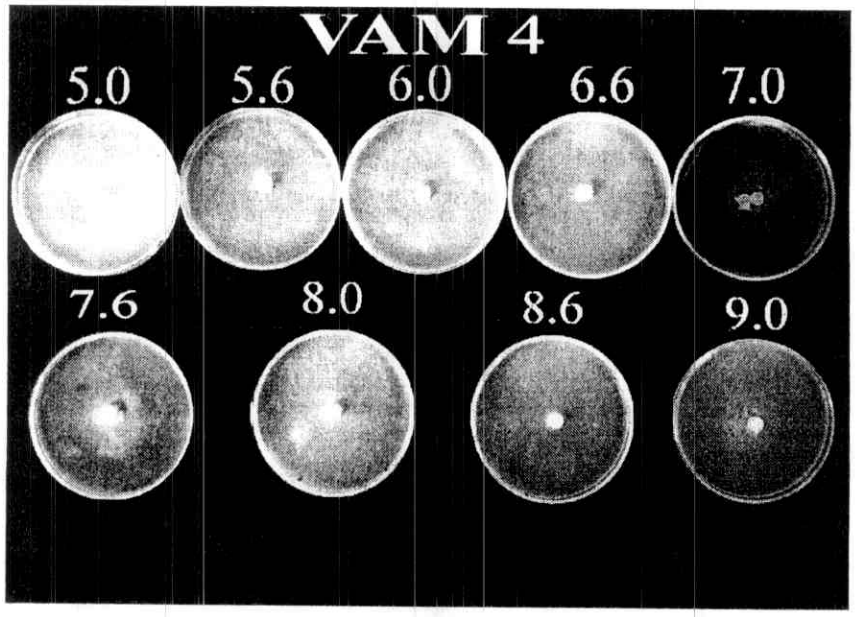



**Fig. (13a):** Effect of different pH values on the linear growth of the isolate VAM-M.

**6.2. Effect on the dry weight of growth:**

Data in **Table (13b)** reveal that, dry weight of growth (DWM-growth), for example isolate VAM-M **(Fig., 13.b)**, was affected by the pH values in similar way as previously described in ML-growth. It was gradually increased as pH increased from pH 5.0 (236.88mg) to pH 7.0 (400.0mg) then gradually decreased by elevating pH value up to 9.0 (333.13mg). Also, the higher pH values were more efficient for DWM-growth of VAM-fungi than the lower ones.

The average DWM-growth recorded on media with pH 5.0-6.6 was ranged between 236.88-276.88mg while at pH 7:6-9.0 it was

ranged between 392.5-333.13mg. In this regard, the DWM-growth of the four tested VAM-isolates was significantly varied as VAM-O, VAM-B, VAM-S and VAM-M recorded 350.56, 304.72, 304.72 and 329.72mg, respectively. However, VAM-O recorded its highest DWM-growth at pH 7.6 (422.5mg). The lowest DWM-growth was produced by VAM-B and VAM-S grown at pH 5.0 (217.5mg).

**Table (13b):** Effect of pH values on dry weight of growth (in mg) of tested VAM isolates.

| pH values | VAM isolates | | | | Mean |
|---|---|---|---|---|---|
| | VAM-O | VAM-B | VAM-S | VAM-M | |
| 5.0 | 280.0 | 217.5 | 217.5 | 232.5 | 236.88 |
| 5.6 | 307.5 | 225.0 | 225.0 | 245.0 | 250.63 |
| 6.0 | 315.0 | 237.5 | 237.5 | 247.5 | 259.38 |
| 6.6 | 320.0 | 262.5 | 262.5 | 262.5 | 276.88 |
| 7.0 | 390.0 | 410.0 | 410.0 | 390.0 | 400.00 |
| 7.6 | 422.5 | 360.0 | 360.0 | 427.5 | 392.50 |
| 8.0 | 417.5 | 352.5 | 352.5 | 412.5 | 383.75 |
| 8.6 | 390.0 | 352.5 | 352.5 | 380.0 | 368.75 |
| 9.0 | 312.5 | 325.0 | 325.0 | 370.0 | 333.13 |
| Mean | 350.56 | 304.72 | 304.72 | 329.72 | |

| LSD. At 5% for: | pH | Isolates | Interaction |
|---|---|---|---|
| | 0.674 | 1.517 | 6.068 |

### 6.3. Effect on VAM-sporangiospores production:

Ability of tested VAM fungi to produce Sp-spores was significantly affected by the pH **(Table, 13c)**. The number of Sp-spores was significantly increased as pH increased from pH 5.0 (90.53) to pH 7.6 (140.4) then gradually decreased by elevating pH value up to 9.0 (130.21). Thus, the Sp-spores production seems to be enhanced at the higher pH values than the lower ones. The average number of Sp-spores recorded on media with pHs 5.0-6.6 was ranged between 90.53-100.45 while at pHs 7.0-9.0 it was ranged between 130.21-140.4. Concerning with VAM-isolates, VAM-S produces the highest number of Sp-spores (148.12) followed by VAM-O (145.41), VAM-B (108.36) and VAM-M

(70.94), respectively. VAM-S, however, recorded the highest number of Sp-spores at pH 7.6 (180.74) while, VAM-M recorded the lowest numbers at pH 5.0 (57.2).

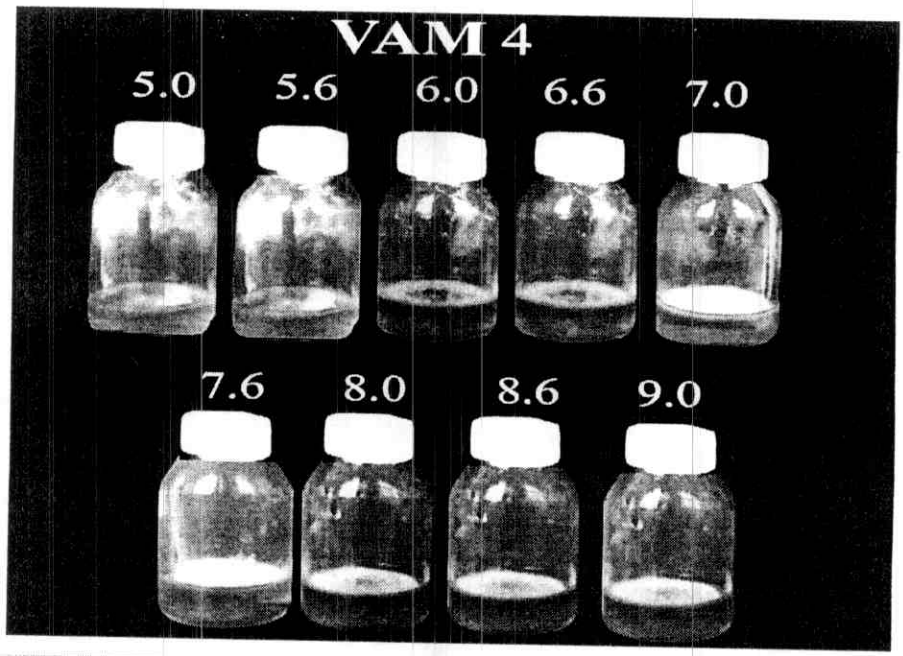



**Fig. (13b):** Effect of different pH values on the amount of growth of the isolate VAM-M.

**Table (13c):** Effect of pH values on sporangiospores production (spores no./microscopic field "300X") of tested VAM isolates.

| pH values | VAM isolates | | | | Mean |
|---|---|---|---|---|---|
| | VAM-O | VAM-B | VAM-S | VAM-M | |
| 5.0 | 107.10 | 88.13 | 109.69 | 57.20 | 90.53 |
| 5.6 | 111.95 | 91.40 | 113.30 | 58.76 | 93.85 |
| 6.0 | 115.51 | 94.30 | 116.49 | 60.10 | 96.60 |
| 6.6 | 120.42 | 99.30 | 120.18 | 61.91 | 100.45 |
| 7.0 | 170.36 | 131.15 | 172.07 | 79.32 | 138.22 |
| 7.6 | 175.99 | 120.43 | 180.74 | 84.45 | 140.40 |
| 8.0 | 173.35 | 118.99 | 178.05 | 82.43 | 138.20 |
| 8.6 | 170.27 | 118.65 | 174.85 | 77.80 | 135.39 |
| 9.0 | 163.74 | 112.90 | 167.75 | 76.45 | 130.21 |
| Mean | 145.41 | 108.36 | 148.12 | 70.94 | |
| LSD. At 5% for: | pH | Isolates | Interaction | | |
| Treatments | 0.368 | 0.829 | 3.315 | | |

### 6.4. Effect on VAM-chlamydospores production:

Data in **Table (13d)** reveal that, the ability of tested VAM fungi to produce Ch-spores was significantly affected also by the pH values in the growth media. Number of Ch-spores was significantly increased as pH increased from pH 5.0 (5.72) to pH 7.6 (8.61) then gradually decreased by elevating pH value up to 9.0 (7.94). Formation of Ch-spores seems to be favored at the higher pH values than the lower ones. Regardless pH value, the four tested VAM-isolates was clearly varied in formation of Ch-spores. In this respect, VAM-O recorded the highest number (10.55) followed by VAM-B (7.04) while the lowest numbers were produced by VAM3 and VAM-M (5.81). The isolate VAM-O recorded the highest number of Ch-spores (12.36-12.78) at pHs 7.0-8.6. At the same pH values, the number of Ch-spores produced by VAM-B, VAM-S and VAM-M was ranged between (6.38-7.81).

**Table (13d):** Effect of pH values on chlamydospores production (spores no./microscopic field "300X") of tested VAM isolates.

| pH values | VAM isolates | | | | Mean |
|---|---|---|---|---|---|
| | VAM-O | VAM-B | VAM-S | VAM-M | |
| 5.0 | 7.78 | 5.73 | 4.69 | 4.69 | 5.72 |
| 5.6 | 8.13 | 5.94 | 4.82 | 4.82 | 5.92 |
| 6.0 | 8.38 | 6.12 | 4.93 | 4.93 | 6.09 |
| 6.6 | 8.73 | 6.45 | 5.07 | 5.07 | 6.33 |
| 7.0 | 12.36 | 8.52 | 6.50 | 6.50 | 8.47 |
| 7.6 | 12.78 | 7.81 | 6.92 | 6.92 | 8.61 |
| 8.0 | 12.59 | 7.72 | 6.76 | 6.76 | 8.46 |
| 8.6 | 12.36 | 7.71 | 6.38 | 6.38 | 8.21 |
| 9.0 | 11.89 | 7.33 | 6.27 | 6.27 | 7.94 |
| Mean | 10.55 | 7.04 | 5.81 | 5.81 | |

| LSD. At 5% for: | pH | Isolates | Interaction |
|---|---|---|---|
| | 0.029 | 0.065 | 0.260 |

## 7. Effect of different light waves:

### 7.1. On the linear growth of tested VAM isolates:

Data in **Table (14a)** and **Fig. (14a)** illustrated that enveloping the growing in-vitro cultures of tested VAM isolates with different colored cellophane paper (hyaline, yellow, red, green, blue lights and black had no significant effect on the ML-growth of the 4 VAM isolates (70.0mm).

**Table (14a):** Effect of light wavelength on linear growth (in mm) of tested VAM isolates.

| Light wave | VAM isolates | | | | Mean |
|---|---|---|---|---|---|
| | VAM-O | VAM-B | VAM-S | VAM-M | |
| Hyaline | 70 | 70 | 70 | 70 | 70.00 |
| Yellow | 70 | 70 | 70 | 70 | 70.00 |
| Red | 70 | 70 | 70 | 70 | 70.00 |
| Green | 70 | 70 | 70 | 70 | 70.00 |
| Blue | 70 | 70 | 70 | 70 | 70.00 |
| Black | 70 | 70 | 70 | 70 | 70.00 |
| Mean | 70.00 | 70.00 | 70.00 | 70.00 | |
| LSD at 5% for: | Light NS. | Isolates NS. | Interaction NS. | | |

### 7.2. On the dry weight of growth:

Unlike ML-growth, the data in **Table (4b)** and **Fig., (14b and c)** illustrated that the dry weight of growth (DWM-growth) of the tested VAM isolates was varied significantly under tested light conditions. The highest DWM-growth was produced by the hyaline light (332.5mg) followed by the green light (313.44mg), blue light (281.56mg), yellow light (280.0mg), red light (264.38mg) and dark (260.63mg), respectively. Under the tested light conditions, VAM-M produces the highest DWM-growth (307.71mg) followed by VAM-O (290.83mg), VAM-S (287.27mg) and VAM-B (269.17mg), respectively. As for interaction, the hyaline light was the best for DWM-growth of isolates VAM-O (350.0mg), VAM-M (337.5mg) and VAM-S (322.5mg)

whereas VAM-B produces the highest DWM-growth of under green light conditions (341.25mg). On the opposite side, the red light caused the lowest DWM-growth of VAM-B (210.0mg) and VAM-M (266.25mg) while dark conditions induced the lowest values for VAM-O (243.75mg) and VAM-S (247.5mg).

**Table (14b):** Effect of different light wavelengths on weight of growth (in mg) of tested VAM isolates.

| Light wave | VAM isolates | | | | Mean |
|---|---|---|---|---|---|
| | VAM-O | VAM-B | VAM-S | VAM-M | |
| Hyaline | 350.0 | 320.0 | 322.5 | 337.5 | 332.5 |
| Yellow | 306.3 | 225.0 | 312.5 | 276.3 | 280.0 |
| Red | 273.8 | 210.0 | 307.5 | 266.3 | 264.4 |
| Green | 311.3 | 341.3 | 276.3 | 325.0 | 313.4 |
| Blue | 260.0 | 278.8 | 257.5 | 330.0 | 281.6 |
| Black | 243.8 | 240.0 | 247.5 | 311.3 | 260.6 |
| Mean | 290.8 | 269.2 | 287.3 | 307.7 | |

| LSD at 5% for: | Light | Isolates | Interaction |
|---|---|---|---|
| | 4.246 | 6.369 | 25.477 |

### 7.3. Effect on VAM-sporangiospores production:

Number of sporangiospores (Sp-spores) produced by the 4 VAM isolates was significantly varied under tested light conditions **(Table, 14c)**. The highest average number was produced under the hyaline light conditions (261.63) followed by the green light (238.83), yellow light (220.37), blue light (209.0), red light (208.62) and dark conditions (205.48), respectively. Regardless light conditions, VAM-O produces the highest number of Sp-spores (275.37) followed by VAM-S (265.0), VAM-B (213.76) and VAM-M (141.83), respectively. In general, VAM-O produced the highest number of Sp-spores (331.8) while VAM-B produced the lowest number (157.52) when both were exposed to the hyaline light. Among all interactions, VAM-M exposed to red or yellow light produces the lowest number i.e. 122.85 and 126.65, respectively.

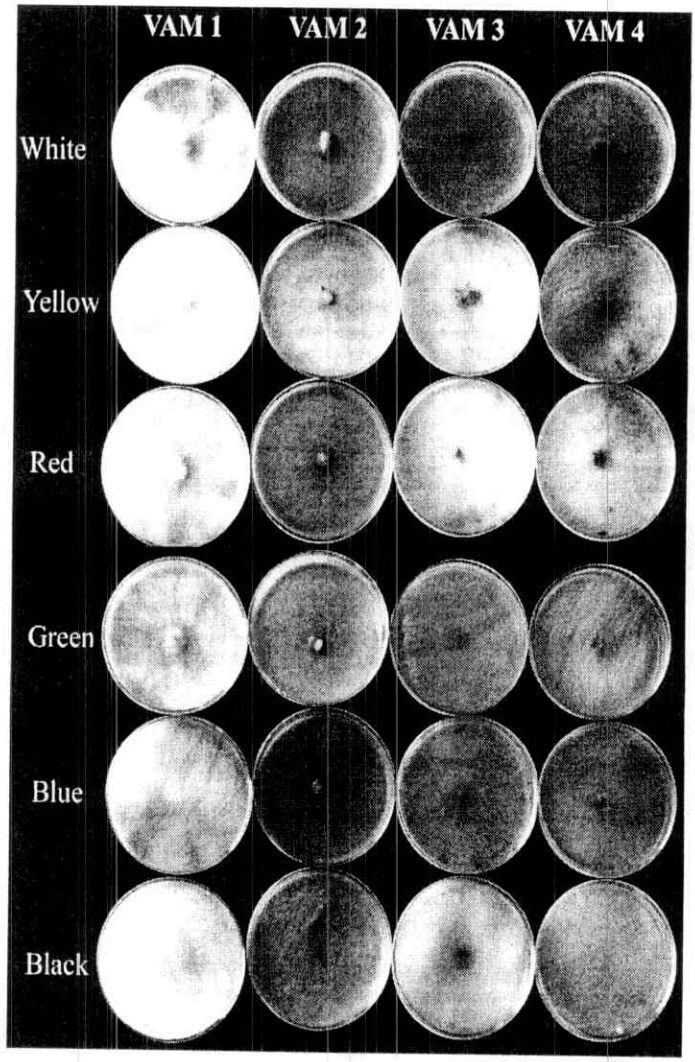



**Fig. (14a):** Effect of different light regimes on the linear growth of isolates VAM-O, VAM-B, VAM-S and VAM-M from left to right, respectively.

**Table (14c):** Effect of different light wavelengths on sporangiospores production (spores no./microscopic field "300X") of tested VAM isolates.

| Light wave | VAM isolates | | | | Mean |
|---|---|---|---|---|---|
| | VAM-O | VAM-B | VAM-S | VAM-M | |
| Hyaline | 331.80 | 255.30 | 301.90 | 157.52 | 261.63 |
| Yellow | 283.16 | 177.61 | 294.08 | 126.65 | 220.37 |
| Red | 266.86 | 165.67 | 279.12 | 122.85 | 208.62 |
| Green | 298.36 | 269.97 | 238.72 | 148.28 | 238.83 |
| Blue | 240.63 | 222.43 | 220.85 | 152.11 | 209.00 |
| Black | 231.41 | 191.59 | 255.34 | 143.58 | 205.48 |
| Mean | 275.37 | 213.76 | 265.00 | 141.83 | |

| LSD at 5% for: | Light | Isolates | Interaction |
|---|---|---|---|
| | 2.584 | 3.876 | 15.504 |

### 7.4. Effect on VAM-chlamydospores production:

The VAM-clamydospores (Ch-spores) was affected by light waves in similar way as previously described in the Sp-spores production. The obtained results **(Table, 14d)** illustrated that, the highest average number of Ch-spores was produced by the hyaline light (11.1) followed by the green light (10.3), yellow light (9.26), red and blue lights (8.79) and dark (8.46), respectively. As for VAM isolates, VAM-O produces the highest number of Sp-spores (13.68) followed by VAM-S (8.82), VAM-B (8.64) and VAM-M (6.67), respectively. As for interaction, the same results indicated that VAM-O exposed to the hyaline light produced the highest number of Ch-spores (16.51) while the lowest number was produced by VAM-M exposed to red light (5.77).

**Table (14d):** Effect of different light wavelengths on chlamydospores production (spores no./microscopic field "300X") of tested VAM isolates.

| Light wave | VAM isolates | | | | Mean |
|---|---|---|---|---|---|
| | VAM-O | VAM-B | VAM-S | VAM-M | |
| Hyaline | 16.51 | 10.35 | 10.14 | 7.40 | 11.10 |
| Yellow | 14.01 | 7.23 | 9.83 | 5.96 | 9.26 |
| Red | 13.33 | 6.73 | 9.33 | 5.77 | 8.79 |
| Green | 14.78 | 10.91 | 8.55 | 6.98 | 10.30 |
| Blue | 11.48 | 8.93 | 7.63 | 7.14 | 8.79 |
| Black | 11.98 | 7.70 | 7.43 | 6.75 | 8.46 |
| Mean | 13.68 | 8.64 | 8.82 | 6.67 | |

| LSD at 5% for: | Light | Isolates | Interaction |
|---|---|---|---|
| | 0.154 | 0.231 | 0.924 |

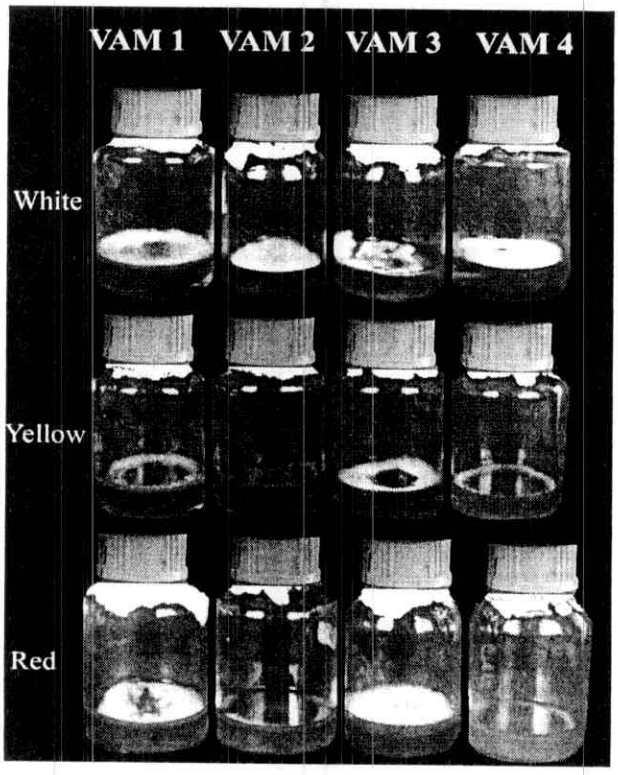



**Fig. (14b):** Effect of white, yellow and red light regimes on the growth amount of the four VAM isolates.

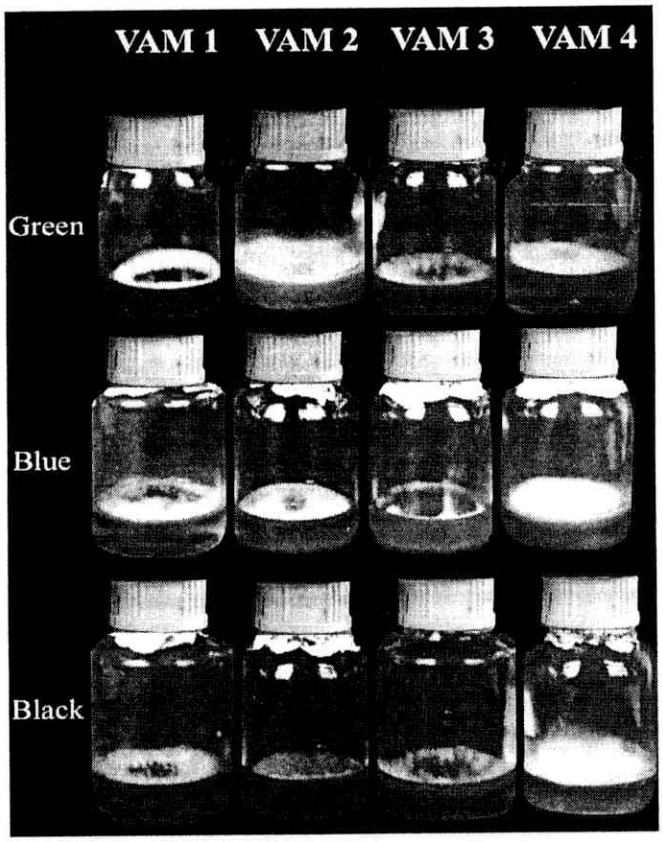



**Fig. (14c):** Effect of green, blue and darkness light regimes on the growth amount of the four VAM isolates.

**Greenhouse Results:**

**1. Pathogenicity test:**

Data in **Table (15)** indicate that, the three tested pathogenic fungi were significantly in their pathogenic abilities. In this regard, *Cephalosporium maydis* was the most virulent as it caused the highest incidence of pre- and post emergence damping off and resulted in the lowest percentage of survived plants particularly in the second sowing. *Rhizoctmia solani* ranked the second followed by *Fusarium monioliforme*.

**Table (15):** Effect of different tested pathogenic fungi on percentages of pre- and post-emergence damping of maize plants through 2 successive sowings.

| | First sowing | | | Second sowing | | |
|---|---|---|---|---|---|---|
| Pathogenic fungi | Pre- | Post- | Survivals | Pre- | Post- | Survivals |
| Control | 4.0 | 6.0 | 90.0 | 10.0 | 15.0 | 75.0 |
| *C. maydis* | 14.0 | 18.0 | 68.0 | 20.0 | 22.5 | 57.5 |
| *F. monioliforme* | 8.0 | 18.0 | 74.0 | 7.5 | 20.0 | 72.5 |
| *R. solani* | 8.0 | 24.0 | 68.0 | 22.5 | 10.0 | 67.5 |
| LSD at 5% for | 0.341 | 0.530 | 0.658 | 0.839 | 0.560 | 0.815 |

**2. Effect of inoculation with VAM isolates each alone or combined with some soil pathogenic fungi on controlling incidence of damping-off disease of maize:**

Tow pot experiments were conducted to determine the effect of inoculation with the in vitro produced isolates of vesicular arbuscular mycorrhizal "VAM" fungi each alone or combined with some soil borne pathogens on the incidence of damping-off and some growth parameters of maize plants.

**2.1. Percentage of pre-emergence damping-off:**

Data in **Table (16a)** prove that *Rhizoctmia solani* caused the highest significant increase in the incidence of pre-emergence damping off particularly in the second sowing (18.5%) followed by

*Cephalosporium maydis* (14.5%), control (9.5%) and *Fusarium monioliforme* (8.0%). Inoculation with VAM isolates, pathogenic fungi and the interaction between them had no significant effect on the incidence of pre-emergence damping-off in both sowings.

**Table (16a):** Effect of four VAM isolates and three pathogenic fungi on pre-emergence (%) of maize plants through 2 successive sowings.

| | | Pathogens tested | | | | |
|---|---|---|---|---|---|---|
| | VAM isolates | Control | *C. maydis* | *F. monioliforme.* | *R. solani* | Mean |
| First sowing | Control | 4.0 | 14.0 | 8.0 | 8.0 | 8.50 |
| | VAM-O | 4.0 | 10.0 | 2.0 | 6.0 | 5.50 |
| | VAM-B | 4.0 | 8.0 | 8.0 | 14.0 | 8.50 |
| | VAM-S | 4.0 | 8.0 | 8.0 | 4.0 | 6.00 |
| | VAM-M | 4.0 | 4.0 | 4.0 | 4.0 | 4.00 |
| | Mean | 4.00 | 8.80 | 6.00 | 7.20 | |
| Second sowing | Control | 10.0 | 20.0 | 7.5 | 22.5 | 15.00 |
| | VAM-O | 10.0 | 15.0 | 7.5 | 15.0 | 11.88 |
| | VAM-B | 10.0 | 12.5 | 10.0 | 17.5 | 12.50 |
| | VAM-S | 10.0 | 15.0 | 5.0 | 17.5 | 11.88 |
| | VAM-M | 7.5 | 10.0 | 10.0 | 20.0 | 11.88 |
| | Mean | 9.50 | 14.50 | 8.00 | 18.50 | |

| L.S.D. at 5% for: | 1st sowing | 2nd sowing |
|---|---|---|
| VAM | NS. | NS. |
| Pathogen | NS. | 0.775 |
| Interaction | NS. | NS. |

**2.2. Percentage of post-emergence damping-off:**

Percentages of post-emergence damping off **(Table, 16b)** were significantly affected by tested pathogenic fungi in both, first and second, sowings. In the first sowing, the highest percentage of post-emergence damping-off was produced by *Fusarium monioliforme* (16.0%) and *Rhizoctonia solani* (15.2%) without significant differences between them followed by *Cephalosporium maydis* (13.6%) compared with the control treatment (3.6%). While, in the second sowing, *C. maydis* was the most virulent (19.5%) followed by *F. monioliforme* (15.0%), control treatment (10.0%) and *R. solani* (6.0%), respectively.

Inoculation with VAM isolates and the interaction between VAM isolates and pathogenic fungi had no significant effect on the incidence of pre-emergence damping-off in both first and second sowings.

**Table (16b):** Effect of four VAM isolates and three pathogenic fungi on post-emergence (%) of maize plants through 2 successive sowings.

| | VAM isolates | Pathogens tested | | | | Mean |
|---|---|---|---|---|---|---|
| | | Control | *C. maydis* | *F. monioliforme.* | *R. solani* | |
| First sowing | Control | 6.0 | 18.0 | 18.0 | 24.0 | 16.50 |
| | VAM-O | 2.0 | 14.0 | 16.0 | 10.0 | 10.50 |
| | VAM-B | 4.0 | 12.0 | 16.0 | 10.0 | 10.50 |
| | VAM-S | 4.0 | 12.0 | 14.0 | 12.0 | 10.50 |
| | VAM-M | 2.0 | 12.0 | 16.0 | 20.0 | 12.50 |
| | Mean | 3.60 | 13.60 | 16.00 | 15.20 | |
| Second sowing | Control | 15.0 | 22.5 | 20.0 | 10.0 | 16.88 |
| | VAM-O | 10.0 | 20.0 | 12.5 | 2.5 | 11.25 |
| | VAM-B | 10.0 | 22.5 | 12.5 | 7.5 | 13.13 |
| | VAM-S | 7.5 | 20.0 | 17.5 | 2.5 | 11.88 |
| | VAM-M | 7.5 | 12.5 | 12.5 | 7.5 | 10.00 |
| | Mean | 10.00 | 19.50 | 15.00 | 6.00 | |

| L.S.D. at 5% for: | 1st sowing | 2nd sowing |
|---|---|---|
| VAM | NS. | NS. |
| Pathogen | 0.980 | 0.488 |
| Interaction | NS. | NS. |

## 2.3. Percentage of survivals:

Data in **Table (16c)** clearly indicate that percentage of survival in both sowings was significantly decreased by the tested pathogens compared with the control. In the first sowing, *C. maydis*, *F. monioliforme* and *R. solani* decreased percentage of survival to 77.6, 78.0 and 77.6%, respectively without significant differences between the in comparison with the control (92.4). In the second sowing, *C. maydis* caused the highest significant decrease (66.0%) followed by *R. solani* (75.5%) and *F. monioliforme* (77.0%), respectively comparing with the control (80.5%).

**Table (16c):** Effect of four VAM isolates and three pathogenic fungi on survival (%) of maize plants through 2 successive sowings.

| | VAM isolates | Pathogens tested: Control | *C. maydis* | *F. monioliforme.* | *R. solani* | Mean |
|---|---|---|---|---|---|---|
| First sowing | Control | 90.0 | 68.0 | 74.0 | 68.0 | 75.00 |
| | VAM-O | 94.0 | 76.0 | 82.0 | 84.0 | 84.00 |
| | VAM-B | 92.0 | 80.0 | 76.0 | 76.0 | 81.00 |
| | VAM-S | 92.0 | 80.0 | 78.0 | 84.0 | 83.50 |
| | VAM-M | 94.0 | 84.0 | 80.0 | 76.0 | 83.50 |
| | Mean | 92.40 | 77.60 | 78.00 | 77.60 | |
| Second sowing | Control | 75.0 | 57.5 | 72.5 | 67.5 | 68.13 |
| | VAM-O | 80.0 | 65.0 | 80.0 | 82.5 | 76.88 |
| | VAM-B | 80.0 | 65.0 | 77.5 | 75.0 | 74.38 |
| | VAM-S | 82.5 | 65.0 | 77.5 | 80.0 | 76.25 |
| | VAM-M | 85.0 | 77.5 | 77.5 | 72.5 | 78.13 |
| | Mean | 80.50 | 66.00 | 77.00 | 75.50 | |

| L.S.D. at 5% for: | 1st sowing | 2nd sowing |
|---|---|---|
| VAM | NS. | 1.155 |
| Pathogen | 1.367 | 0.924 |
| Interaction | NS. | NS. |

Percentages of survival in the second sowing only was significantly increased by VAM isolates tested in comparison with the control. In this regard, VAM-M recorded the highest significant increase (78.13%) followed by VAM-O (76.88%), VAM-S (76.25%) and VAM-B (74.38%), respectively compared with the control (68.13%). The interaction between VAM isolates and pathogens had no significant effect in both sowings.

### 3. Effect of inoculation with VAM isolates each alone or combined with some soil pathogenic fungi on different growth parameters of maize plants:

#### 3.1. Shoot length (SL):

Data in **Table (17)** prove that the shoot length **(SL)** was affected negatively and significantly by all tested pathogenic fungi compared with the control. In the first sowing, *R. solani* caused the highest decrease (79.12cm) followed by *C. maydis* (82.64) and *F. monioliforme*

(82.88) compared with control (84.44). In the second sowing, *R. solani* was the most virulent (65.57) followed by *F. monioliforme* (68.03) and *C. maydis* (69.55) compared with the control (70.52cm).

**Table (17):** Effect of four VAM isolates and three pathogenic fungi on shoot length (cm) of maize plants through 2 successive sowings.

| | VAM isolates | Pathogens tested | | | | Mean |
|---|---|---|---|---|---|---|
| | | Control | *C. maydis* | *F. monioliforme.* | *R. solani* | |
| First sowing | Control | 76.76 | 74.5 | 73.94 | 70.19 | 73.85 |
| | VAM-O | 87.16 | 85.51 | 82.73 | 79.34 | 83.69 |
| | VAM-B | 86.14 | 86.51 | 88.40 | 81.8 | 85.71 |
| | VAM-S | 86.31 | 86.35 | 86.41 | 84.1 | 85.79 |
| | VAM-M | 85.82 | 80.31 | 82.93 | 80.15 | 82.30 |
| | Mean | 84.44 | 82.64 | 82.88 | 79.12 | |
| Second sowing | Control | 59.98 | 58.05 | 56.36 | 55.59 | 57.50 |
| | VAM-O | 72.85 | 72.41 | 71.16 | 64.10 | 70.13 |
| | VAM-B | 75.51 | 74.26 | 72.25 | 71.35 | 73.34 |
| | VAM-S | 74.07 | 73.24 | 71.63 | 68.62 | 71.89 |
| | VAM-M | 70.21 | 69.76 | 68.76 | 68.17 | 69.22 |
| | Mean | 70.52 | 69.55 | 68.03 | 65.57 | |

| L.S.D. at 5% for: | 1st sowing | 2nd sowing |
|---|---|---|
| VAM | 0.206 | 0.240 |
| Pathogen | 0.165 | 0.192 |
| Interaction | 0.824 | 0.962 |

The shoot length, however, was significantly increased by inoculation with VAM isolates **(Fig., 15a)** in comparison with the control. In the first sowing, the highest increase was produced by VAM-S (85.79) and VAM-B (85.71) followed by VAM-O (83.69) and VAM-M (82.3), respectively compared with the control (73.85). However, VAM-B produces the highest increase in the second sowing (73.34) followed by VAM-S (71.89), VAM-O (70.13) and VAM-M (69.22), respectively compared with the control (57.50).

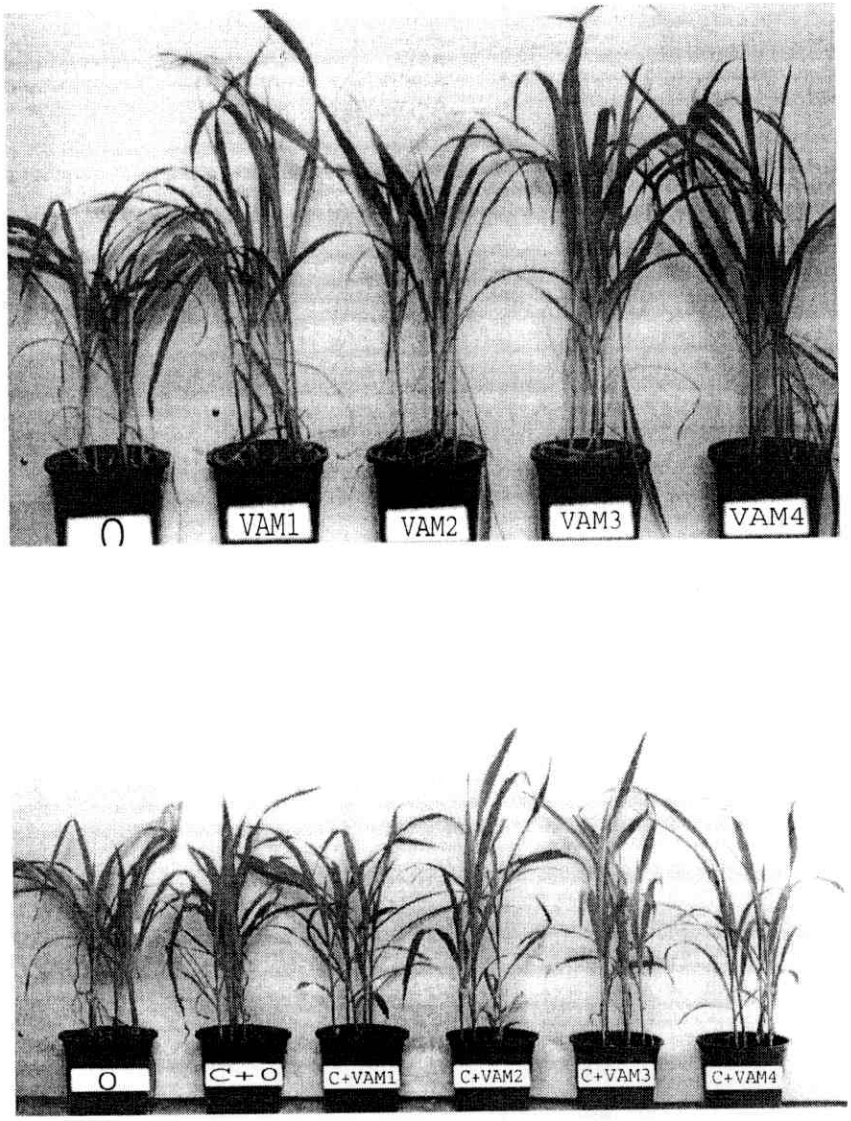
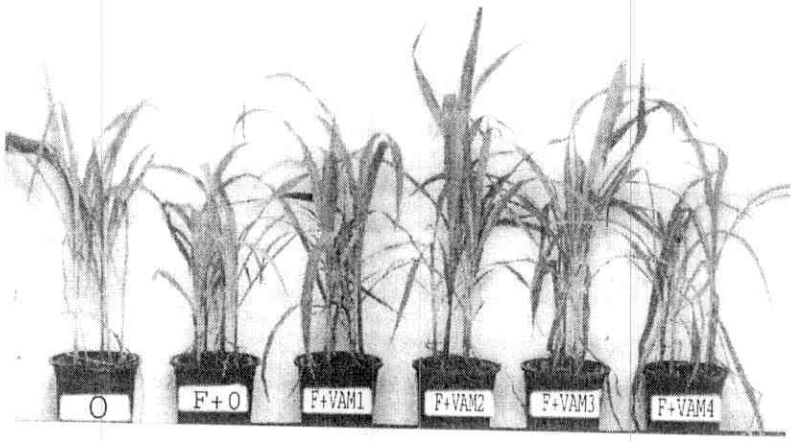



**Fig. (15a):** Effect of inoculation with VAM isolates alone (above) or combined with *C. maydis* (below) on growth of maize seedlings. (O = control).



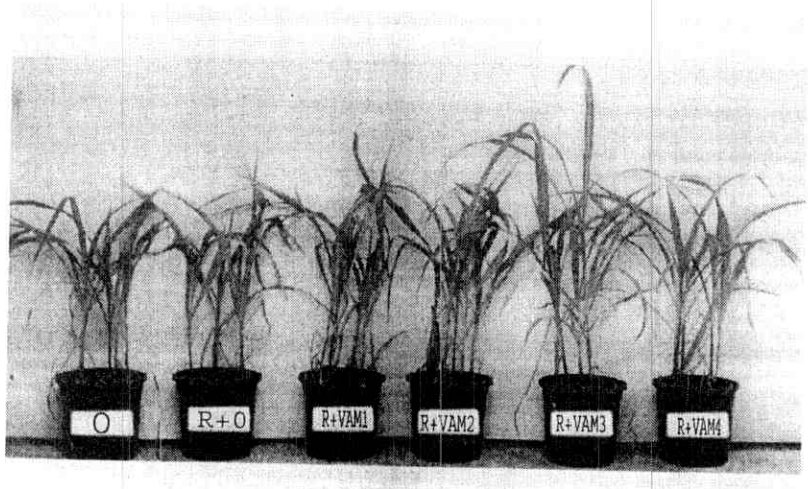




**Fig. (15b):** Effect of inoculation with VAM isolates combined with *F. monioliforme* (above) or *R. solani* (below) on growth of maize seedlings against controls (0).

The interaction between VAM isolates and pathogenic fungi **(Figs., 15a and b)** significantly affected the shoot length in both sowings. In the first sowing, VAM-O added to the pathogen free soil (control), VAM-B added to soils infested with *C. maydis* or *F. monioliforme* and VAM-S added to *R. solani*-infested soil produced the highest significant increase in the shoot length in comparison with their respective controls. While, VAM-B was the best of all in the second sowing either in the pathogen free or pathogen-infested soils.

**3.2. Root length:**

Data in **Table (17)** prove that the root length (cm) was affected negatively and significantly by all tested pathogenic fungi compared with the control. *R. solani* caused the highest decrease in root length in both sowings (29.98 and 25.09cm) whereas the lowest decrease was caused by *F. monioliforme* in the first sowing (33.02) and *C. maydis* in the second sowing (28.95). On the contrary, the root length in both sowings was significantly increased by all VAM isolates tested comparing with the control. In the first sowing, VAM-O, VAM-B and VAM-S were significantly equal and increased root length (34.05-34.10) better than VAM-M (32.38). In the second sowing, VAM-B was the best in this respect (30.16) followed by VAM-S (29.75), VAM-O (29.54) and VAM-M (28.5), respectively compared with the control (21.72cm).

The interaction between VAM isolates and pathogenic fungi significantly affected the root length in both sowings. In the first sowing, VAM-O added to the pathogen free soil (control), VAM-B added to infested soils (*C. maydis* or *F. monioliforme* and *R. solani*) produced the highest significant increase in the shoot length in

comparison with their respective controls. In the second sowing, VAM-O added to pathogen free soil (control), VAM-S added to soil infested with *C. maydis* or *F. monioliforme* and VAM-B added to *R. solani*-infested soil were the best compared with the other VAM inoculation treatments.

**Table (18):** Effect of four VAM isolates and three pathogenic fungi on root length (cm) of maize plants through 2 successive sowings.

| | VAM isolates | Pathogens tested | | | | Mean |
|---|---|---|---|---|---|---|
| | | Control | *C. maydis* | *F. monioliforme.* | *R. solani* | |
| First sowing | Control | 30.3 | 30.3 | 28.2 | 25.7 | 28.60 |
| | VAM-O | 39.0 | 33.4 | 33.3 | 30.7 | 34.09 |
| | VAM-B | 34.3 | 34.4 | 36.0 | 31.8 | 34.10 |
| | VAM-S | 36.3 | 34.1 | 35.0 | 30.8 | 34.05 |
| | VAM-M | 33.3 | 32.7 | 32.6 | 31.0 | 32.38 |
| | Mean | 34.64 | 32.93 | 33.02 | 29.98 | |
| Second sowing | Control | 22.9 | 22.8 | 22.2 | 18.9 | 21.72 |
| | VAM-O | 33.6 | 31.2 | 28.2 | 25.2 | 29.54 |
| | VAM-B | 31.8 | 29.2 | 29.1 | 30.6 | 30.16 |
| | VAM-S | 32.0 | 31.5 | 31.8 | 23.7 | 29.75 |
| | VAM-M | 29.7 | 30.0 | 27.3 | 27.0 | 28.50 |
| | Mean | 29.99 | 28.95 | 27.70 | 25.09 | |

| L.S.D. at 5% for: | 1st sowing | 2nd sowing |
|---|---|---|
| VAM | 0.073 | 0.074 |
| Pathogen | 0.059 | 0.059 |
| Interaction | 0.293 | 0.297 |

All tested VAM isolates successfully colonized roots of maize seedlings. The microscopic examination of the colonized roots showed the different specific VAM structures i.e. arbuscules and coiled mycelium **(Figs., 16 and 17)**, vesicles and H-shaped connections **(Fig., 18)** and spores inside **(Fig., 19)** as well as outside roots **(Fig., 20)**.

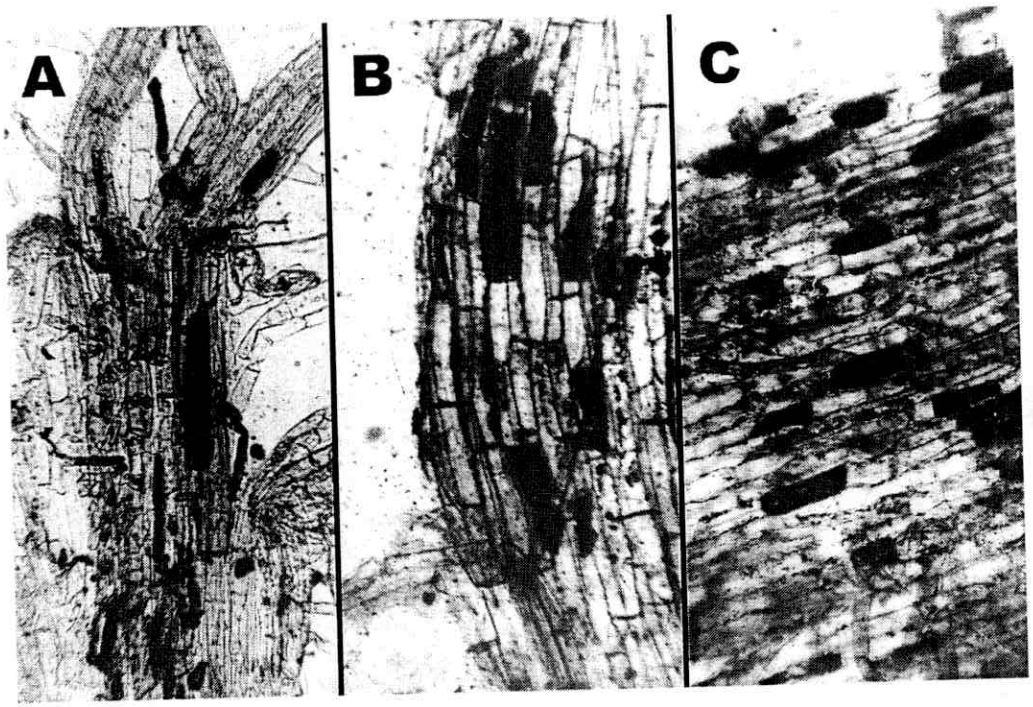



**Fig. (16):** Arbuscules formed in roots of maize plants inoculated with different VAM isolates. VAM-O "A" (100X), VAM-S "B" (150X) and maize- isolate "C" (150X).

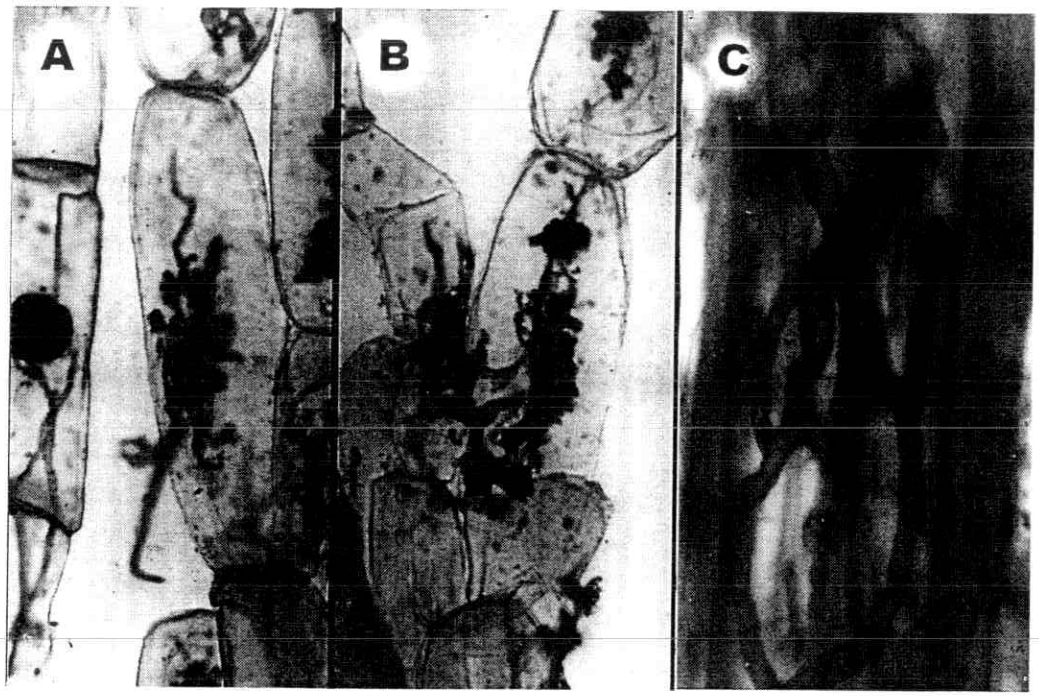



Fig. (17): Arbuscules "A and B" (400X) and coiled mycelium "C" formed in roots of maize plants inoculated with VAM-O (600X).

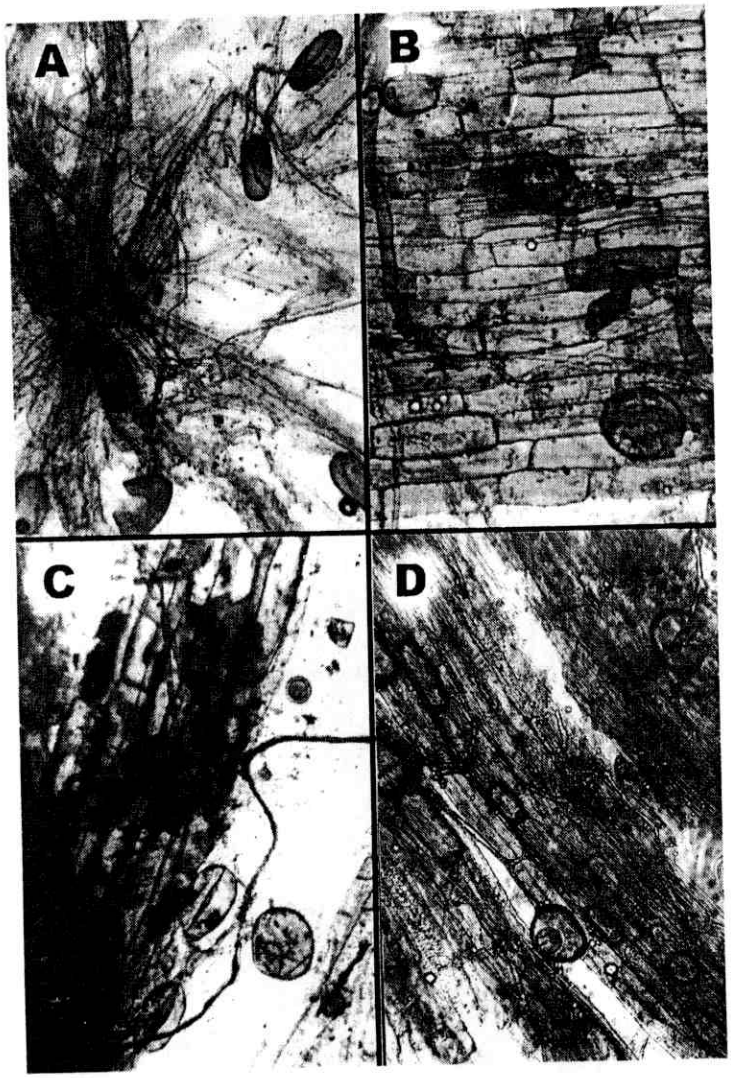



**Fig. (18):** Vesicles formed in roots of maize plants inoculated with VAM-O "A" (300X), VAM-B "B" (300X), VAM-S "C" (240X) and VAM-M "D" (150X). Noted the H-shaped connections in "D".

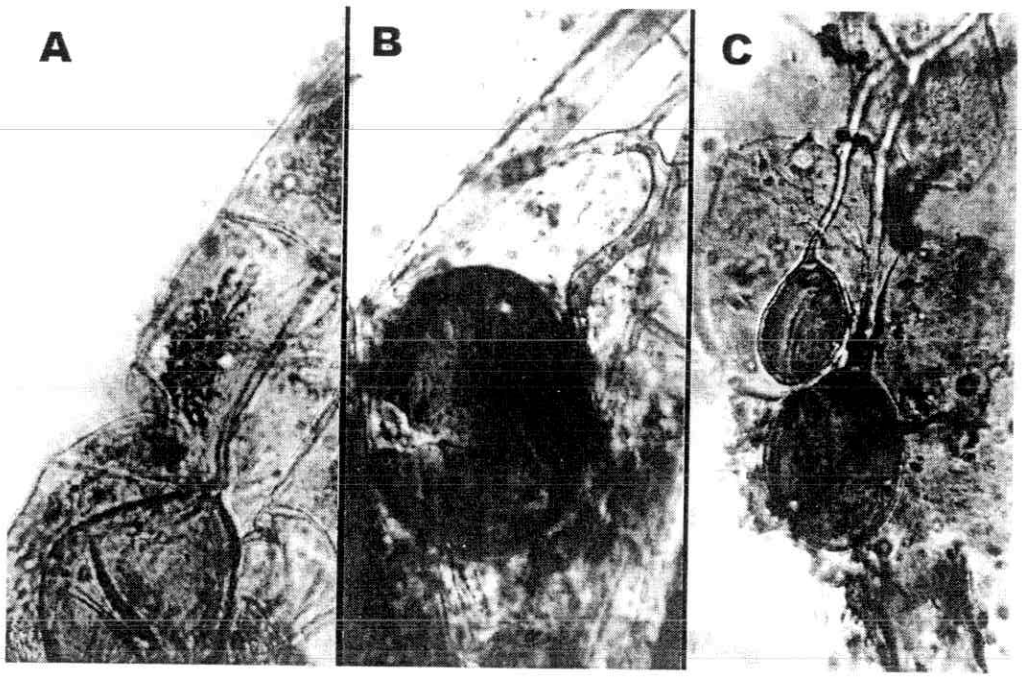



**Fig. (19):** Vesicles formed in roots of maize plants inoculated with VAM-B "600X", VAM-S "600X" and VAM-M "480X".

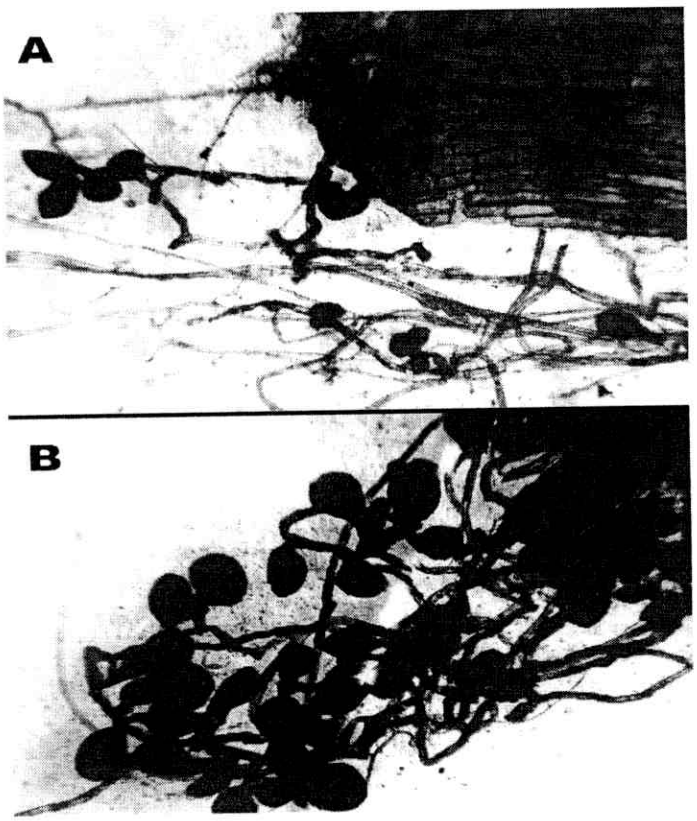



Fig. (20): Extraradical mycelium with excessive spores attached with roots of maize plants inoculated with VAM-S. A= 120X and B=150X".

### 3.3. Stem diameter (SD):

Data in **Table (19)** stated that the stem diameter (cm) of maize plants was reduced significantly by all tested pathogenic fungi. The highest significant reduction in the first sowing, however, was induced by *R. solani* (0.622) and *F. monioliforme* (0.628) while in the second

sowing, the highest significant decrease was caused by *R. solani* (0.49) and *C. maydis* (0.496) compared with the controls of both sowings (0.672 and 0.526).

On the contrary, the stem diameter in both sowings was significantly increased by all VAM isolates tested comparing with the control. In this respect, VAM-B produces the highest significant increase (0.66 and 0.531) followed by VAM-S (0.654 and 0.526), VAM-O (0.649 and 0.51) and VAM-M (0.642 and 0.5), respectively compared with the controls (0.606 and 0.451) of the first and second sowings, respectively.

**Table (19):** Effect of four VAM isolates and three pathogenic fungi on stem diameter (cm) of maize plants through 2 successive sowings.

| | VAM isolates | Pathogens tested | | | | Mean |
|---|---|---|---|---|---|---|
| | | Control | *C. maydis* | *F. monioliforme.* | *R. solani* | |
| First sowing | Control | 0.618 | 0.614 | 0.598 | 0.592 | 0.606 |
| | VAM-O | 0.686 | 0.652 | 0.632 | 0.624 | 0.649 |
| | VAM-B | 0.686 | 0.670 | 0.642 | 0.642 | 0.660 |
| | VAM-S | 0.686 | 0.664 | 0.638 | 0.626 | 0.654 |
| | VAM-M | 0.682 | 0.630 | 0.628 | 0.628 | 0.642 |
| | Mean | 0.672 | 0.646 | 0.628 | 0.622 | |
| Second sowing | Control | 0.482 | 0.450 | 0.442 | 0.430 | 0.451 |
| | VAM-O | 0.520 | 0.512 | 0.514 | 0.492 | 0.510 |
| | VAM-B | 0.556 | 0.512 | 0.526 | 0.528 | 0.531 |
| | VAM-S | 0.556 | 0.504 | 0.524 | 0.520 | 0.526 |
| | VAM-M | 0.518 | 0.502 | 0.498 | 0.482 | 0.500 |
| | Mean | 0.526 | 0.496 | 0.501 | 0.490 | |

| L.S.D. at 5% for: | 1st sowing | 2nd sowing |
|---|---|---|
| VAM | 0.002 | 0.001 |
| Pathogen | 0.002 | 0.001 |
| Interaction | NS. | 0.005 |

Stem diameter was significantly affected by the interaction between VAM isolates and pathogenic fungi in the second sowing only. In this respect, VAM-B was the best VAM inoculation treatment either

added to the pathogen free soil (control) or to the infested soils (*C. maydis* or *F. monioliforme* and *R. solani*).

### 3.4. Number of leaves/plant:

Data in **Table (20)** reveal that, all tested pathogenic fungi significantly reduced number of leaves/plant compared with the control treatments. The highest reduction was recorded by *R. solani* in both sowings (5.756 and 4.65) whereas *C. maydis* (6.512) in the first sowing and *F. monioliforme* in the second sowing (4.936) recorded the lowest reduction compared with 6.656 and 5.052 leaves/plant in the control of both sowings, respectively.

On the opposite side, all VAM isolates tested significantly increased number of leaves/plant compared with the control treatments. In this regard, VAM-O and VAM-B (6.535) in the first sowing and VAM-B (5.207) in the second sowing recorded the highest increase compared with the controls (5.575 and 4.28). While, VAM-M recorded the lowest increase in the number of leaves/plant (6.263 and 4.837) compared with 5.575 and 4.28 in the controls of both sowings, respectively.

The number of leaves/plant was significantly affected by the interaction between VAM isolates and pathogenic fungi tested. In the first sowing, VAM-O added to the pathogen-free soil (7.01) and VAM-B added to soils infested with *C. maydis* (6.8), *F. monioliforme* (6.77) or *R. solani* (6.16) produces the highest number of leaves/plant compared with soils infested with pathogens each alone. While in the second sowing, adding VAM-B to the pathogen-free soil or to soils infested with *F. monioliforme* (5.346) or *R. solani* (5.04) and VAM-S

added to *C. maydis*-infested ssoil (5.112) produced the highest number of leaves/plant compared with soils infested with pathogens each alone.

**Table (20):** Effect of 4 VAM isolates and three pathogenic fungi on number of leaves/plant of maize plants through 2 successive sowings.

| | VAM isolates | Pathogens tested | | | | Mean |
|---|---|---|---|---|---|---|
| | | Control | *C. maydis* | *F. monioliforme* | *R. solani* | |
| First sowing | Control | 5.800 | 5.800 | 5.600 | 5.100 | 5.575 |
| | VAM-O | 7.010 | 6.700 | 6.630 | 5.800 | 6.535 |
| | VAM-B | 6.810 | 6.800 | 6.770 | 6.160 | 6.635 |
| | VAM-S | 6.860 | 6.760 | 6.660 | 6.130 | 6.603 |
| | VAM-M | 6.800 | 6.500 | 6.160 | 5.590 | 6.263 |
| | Mean | 6.656 | 6.512 | 6.364 | 5.756 | |
| Second sowing | Control | 4.348 | 4.284 | 4.266 | 4.222 | 4.280 |
| | VAM-O | 5.186 | 4.932 | 4.952 | 4.554 | 4.906 |
| | VAM-B | 5.346 | 5.094 | 5.346 | 5.040 | 5.207 |
| | VAM-S | 5.248 | 5.112 | 5.166 | 4.932 | 5.115 |
| | VAM-M | 5.132 | 4.762 | 4.952 | 4.500 | 4.837 |
| | Mean | 5.052 | 4.837 | 4.936 | 4.650 | |

| L.S.D. at 5% for: | 1st sowing | 2nd sowing |
|---|---|---|
| VAM | 0.009 | 0.009 |
| Pathogen | 0.007 | 0.007 |
| Interaction | 0.036 | 0.036 |

### 3.5. Total fresh weight/plant:

Data in **Table (21)** reveal that, all tested pathogenic fungi significantly reduced the total fresh weight "g"/plant compared with the control treatments. In this regard, *R. solani* recorded highest reduction in both sowings (13.754 and 10.716g) whereas *C. maydis* in the first sowing (15.652g) and *F. monioliforme* in the second sowing (12.834g) caused lowest reduction compared with the controls (16.731 and 13.251g) of both sowings, respectively.

Inoculation with any of the VAM isolates tested, however, significantly increased total fresh weight/plant compared with the control of both sowings (12.556 and 9.431). In this regard, VAM-B was

the most effective as it recorded the highest figures in both sowings (16.572 and 13.653) followed by VAM-S (16.522 and 13.382), VAM-O (16.253 and 13.157) then VAM-M (15.067 and 11.967), respectively.

**Table (21):** Effect of four VAM isolates and three pathogenic fungi on total fresh weight (g/plant) of maize plants through 2 successive sowings.

| | VAM isolates | Pathogens tested | | | | Mean |
|---|---|---|---|---|---|---|
| | | Control | *C. maydis* | *F. monioliforme.* | *R. solani* | |
| First sowing | Control | 13.676 | 12.674 | 12.368 | 11.504 | 12.556 |
| | VAM-O | 17.960 | 16.552 | 16.320 | 14.180 | 16.253 |
| | VAM-B | 17.078 | 16.908 | 17.380 | 14.920 | 16.572 |
| | VAM-S | 18.000 | 16.680 | 17.000 | 14.408 | 16.522 |
| | VAM-M | 16.940 | 15.448 | 14.120 | 13.758 | 15.067 |
| | Mean | 16.731 | 15.652 | 15.438 | 13.754 | |
| Second sowing | Control | 10.276 | 9.810 | 9.450 | 8.186 | 9.431 |
| | VAM-O | 14.492 | 13.590 | 13.582 | 10.962 | 13.157 |
| | VAM-B | 14.562 | 13.482 | 14.272 | 12.294 | 13.653 |
| | VAM-S | 14.566 | 13.292 | 14.400 | 11.268 | 13.382 |
| | VAM-M | 12.360 | 12.168 | 12.466 | 10.872 | 11.967 |
| | Mean | 13.251 | 12.468 | 12.834 | 10.716 | |

| L.S.D. at 5% for: | 1st sowing | 2nd sowing |
|---|---|---|
| VAM | 0.043 | 0.041 |
| Pathogen | 0.034 | 0.033 |
| Interaction | 0.172 | 0.163 |

The total fresh weight/plant (g) in both sowings was significantly affected by the interaction between VAM isolates and pathogenic fungi tested in comparison with their controls. In the first sowing, VAM-S or VAM-O added to the pathogen-free soil and VAM-B added to soils infested with *C. maydis*, *F. monioliforme* or *R. solani* produces the highest number of leaves/plant compared with soils infested with pathogens each alone. In the second sowing, VAM-B and VAM-S added to the pathogen-free soil, using VAM-O and VAM-B against *C. maydis*, VAM-S against *F. monioliforme* and VAM-B against *R. solani* produced the highest number of leaves/plant compared with soils infested with pathogens each alone.

### 3.6. Total dry weight/plant:

Data in **Table (22)** show that, all tested pathogenic fungi significantly reduced the total dry weight "g"/plant compared with the control. In this regard, *R. solani* recorded highest reduction in both sowings (3.234 and 2.511g) followed by *F. monioliforme* in the first sowing (3.463g) and *C. maydis* in the second sowing (2.626) compared with their controls (3.793 and 2.938g).

**Table (22):** Effect of four VAM isolates and three pathogenic fungi on total dry weight (g/plant) of maize plants through 2 successive sowings.

| | VAM isolates | Pathogens tested | | | | Mean |
|---|---|---|---|---|---|---|
| | | Control | *C. maydis* | *F. monioliforme.* | *R. solani* | |
| First sowing | Control | 3.002 | 2.932 | 2.804 | 2.390 | 2.782 |
| | VAM-O | 4.186 | 3.738 | 3.598 | 3.358 | 3.720 |
| | VAM-B | 3.742 | 3.888 | 3.878 | 3.542 | 3.763 |
| | VAM-S | 4.204 | 3.800 | 3.724 | 3.484 | 3.803 |
| | VAM-M | 3.830 | 3.648 | 3.310 | 3.398 | 3.547 |
| | Mean | 3.793 | 3.601 | 3.463 | 3.234 | |
| Second sowing | Control | 2.236 | 2.214 | 2.180 | 2.130 | 2.190 |
| | VAM-O | 3.072 | 2.952 | 2.988 | 2.554 | 2.892 |
| | VAM-B | 3.306 | 2.862 | 3.278 | 2.796 | 3.061 |
| | VAM-S | 3.314 | 2.710 | 3.296 | 2.600 | 2.980 |
| | VAM-M | 2.764 | 2.394 | 2.646 | 2.476 | 2.570 |
| | Mean | 2.938 | 2.626 | 2.878 | 2.511 | |

| L.S.D. at 5% for: | 1st sowing | 2nd sowing |
|---|---|---|
| VAM | 0.014 | 0.007 |
| Pathogen | 0.011 | 0.006 |
| Interaction | 0.054 | 0.028 |

Soil inoculation, in both sowings, significantly increased total dry weight/plant. In the first sowing, VAM-S recorded the highest increase (3.803g) followed by VAM-B (3.763g), VAM-O (3.72g) and VAM-M (3.547g), respectively in comparison with the control (2.782g). While in the second sowing, VAM-B was the best (3.061g) followed by VAM-S (2.98g), VAM-O (2.89g) and VAM-M (2.57g), respectively comparing with the control (2.19g).

The same data reveal that the highest significant increase in the total dry weight/plant in the pathogen-free soil in both sowing was recorded by VAM-S (4.204 and 3.314g). However, using VAM-B against any of the pathogens tested in the first sowing and VAM-O, VAM-S and VAM-B against *C. maydis*, *F. monioliforme* or *R. solani*, respectively was the best of all in this respect.

**4. Effect of inoculation with VAM isolates each alone or combined with some soil pathogenic fungi on the photosynthetic maize-leaf-pigments:**

**4.1. Chlorophyll a:**

All pathogenic fungi tested caused considerable reduction in the chlorophyll-a "Ch-a" content (mg/g fresh weight) compared with the control **(Table, 23a)**. The highest reduction in both sowings was induced by *F. monioliforme* (3.33 and 2.845) followed by *R. solani* (3.555 and 2.93) and *C. maydis* (6.091 and 5.27), respectively compared with their controls (6.171 and 5.557).

Regardless pathogenic fungi, VAM isolates tested increased the "Ch-a" content to different extents in comparison with the control one. In both sowings, VAM-S was the most effective for increasing the "Ch-a" content (6.179 and 5.115) whereas, VAM-O caused the least increase in this respect (4.554 and 4.167) compared with the control (3.519 and 2.881) of both sowings.

Concerning interaction between VAM isolates and pathogens, it could be noticed that applying VAM-S (in both sowings) either in the pathogen free soil or the soil infested with *C. maydis* resulted in the highest "Ch-a" content compared with their respective controls. Whereas, in soils infested with *F. monioliforme* or *R. solani* applying

VAM+2 and VAM-S, respectively in the first sowing and VAM-B in the second sowing were the best of all in this respect.

**Table (23a):** Effect of four VAM isolates and three pathogenic fungi on Chlorophyll a (mg/g fresh weight) of maize plants through 2 successive sowings.

| | VAM isolates | Pathogens tested | | | | Mean |
|---|---|---|---|---|---|---|
| | | Control | *C. maydis* | *F. monioliforme.* | *R. solani* | |
| First sowing | Control | 4.428 | 4.154 | 2.815 | 2.678 | 3.519 |
| | VAM-O | 5.367 | 5.443 | 3.787 | 3.617 | 4.554 |
| | VAM-B | 5.789 | 5.677 | 4.410 | 3.699 | 4.894 |
| | VAM-S | 8.923 | 8.884 | 2.813 | 4.094 | 6.179 |
| | VAM-M | 6.349 | 6.295 | 2.823 | 3.688 | 4.789 |
| | Mean | 6.171 | 6.091 | 3.330 | 3.555 | |
| Second sowing | Control | 3.802 | 3.361 | 2.211 | 2.149 | 2.881 |
| | VAM-O | 4.934 | 4.620 | 3.674 | 3.440 | 4.167 |
| | VAM-B | 5.329 | 4.796 | 3.784 | 3.596 | 4.376 |
| | VAM-S | 7.818 | 7.722 | 2.211 | 2.710 | 5.115 |
| | VAM-M | 5.904 | 5.850 | 2.346 | 2.758 | 4.215 |
| | Mean | 5.557 | 5.270 | 2.845 | 2.930 | |

### 4.2. Chlorophyll b:

Data in **Table (23b)** show that, the chlorophyll b "Chl-b" content in leaves of maize plants was considerably decreased by all tested pathogenic fungi compared with their controls. *F. monioliforme* in the first sowing (3.111) and *R. solani* in the second one (3.021) recorded highest reduction whereas *C. maydis* recorded the lowest reduction in both sowings (7.604 and 5.982) compared with their controls (8.136 and 6.671).

On the contrary, all VAM isolates tested increased Chl-b content compared with the control. In this regard, VAM-S recorded the highest increase (8.296 and 6.045) followed by VAM-M (5.708 and 4.881) meanwhile VAM-B recorded the lowest increase (5.255 and 4.333) compared with control of both sowings (3.881 and 3.566). The efficacy

of VAM isolates tested for increasing Chl-b content, however, was greatly varied in the pathogen(s)-infested soils. Using VAM-S in the pathogen-free soil or in the *C. maydis*-infested soil and VAM-O in the *F. monioliforme*-infested soil, in both sowings, resulted in the highest Chl-b content compared with their controls. While, VAM-M and VAM-B were the best in soils infested with *R. solani* in the first and second sowings, respectively.

### 4.3. Total chlorophyll "a+b":

Data in **Table (23c)** show that, the total chlorophyll (mg/g fresh weight) was decreased considerably by all tested pathogenic fungi. *Fusarium monioliforme*, in both sowings, recorded highest reduction (6.441 and 5.927) followed by *R. solani* (7.628 and 5.951) and *C. maydis* (13.695 and 11.252), respectively compared with the control of both sowings (14.307 and 12.229).

**Table (23b):** Effect of four VAM isolates and and 3 pathogenic fungi on Chlorophyll b (mg/g fresh weight) of maize plant leaves through 2 successive sowings.

| | | Pathogens tested | | | | |
|---|---|---|---|---|---|---|
| | VAM isolates | Control | *C. maydis* | *F. monioliforme.* | *R. solani* | Mean |
| First sowing | Control | 4.811 | 4.941 | 2.853 | 2.918 | 3.881 |
| | VAM-O | 8.094 | 6.466 | 3.774 | 3.729 | 5.516 |
| | VAM-B | 7.266 | 6.376 | 2.933 | 4.445 | 5.255 |
| | VAM-S | 12.943 | 12.752 | 2.896 | 4.592 | 8.296 |
| | VAM-M | 7.565 | 7.486 | 3.101 | 4.681 | 5.708 |
| | Mean | 8.136 | 7.604 | 3.111 | 4.073 | |
| Second sowing | Control | 4.689 | 3.893 | 3.098 | 2.583 | 3.566 |
| | VAM-O | 6.708 | 5.223 | 3.744 | 2.808 | 4.621 |
| | VAM-B | 6.227 | 5.139 | 2.393 | 3.572 | 4.333 |
| | VAM-S | 8.899 | 8.903 | 3.098 | 3.281 | 6.045 |
| | VAM-M | 6.833 | 6.754 | 3.076 | 2.859 | 4.881 |
| | Mean | 6.671 | 5.982 | 3.082 | 3.021 | |

**Table (23c):** Effect of 4 VAM isolates and three pathogenic fungi on the total Chlorophyll a+b (mg/g fresh weight) through 2 successive sowings.

| | VAM isolates | Pathogens tested | | | | Mean |
|---|---|---|---|---|---|---|
| | | Control | *C. maydis* | *F. monioliforme.* | *R. solani* | |
| First sowing | Control | 9.239 | 9.095 | 5.668 | 5.597 | 7.400 |
| | VAM-O | 13.462 | 11.909 | 7.561 | 7.346 | 10.070 |
| | VAM-B | 13.054 | 12.052 | 7.343 | 8.144 | 10.148 |
| | VAM-S | 21.866 | 21.636 | 5.709 | 8.686 | 14.474 |
| | VAM-M | 13.914 | 13.781 | 5.924 | 8.369 | 10.497 |
| | Mean | 14.307 | 13.695 | 6.441 | 7.628 | |
| Second sowing | Control | 8.491 | 7.254 | 5.309 | 4.732 | 6.447 |
| | VAM-O | 11.642 | 9.842 | 7.418 | 6.247 | 8.787 |
| | VAM-B | 11.556 | 9.935 | 6.177 | 7.168 | 8.709 |
| | VAM-S | 16.718 | 16.626 | 5.309 | 5.990 | 11.161 |
| | VAM-M | 12.738 | 12.605 | 5.422 | 5.617 | 9.095 |
| | Mean | 12.229 | 11.252 | 5.927 | 5.951 | |

All VAM isolates tested, regardless pathogenic fungi, considerably increased the total chlorophyll content in comparison with the control one. In both sowings, VAM-S recorded the highest increase (14.474 and 11.161) followed by VAM-M (10.497 and 9.095) meanwhile VAM-O in the first sowing (10.07) and VAM-B in the second one (8.709) recorded the lowest increase (compared with control of both sowings (7.4 and 6.447).

The efficacy of VAM isolates tested for increasing total chlorophyll content, however, was greatly varied in the pathogen(s)-infested soils. Using VAM-S in the pathogen-free soil or in the *C. maydis*-infested soil and VAM-O in the *F. monioliforme*-infested soil, in both sowings, resulted in the highest total chlorophyll content compared with their controls. While, VAM-S and VAM-B were the best in soils infested with *R. solani* in the first and second sowings, respectively.

### 4.4. Carotenoids:

Data in **Table (23d)** show that, the carotenoids "carotene" content in leaves of maize plants was affected differently by pathogenic fungi tested compared with the control treatments. In the first and second sowings, *F. monioliforme* and *R. solani* decreased carotene content meanwhile *C. maydis* increased it compared with the controls.

**Table (23d):** Effect of inoculation with 4 VAM isolates and 3 pathogenic fungi on Carotenoids (mg/g) of maize plants through 2 successive sowings.

| | | Pathogens tested | | | | |
|---|---|---|---|---|---|---|
| | VAM isolates | Control | *C. maydis* | *F. monioliforme.* | *R. solani* | Mean |
| First sowing | Control | 0.025 | 0.196 | 0.398 | 0.080 | 0.175 |
| | VAM-O | 2.832 | 3.476 | 0.154 | 0.457 | 1.730 |
| | VAM-B | 2.393 | 2.836 | 0.177 | 1.269 | 1.669 |
| | VAM-S | 0.487 | 0.141 | 0.752 | 1.485 | 0.716 |
| | VAM-M | 2.777 | 2.473 | 0.261 | 1.731 | 1.811 |
| | Mean | 1.703 | 1.824 | 0.349 | 1.004 | |
| Second sowing | Control | 0.313 | 0.037 | 0.103 | 0.365 | 0.204 |
| | VAM-O | 2.821 | 3.645 | 0.005 | 0.520 | 1.748 |
| | VAM-B | 0.492 | 1.323 | 0.596 | 0.928 | 0.835 |
| | VAM-S | 0.805 | 0.479 | 0.441 | 0.564 | 0.572 |
| | VAM-M | 2.281 | 2.164 | 0.052 | 1.534 | 1.508 |
| | Mean | 1.342 | 1.530 | 0.239 | 0.782 | |

On the opposite side, all VAM isolates tested caused appreciable increase in the carotene content in comparison with the control. The highest increase, in both sowings, was associated with VAM-M (1.811 and 1.508) and VAM-O (1.73 and 1.748) while the lowest increase was produced by VAM-S (0.716 and 0.572) compared with the control of both sowings (0.175 and 0.204).

Applying VAM-O in the pathogen-free soil or in soil infested with *C. maydis* produced the highest carotene content compared with the control of both soils. This trend was true in both sowings. While,

using VAM-S produces the highest carotene content in soils infested with *F. monioliforme* and *R. solani*, respectively particularly in the first sowing.

### 4.5. Total leaf pigments:

Data in **Table (23e)** show that, the total photosynthetic pigments (chlorophyll a and b, and carotenoids) in leaves of maize plants was decreased by all tested pathogenic fungi compared with the control treatments. In both sowings, the highest reduction was induced by *F. monioliforme* (6.79 and 6.166) followed by *R. solani* (8.633 and 6.733) whereas *C. maydis* caused the lowest reduction (15.519 and 12.782) compared with their controls (16.01 and 13.571).

**Table (23e):** Effect of different combinations between four isolates of VAM fungi and three pathogenic fungi on total pigments (mg/g) of maize plants through 2 successive sowings.

| | VAM isolates | Pathogens tested | | | | Mean |
|---|---|---|---|---|---|---|
| | | Control | *C. maydis* | *F. monioliforme.* | *R. solani* | |
| First sowing | Control | 9.264 | 9.291 | 6.067 | 5.677 | 7.575 |
| | VAM-O | 16.294 | 15.385 | 7.715 | 7.803 | 11.799 |
| | VAM-B | 15.447 | 14.888 | 7.520 | 9.413 | 11.817 |
| | VAM-S | 22.353 | 21.777 | 6.461 | 10.171 | 15.191 |
| | VAM-M | 16.691 | 16.254 | 6.185 | 10.099 | 12.307 |
| | Mean | 16.010 | 15.519 | 6.790 | 8.633 | |
| Second sowing | Control | 8.804 | 7.291 | 5.412 | 5.097 | 6.651 |
| | VAM-O | 14.463 | 13.487 | 7.423 | 6.767 | 10.535 |
| | VAM-B | 12.048 | 11.258 | 6.772 | 8.096 | 9.544 |
| | VAM-S | 17.523 | 17.105 | 5.750 | 6.554 | 11.733 |
| | VAM-M | 15.019 | 14.769 | 5.474 | 7.151 | 10.603 |
| | Mean | 13.571 | 12.782 | 6.166 | 6.733 | |

All VAM isolates tested, however, considerably increased the leaf pigments in comparison with the control. In this regard, VAM-S produces the highest increase in both sowings (15.191 and 11.733) whereas VAM-O in the first sowing (11.799) and VAM-B in the second

one (9.544) produced the lowest increase compared with the control of both sowings (7.575 and 6.651).

As for interaction, using VAM-S either in the pathogen-free soil or in soil infested with *C. maydis* and VAM-O in soil infested with *F. monioliforme* produced the highest increase in the total leaf-pigments in both sowings. While, VAM-S and VAM-B were the best in soils infested with or *R. solani* in the first and second sowings, respectively.

**5. Effect of VAM isolates and pathogenic fungi tested on acidity "pH value" in soil and rhizosphere of maize plants:**

**5.1. Acidity value "pH" in rhizosphere:**

Data in **Table (24a)** reveal that the pH value in the rhizosphere of maize plants was appreciably increased by both pathogenic fungi and VAM isolates as well as by their interaction. As for pathogens, *F. monioliforme* induced the highest increase in both sowings (7.91 and 8.04) followed by *R. solani* (7.9 and 8.0) and *C. maydis* (7.81 and 8.0) compared with the control (7.68 and 7.73).

Concerning VAM isolates, VAM-O caused the highest increase in pH of rhizosphere in the first sowing (7.93) followed by VAM-S (7.89), VAM-B (7.83) and VAM-M (7.79), respectively comparing with the control (7.69). In the second sowing, VAM-S recorded the highest increase (8.18) followed by VAM-O (8.09), VAM-B (7.86) and VAM-M (7.84), respectively compared with the control (7.73).

The pH value in the rhizosphere region seems to be depending on the pathogen/VAM interaction. Using VAM-S in the pathogen-free soil (in both sowings) and against *C. maydis* or *F. monioliforme* (in the second sowing), VAM-O against *C. maydis* or *F. monioliforme* (in the

first sowing) or *R. solani* (in both sowings) recorded the highest increase in the pH value compared with any other treatment.

**Table (24a):** Effect of four VAM isolates and three pathogenic fungi on pH values in rhizosphere of maize plants through 2 successive sowings.

| | VAM isolates | Pathogens tested | | | | Mean |
|---|---|---|---|---|---|---|
| | | Control | *C. maydis* | *F. monioliforme.* | *R. solani* | |
| First sowing | Control | 7.67 | 7.68 | 7.74 | 7.68 | 7.69 |
| | VAM-O | 7.68 | 8.04 | 8.02 | 7.99 | 7.93 |
| | VAM-B | 7.69 | 7.79 | 7.89 | 7.96 | 7.83 |
| | VAM-S | 7.75 | 7.83 | 8.01 | 7.97 | 7.89 |
| | VAM-M | 7.64 | 7.74 | 7.89 | 7.91 | 7.79 |
| | Mean | 7.68 | 7.81 | 7.91 | 7.90 | |
| Second sowing | Control | 7.58 | 7.88 | 7.88 | 7.58 | 7.73 |
| | VAM-O | 7.93 | 8.08 | 8.18 | 8.18 | 8.09 |
| | VAM-B | 7.58 | 8.08 | 7.98 | 7.83 | 7.86 |
| | VAM-S | 7.98 | 8.18 | 8.18 | 8.38 | 8.18 |
| | VAM-M | 7.58 | 7.78 | 7.98 | 8.04 | 7.84 |
| | Mean | 7.73 | 8.00 | 8.04 | 8.00 | |

**5.2. Acidity value "pH" in soil:**

Data in **Table (24b)** illustrate pH value in soil region as affected by pathogenic fungi and VAM isolates as well as the interaction between them. Unlike rhizospher pH, all pathogenic fungi caused considerable decreases in the soil pH. In this respect, *R. solani* caused the highest decrease in both sowings (8.26 and 8.3) followed by *F. monioliforme* (8.33 and 8.3) and *C. maydis* (8.47 and 8.45) compared with the control (8.49 and 8.45) of both sowings.

On the contrary, all VAM isolates increased soil pH i.e. 8.40-8.52 in the first sowing and 8.30-8.46 in the second sowing compared with the control (8.17-8.20) of both sowings, respectively. The highest pH limit was recorded by VAM-M in both sowings.

However, the soil pH was depending on pathogen/VAM interaction. In the first sowing, using VAM-M either in the pathogen-

free soil or soils infested with *C. maydis* or *F. monioliforme* and VAM-O in soils infested with *R. solani* recorded the highest soil pH values compared with the other interactions. In the second sowing, the same results were obtained by using VAM-M in the pathogen-free soil or soil infested with *F. monioliforme* and VAM-B and VAM-O in soils infested with *C. maydis* and *R. solani*, respectively.

**Table (24b):** Effect of four VAM isolates and three pathogenic fungi on pH values in soil of maize plants through 2 successive sowings.

| | VAM isolates | Pathogens tested | | | | Mean |
|---|---|---|---|---|---|---|
| | | Control | *C. maydis* | *F. monioliforme.* | *R. solani* | |
| First sowing | Control | 7.86 | 8.35 | 8.45 | 8.02 | 8.17 |
| | VAM-O | 8.54 | 8.55 | 7.99 | 8.52 | 8.40 |
| | VAM-B | 8.62 | 8.51 | 8.37 | 8.22 | 8.43 |
| | VAM-S | 8.65 | 8.30 | 8.32 | 8.32 | 8.40 |
| | VAM-M | 8.74 | 8.60 | 8.49 | 8.22 | 8.52 |
| | Mean | 8.49 | 8.47 | 8.33 | 8.26 | |
| Second sowing | Control | 7.82 | 8.46 | 8.50 | 8.02 | 8.20 |
| | VAM-O | 8.42 | 8.37 | 8.17 | 8.52 | 8.37 |
| | VAM-B | 8.67 | 8.57 | 8.20 | 8.32 | 8.44 |
| | VAM-S | 8.59 | 8.28 | 8.09 | 8.22 | 8.30 |
| | VAM-M | 8.72 | 8.20 | 8.50 | 8.42 | 8.46 |
| | Mean | 8.45 | 8.38 | 8.30 | 8.30 | |

**Field results:**

**1. Effect of the in vitro produced VAM isolates on some pathological parameters:**

**1.1. Seed germination:**

Data in **Table (25a)** reveal that applying different levels of VAM inoculum alone was significantly better for increasing seed germination (73.25-78.33%) than the untreated control (60.0%) or application of P (62.33%) or N (63.33%) fertilizers each alone in 2002 season. Similar trend with slight differences was reported in 2003 season.

Seed germination % was significantly increased by VAM inoculum + N application (81.17-82.92%) in season 2002 compared with VAM inoculum alone. The N fertilizer + inoculum (20 Kg/fed.) of VAM-O, VAM-B and VAM-M isolates recorded the highest increase in seed germination i.e. 85.33, 84.33 and 79.0%, respectively.

**Table (25a):** Effect of different tested treatments on percentages of *Zea mays* seed germination.

| | Treatments | VAM isolates | | | | Mean |
|---|---|---|---|---|---|---|
| | | VAM-O | VAM-B | VAM-S | VAM-M | |
| 2002 season | Control | 60.00 | 60.00 | 60.00 | 60.00 | 60.00 |
| | P fertilization | 62.33 | 62.33 | 62.33 | 62.33 | 62.33 |
| | N fertilization | 63.33 | 63.33 | 63.33 | 63.33 | 63.33 |
| | VAM [low level]* | 80.67 | 67.00 | 79.33 | 66.00 | 73.25 |
| | VAM [middle level] | 80.67 | 73.00 | 79.33 | 67.33 | 75.08 |
| | VAM [high level] | 81.67 | 81.33 | 79.33 | 71.00 | 78.33 |
| | N+VAM [low level] | 83.67 | 82.33 | 85.00 | 73.67 | 81.17 |
| | N+VAM [middle level] | 83.33 | 83.00 | 84.00 | 75.33 | 81.42 |
| | N+VAM [high level] | 85.33 | 84.33 | 83.00 | 79.00 | 82.92 |
| | Mean | 75.67 | 72.96 | 75.07 | 68.67 | |
| 2003 season | Control | 64.00 | 64.00 | 64.00 | 64.00 | 64.00 |
| | P fertilization | 68.67 | 68.67 | 68.67 | 68.67 | 68.67 |
| | N fertilization | 73.50 | 73.50 | 73.50 | 73.50 | 73.50 |
| | VAM [low level] | 75.83 | 64.00 | 64.67 | 60.83 | 66.33 |
| | VAM [middle level] | 79.17 | 66.33 | 68.67 | 63.67 | 69.46 |
| | VAM [high level] | 77.33 | 70.00 | 68.67 | 64.17 | 70.04 |
| | N+VAM [low level] | 81.33 | 76.67 | 74.50 | 65.33 | 74.46 |
| | N+VAM [middle level] | 81.33 | 77.67 | 73.33 | 69.17 | 75.38 |
| | N+VAM [high level] | 82.17 | 76.67 | 70.17 | 63.17 | 73.04 |
| | Mean | 75.93 | 70.83 | 69.57 | 65.83 | |
| | L.S.D. at 5% | Season 2002 | | Season 2003 | | |
| | VAM isolates | 0.277 | | 0.300 | | |
| | Treatments | 0.692 | | 0.751 | | |
| | Interaction | 2.768 | | 3.002 | | |

* VAM [low level] = 10kg/fed; VAM [middle level] = 15kg/fed; VAM [high level] = 20kg/fed, respectively.

Applying inoculum of these VAM isolates each alone recorded 81.67, 81.33 and 71.0%, respectively. On the contrary, the lowest inoculum level (10 Kg/fed.) of VAM-S isolate combined with N

application recorded the highest seed germination (85.0%) compared with the same inoculum level alone (79.33%). In 2003 season, applying inoculum of VAM-O (at 15 and 20 Kg/fed.) alone or combined with N fertilizer and VAM-B (at 10, 15 and 20 Kg/fed.) combined with N application only resulted in significant increase in seed germination compared with application of P and N fertilizers each alone. Regardless treatments, VAM-O isolate was superior for improving seed germination while, VAM-M isolate was the inferior one during both seasons.

**1.2. Percentage of dead-wilted maize plants:**

Data in **Table (25b)** reveal that the VAM-B was the most effective for suppressing percentage of dead-wilted maize plants **(Fig., 21)** in 2003 season (7.5%) followed by VAM-S, VAM-O, and VAM-M which recorded 7.85, 9.17 and 11.37%, respectively. However, no significant variation was detected between these isolates in 2002 season. Applying N and P fertilizers in season 2002 significantly decreased dead-wilted maize plants to 10.66 and 9.6% compared with 11.96% in the untreated control. In 2003 season, applying N alone significantly decreased dead-wilted maize plants (4.68%) whereas P application had no significant effect (16.4%) compared with the untreated control (16.27%). Compared with P fertilizer, applying VAM inoculum alone at the high level (20 kg/fed) was the only treatment that significantly decreased dead-wilted maize plants to (7.97%) in 2002 season. While, all levels of VAM inoculum in 2003 season were significantly effective in this regard compared with P application. The dead-wilted maize plants were decreased to 14.96, 10.41 and 6.96 by

using VAM inoculum at low, middle and high (10, 15 and 20 kg/fed.), respectively.

**Table (25b)**: Effect of different tested treatments on percentages of wilt disease incidence on *Zea mays* plants.

| | Treatments | VAM isolates | | | | Mean |
|---|---|---|---|---|---|---|
| | | VAM-O | VAM-B | VAM-S | VAM-M | |
| 2002 season | Control | 11.96 | 11.96 | 11.96 | 11.96 | 11.96 |
| | P fertilization | 9.60 | 9.60 | 9.60 | 9.60 | 9.60 |
| | N fertilization | 10.66 | 10.66 | 10.66 | 10.66 | 10.66 |
| | VAM [low level]* | 16.96 | 11.79 | 11.88 | 14.53 | 13.79 |
| | VAM [middle level] | 5.54 | 9.69 | 10.37 | 14.45 | 10.01 |
| | VAM [high level] | 6.14 | 9.19 | 7.90 | 8.65 | 7.97 |
| | N+VAM [low level] | 4.44 | 7.33 | 6.81 | 4.97 | 5.89 |
| | N+VAM [middle level] | 6.00 | 4.60 | 5.87 | 5.28 | 5.44 |
| | N+VAM [high level] | 1.65 | 3.60 | 3.73 | 11.09 | 5.02 |
| | Mean | 8.11 | 8.71 | 8.75 | 10.13 | |
| 2003 season | Control | 16.27 | 16.27 | 16.27 | 16.27 | 16.27 |
| | P fertilization | 16.40 | 16.40 | 16.40 | 16.40 | 16.40 |
| | N fertilization | 4.68 | 4.68 | 4.68 | 4.68 | 4.68 |
| | VAM [low level] | 17.54 | 14.47 | 14.47 | 13.38 | 14.96 |
| | VAM [middle level] | 9.14 | 10.08 | 10.07 | 12.36 | 10.41 |
| | VAM [high level] | 10.80 | 2.57 | 2.74 | 11.72 | 6.96 |
| | N+VAM [low level] | 2.63 | 1.46 | 1.79 | 9.63 | 3.88 |
| | N+VAM [middle level] | 2.70 | 0.74 | 2.29 | 8.49 | 3.55 |
| | N+VAM [high level] | 2.34 | 0.86 | 1.93 | 9.38 | 3.63 |
| | Mean | 9.17 | 7.50 | 7.85 | 11.37 | |
| | L.S.D. at 5% | Season 2002 | | Season 2003 | | |
| | VAM isolates | NS. | | 0.254 | | |
| | Treatments | 0.643 | | 0.635 | | |
| | Interaction | NS. | | 2.540 | | |

* VAM [low level] = 10kg/fed; VAM [middle level] = 15kg/fed; VAM [high level] = 20kg/fed, respectively.

In 2003 season, the N fertilizer combined with the middle or high levels of VAM-B inoculum was the most effective for suppressing dead-wilted plants (0.75 – 0.86%) compared with application of P or N fertilizers each alone. On the contrary, applying N fertilizer combined with VAM-M inoculum significantly increased dead-wilted plants compared with N alone. In 2002 season, however, no significant interaction was detected between effects of treatments and VAM isolates.

**Fig. (21):** Different forms of dead-wilted maize plants.

**1.3. Percentage of common smutted maize plants:**

Concerning with common smut disease **(Fig., 22)**, the data in **Table (25c)** show significant differences between tested VAM isolates in 2002 season only. In this regard, VAM-M was the most effective for suppressing disease incidence (1.09%) followed by VAM-O and VAM-S (1.88%) and VAM-B (1.98%), respectively. However, no significant variation was detected between these isolates in 2003 season. Applying P fertilizer in 2002 season and N fertilizer in both 2002 and 2003 seasons significantly increased incidence of common smut compared

with the untreated control. Application of N fertilizer alone caused the highest disease incidence in both seasons.

**Table (25c)**: Effect of different tested treatments on percentages of common smut disease incidence on *Zea mays* plants.

| | Treatments | VAM isolates | | | | Mean |
|---|---|---|---|---|---|---|
| | | VAM-O | VAM-B | VAM-S | VAM-M | |
| 2002 season | Control | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 |
| | P fertilization | 1.78 | 1.78 | 1.78 | 1.78 | 1.78 |
| | N fertilization | 3.11 | 3.11 | 3.11 | 3.11 | 3.11 |
| | VAM [low level]* | 1.33 | 1.78 | 1.78 | 0.44 | 1.33 |
| | VAM [middle level] | 1.78 | 1.78 | 1.78 | 0.44 | 1.44 |
| | VAM [high level] | 1.33 | 1.78 | 1.78 | 0.44 | 1.33 |
| | N+VAM [low level] | 2.22 | 2.22 | 1.78 | 0.89 | 1.78 |
| | N+VAM [middle level] | 2.22 | 2.22 | 2.22 | 0.89 | 1.89 |
| | N+VAM [high level] | 2.22 | 2.22 | 1.78 | 0.89 | 1.78 |
| | Mean | 1.88 | 1.98 | 1.88 | 1.09 | |
| 2003 season | Control | 1.43 | 1.43 | 1.43 | 1.43 | 1.43 |
| | P fertilization | 1.43 | 1.43 | 1.43 | 1.43 | 1.43 |
| | N fertilization | 4.29 | 4.29 | 4.29 | 4.29 | 4.29 |
| | VAM [low level] | 1.43 | 1.91 | 1.91 | 1.91 | 1.79 |
| | VAM [middle level] | 2.38 | 1.91 | 1.91 | 1.91 | 2.03 |
| | VAM [high level] | 1.43 | 1.91 | 1.91 | 1.91 | 1.79 |
| | N+VAM [low level] | 3.34 | 1.91 | 2.38 | 2.86 | 2.62 |
| | N+VAM [middle level] | 2.86 | 2.38 | 1.91 | 2.86 | 2.50 |
| | N+VAM [high level] | 1.91 | 1.91 | 1.91 | 2.38 | 2.03 |
| | Mean | 2.28 | 2.12 | 2.12 | 2.33 | |
| | L.S.D. at 5% | Season 2002 | | Season 2003 | | |
| | VAM isolates | 0.070 | | NS | | |
| | Treatments | 0.176 | | 0.196 | | |
| | Interaction | NS | | NS | | |

* VAM [low level] = 10kg/fed; VAM [middle level] = 15kg/fed; VAM [high level] = 20kg/fed, respectively.

On the other hand, applying different levels of VAM inoculum alone was more effective in controlling the common smut disease than application of P fertilizer in 2002 season and N fertilizer alone or combined with VAM inoculum in both seasons. While, the opposite trend was noticed in 2003 season compare with application of P fertilizer. No significant differences were found between levels of VAM inoculum when used either alone or

combined with N fertilizer. No significant interaction in both seasons was detected between effects of treatments and VAM isolates.

**Fig. (22):** Different symptoms of common smutted maize plants.

**1.4. Percentage of stunted maize plants:**

Percentage of stunted maize plants **(Fig., 23)** in both 2002 and 2003 seasons was significantly affected by tested treatments **(Table, 25d)**. Application of P fertilizer in both seasons and N fertilizer in 2003 season had no significant effect in this respect compared with the untreated control.

**Table (25d)**: Effect of different tested treatments on percentages of stunt disease incidence on *Zea mays* plants.

| | Treatments | VAM isolates | | | | Mean |
|---|---|---|---|---|---|---|
| | | VAM-O | VAM-B | VAM-S | VAM-M | |
| 2002 season | Control | 4.89 | 4.89 | 4.89 | 4.89 | 4.89 |
| | P fertilization | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 |
| | N fertilization | 0.44 | 0.44 | 0.44 | 0.44 | 0.44 |
| | VAM [low level]* | 2.22 | 0.89 | 1.33 | 2.22 | 1.67 |
| | VAM [middle level] | 1.33 | 0.89 | 0.00 | 1.78 | 1.00 |
| | VAM [high level] | 1.33 | 0.89 | 0.00 | 2.67 | 1.22 |
| | N+VAM [low level] | 0.44 | 0.00 | 0.00 | 0.00 | 0.11 |
| | N+VAM [middle level] | 0.89 | 0.00 | 0.00 | 0.00 | 0.22 |
| | N+VAM [high level] | 0.89 | 0.00 | 0.00 | 0.00 | 0.22 |
| | Mean | 1.83 | 1.33 | 1.18 | 1.78 | |
| 2003 season | Control | 1.33 | 1.33 | 1.33 | 1.33 | 1.33 |
| | P fertilization | 1.33 | 1.33 | 1.33 | 1.33 | 1.33 |
| | N fertilization | 1.33 | 1.33 | 1.33 | 1.33 | 1.33 |
| | VAM [low level] | 1.33 | 1.00 | 1.00 | 1.00 | 1.08 |
| | VAM [middle level] | 1.33 | 1.00 | 1.00 | 1.00 | 1.08 |
| | VAM [high level] | 0.67 | 0.67 | 1.00 | 0.67 | 0.75 |
| | N+VAM [low level] | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 |
| | N+VAM [middle level] | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 |
| | N+VAM [high level] | 0.33 | 0.67 | 0.67 | 0.33 | 0.50 |
| | Mean | 1.00 | 0.96 | 1.00 | 0.93 | |
| | L.S.D. at 5% | Season 2002 | | Season 2003 | | |
| | VAM isolates | NS. | | NS. | | |
| | Treatments | 0.309 | | 0.145 | | |
| | Interaction | NS. | | NS. | | |

* VAM [low level] = 10kg/fed; VAM [middle level] = 15kg/fed; VAM [high level] = 20kg/fed, respectively.

Compared with P fertilizer application (4.0% in 2002 season and 1.33% in 2003 season), the disease incidence was significantly decreased to 1.67, 1.0, 1.22% in 2002 season and 1.08, 1.08 and 0.75% by using VAM inoculum at levels of 10, 15 and 20 Kg/fed., respectively. However, applying N fertilizer combined with VAM inoculum (10 Kg/fed.) was the most effective for decreasing stunt disease incidence (0.11%) in 2002 season compared with application of N fertilizer alone (0.44%). While, the disease was decreased to 0.67,

0.67 and 0.5% in 2003 season by using N combined with VAM inoculum at levels of 10, 15 and 20 Kg/fed., respectively compared with N fertilizer alone (1.33%). Percentage of stunt disease incidence was not affected significantly by the interaction between treatments and VAM isolates in both seasons.

**Fig. (23):** Different symptoms of stunted maize plants.

## 2. Effect of the in vitro produced VAM isolates on some plant growth parameters:

### 2.1. Plant height:

Data in **Table (26a)** reveal that, all tested treatments significantly increased plant height compared with the untreated control. Concerning with chemical fertilization, applying N fertilizer was significantly better in this respect compared with P fertilizer. Using the VAM inoculum alone significantly increased plant height more P fertilizer application. This trend was true in both 2002 and 2003 seasons.

**Table (26a)**: Effect of different tested treatments on the plant height (cm) of *Zea mays* plant.

| | Treatments | VAM isolates | | | | Mean |
|---|---|---|---|---|---|---|
| | | VAM-O | VAM-B | VAM-S | VAM-M | |
| 2002 season | Control | 219.3 | 219.3 | 219.3 | 219.3 | 219.3 |
| | P fertilization | 230.0 | 230.0 | 230.0 | 230.0 | 230.0 |
| | N fertilization | 279.7 | 279.7 | 279.7 | 279.7 | 279.7 |
| | VAM [low level]* | 261.7 | 257.7 | 250.0 | 250.7 | 255.0 |
| | VAM [middle level] | 267.3 | 265.0 | 259.3 | 266.1 | 264.4 |
| | VAM [high level] | 264.7 | 272.0 | 258.7 | 269.3 | 266.2 |
| | N+VAM [low level] | 283.3 | 296.7 | 283.3 | 297.7 | 290.3 |
| | N+VAM [middle level] | 288.0 | 300.0 | 279.7 | 302.7 | 292.6 |
| | N+VAM [high level] | 300.3 | 299.3 | 276.3 | 283.3 | 289.8 |
| | Mean | 266.0 | 268.9 | 259.6 | 266.5 | |
| 2003 season | Control | 236.7 | 236.7 | 236.7 | 236.7 | 236.7 |
| | P fertilization | 240.0 | 240.0 | 240.0 | 240.0 | 240.0 |
| | N fertilization | 281.7 | 281.7 | 281.7 | 281.7 | 281.7 |
| | VAM [low level] | 238.9 | 256.1 | 261.8 | 256.7 | 253.4 |
| | VAM [middle level] | 257.2 | 259.4 | 265.0 | 262.6 | 261.1 |
| | VAM [high level] | 253.3 | 262.8 | 269.5 | 266.7 | 263.1 |
| | N+VAM [low level] | 267.4 | 265.6 | 278.3 | 280.0 | 272.8 |
| | N+VAM [middle level] | 269.4 | 277.0 | 273.5 | 280.3 | 275.1 |
| | N+VAM [high level] | 274.5 | 275.0 | 273.4 | 279.5 | 275.6 |
| | Mean | 257.7 | 261.6 | 264.4 | 264.9 | |
| | L.S.D. at 5% | Season 2002 | | Season 2003 | | |
| | VAM isolates | 0.589 | | 0.724 | | |
| | Treatments | 1.473 | | 1.810 | | |
| | Interaction | 5.894 | | NS. | | |

* VAM [low level] = 10kg/fed; VAM [middle level] = 15kg/fed; VAM [high level] = 20kg/fed, respectively.

The plant height was proportionally increased as VAM inoculum level increased. In 2002 season only, the plant height responded similarly by applying the N fertilizer in combination with VAM inoculum compared with application of N fertilizer alone. In this respect, using N combined with VAM inoculum at low, middle and high levels increased plant height to 290.3, 292.6 and 289.8cm compared with N fertilizer alone (279.7) in 2002 season. However, the same combinations induced significant decreases in plant height in 2003 season compared with N fertilizer alone.

**2.2. Fresh weight of leaves/plant:**

Data in **Table (26b)** reveal that, the fresh weight of leaves/plant (FWL/plant) during both 2002 and 2003 seasons was significantly affected by the tested treatments. Applying P fertilizer in 2003 season only and N fertilizer in both 2002 and 2003 seasons showed positive significant effect on the FWL/plant compared with the unfertilized control. Using any of the VAM inoculum levels in 2002 but not in 2003 season significantly increased the FWL/plant compared with P fertilizer application.

However, applying N fertilizer combined with any VAM inoculum level (in both seasons) excreted significant increase in the FWL/plant compared with application of N fertilizer alone. Using N combined with VAM inoculum at low, middle and high levels increased FWL/plant to 106.25, 108.19 and 108.06g in 2002 season and 54.03, 52.33 and 53.97g in 2003 season compared with 100.0 and 51.11g in both seasons, respectively when N fertilizer was used alone. Regardless treatment effect, the highest significant increase in FWL/plant in 2003 season was associated with applying VAM-B

(49.96g) and VAM-O (49.89g) without significant differences in between followed by VAM-S (48.12g) and VAM-M (46.33g), respectively. In 2002 season, no significant variation was detected between the 4 isolates. The FWL/plant was not affected significantly by the interaction between treatments and VAM isolates in both seasons.

**Table (26b)**: Effect of different tested treatments on the fresh weight of leaves (g)/plant of *Zea mays* plant.

| | Treatments | VAM isolates | | | | Mean |
|---|---|---|---|---|---|---|
| | | VAM-O | VAM-B | VAM-S | VAM-M | |
| 2002 season | Control | 62.78 | 62.78 | 62.78 | 62.78 | 62.78 |
| | P fertilization | 63.33 | 63.33 | 63.33 | 63.33 | 63.33 |
| | N fertilization | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| | VAM [low level]* | 65.56 | 75.56 | 64.45 | 62.78 | 67.08 |
| | VAM [middle level] | 78.89 | 77.78 | 75.00 | 65.00 | 74.17 |
| | VAM [high level] | 75.00 | 82.22 | 66.11 | 68.89 | 73.06 |
| | N+VAM [low level] | 103.33 | 102.78 | 110.00 | 108.89 | 106.25 |
| | N+VAM [middle level] | 113.33 | 103.34 | 105.55 | 110.55 | 108.19 |
| | N+VAM [high level] | 122.22 | 101.67 | 100.00 | 108.33 | 108.06 |
| | Mean | 87.16 | 85.49 | 83.02 | 83.39 | |
| 2003 season | Control | 43.33 | 43.33 | 43.33 | 43.33 | 43.33 |
| | P fertilization | 46.11 | 46.11 | 46.11 | 46.11 | 46.11 |
| | N fertilization | 51.11 | 51.11 | 51.11 | 51.11 | 51.11 |
| | VAM [low level] | 46.11 | 45.22 | 41.78 | 41.89 | 43.75 |
| | VAM [middle level] | 48.33 | 46.11 | 44.56 | 43.33 | 45.58 |
| | VAM [high level] | 46.67 | 47.89 | 47.78 | 45.56 | 46.97 |
| | N+VAM [low level] | 54.44 | 55.78 | 55.67 | 50.22 | 54.03 |
| | N+VAM [middle level] | 56.22 | 57.33 | 52.22 | 43.56 | 52.33 |
| | N+VAM [high level] | 56.67 | 56.78 | 50.56 | 51.89 | 53.97 |
| | Mean | 49.89 | 49.96 | 48.12 | 46.33 | |
| | L.S.D. at 5% | Season 2002 | | Season 2003 | | |
| | VAM isolates | NS. | | 0.455* | | |
| | Treatments | 1.761 | | 1.138 | | |
| | Interaction | NS. | | NS. | | |

* VAM [low level] = 10kg/fed; VAM [middle level] = 15kg/fed; VAM [high level] = 20kg/fed, respectively.

### 2.3. Fresh weight of stem/plant:

Data in **Table (26c)** reveal that applying P fertilizer (in 2002 season only) and N fertilizer (in both 2002 and 2003 seasons) significantly increased the fresh weight of stem/plant (FWS/plant)

compared with the unfertilized control. Using the VAM inoculum at the low, middle and high levels, however, increased the FWS/plant to 144.1, 166.0 and 167.3g in 2002 season and to 135.7, 143.8 and 147.2g in 2003 season compared with P fertilizer application which produced 134.8 and 116.7g for FWS/plant in both seasons, respectively.

**Table (26c)**: Effect of different tested treatments on the fresh weight of stem (g)/plant of *Zea mays* plant.

| | Treatments | VAM isolates | | | | Mean |
|---|---|---|---|---|---|---|
| | | VAM-O | VAM-B | VAM-S | VAM-M | |
| 2002 season | Control | 134.8 | 134.8 | 134.8 | 134.8 | 134.8 |
| | P fertilization | 141.3 | 141.3 | 141.3 | 141.3 | 141.3 |
| | N fertilization | 205.6 | 205.6 | 205.6 | 205.6 | 205.6 |
| | VAM [low level]* | 150.9 | 154.7 | 153.1 | 117.8 | 144.1 |
| | VAM [middle level] | 194.6 | 166.7 | 155.6 | 147.1 | 166.0 |
| | VAM [high level] | 191.7 | 168.3 | 155.3 | 153.9 | 167.3 |
| | N+VAM [low level] | 219.8 | 215.6 | 229.1 | 218.9 | 220.8 |
| | N+VAM [middle level] | 230.6 | 218.9 | 219.5 | 222.2 | 222.8 |
| | N+VAM [high level] | 233.6 | 217.1 | 218.2 | 217.8 | 221.7 |
| | Mean | 189.2 | 180.3 | 179.2 | 173.3 | |
| 2003 season | Control | 116.7 | 116.7 | 116.7 | 116.7 | 116.7 |
| | P fertilization | 117.8 | 117.8 | 117.8 | 117.8 | 117.8 |
| | N fertilization | 173.3 | 173.3 | 173.3 | 173.3 | 173.3 |
| | VAM [low level] | 137.8 | 136.7 | 135.0 | 133.3 | 135.7 |
| | VAM [middle level] | 154.5 | 142.8 | 140.0 | 137.8 | 143.8 |
| | VAM [high level] | 151.1 | 150.0 | 145.6 | 142.2 | 147.2 |
| | N+VAM [low level] | 192.8 | 183.3 | 200.0 | 191.3 | 191.9 |
| | N+VAM [middle level] | 194.4 | 192.2 | 194.4 | 189.2 | 192.6 |
| | N+VAM [high level] | 204.4 | 188.9 | 192.2 | 190.2 | 193.9 |
| | Mean | 160.3 | 155.7 | 157.2 | 154.7 | |
| | L.S.D. at 5% | Season 2002 | | Season 2003 | | |
| | VAM isolates | 0.832 | | 0.676 | | |
| | Treatments | 2.080 | | 1.690 | | |
| | Interaction | 8.321 | | NS. | | |

* VAM [low level] = 10kg/fed; VAM [middle level] = 15kg/fed; VAM [high level] = 20kg/fed, respectively.

Combination between N fertilizer and VAM inoculum at the low, middle and high levels, respectively significantly increased FWS/plant to 220.8, 222.8 and 221.7g in 2002 season and 191.9, 192.6 and

193.9g in 2003 season compared with applying N fertilizer alone during seasons 2002 (205.6g) and 2003 (173.3g).

Concerning VAM isolates, VAM-O was the most effective as it recorded the highest significant increase in FWS/plant in both 2002 season (189.2g) and 2003 season (160.3g) while, VAM-M was the least effective since recording 173.3 and 154.7g in both seasons, respectively. The FWS/plant was affected significantly by the interaction between treatments and VAM isolates in 2002 season only. In the latter season, the highest significant increase in the FWS/plant was produced by N fertilizer combined with VAM-O at the high level (233.6g) and VAM-S at the low level (229.1g), respectively.

**2.4. Total fresh weight/plant:**

Data in **Tables (26d)** illustrate that the VAM-O recorded the highest significant increases in the total fresh weight (TFW/plant) of the aboveground parts (276.3g) in 2002 season compared with VAM-M which was the least effective in this respect (256.7g). However, no significant variations were detected between the 4 tested VAM isolates in 2003 season. The TFW/plant was significantly increased during both 2002 and 2003 seasons by fertilization with P fertilizer (204.7 and 163.9g) and N fertilizer (305.6 and 224.5g) compared with the untreated control (197.6 and 160.0g). Thus, application of N fertilizer was significantly better in this respect than P fertilizer.

**Table (26d)**: Effect of different tested treatments on the total fresh weight of the aboveground parts of *Zea mays* plant (g).

| | Treatments | VAM isolates | | | | Mean |
|---|---|---|---|---|---|---|
| | | VAM-O | VAM-B | VAM-S | VAM-M | |
| 2002 season | Control | 197.6 | 197.6 | 197.6 | 197.6 | 197.6 |
| | P fertilization | 204.7 | 204.7 | 204.7 | 204.7 | 204.7 |
| | N fertilization | 305.6 | 305.6 | 305.6 | 305.6 | 305.6 |
| | VAM [low level]* | 216.5 | 230.2 | 217.6 | 180.6 | 211.2 |
| | VAM [middle level] | 273.4 | 244.5 | 230.6 | 212.1 | 240.1 |
| | VAM [high level] | 266.7 | 250.6 | 221.4 | 222.8 | 240.4 |
| | N+VAM [low level] | 323.1 | 318.3 | 339.1 | 327.8 | 327.1 |
| | N+VAM [middle level] | 343.9 | 322.2 | 325.0 | 332.8 | 331.0 |
| | N+VAM [high level] | 355.8 | 318.8 | 318.2 | 326.1 | 329.7 |
| | Mean | 276.3 | 265.8 | 262.2 | 256.7 | |
| 2003 season | Control | 160.0 | 160.0 | 160.0 | 160.0 | 160.0 |
| | P fertilization | 163.9 | 163.9 | 163.9 | 163.9 | 163.9 |
| | N fertilization | 224.5 | 224.5 | 224.5 | 224.5 | 224.5 |
| | VAM [low level] | 183.9 | 181.9 | 176.8 | 175.2 | 179.4 |
| | VAM [middle level] | 202.8 | 188.9 | 184.6 | 181.1 | 189.3 |
| | VAM [high level] | 197.8 | 197.9 | 193.3 | 187.8 | 194.2 |
| | N+VAM [low level] | 247.2 | 239.1 | 255.7 | 241.6 | 245.9 |
| | N+VAM [middle level] | 250.7 | 249.6 | 246.7 | 239.4 | 246.6 |
| | N+VAM [high level] | 261.1 | 245.7 | 242.8 | 242.1 | 247.9 |
| | Mean | 210.2 | 205.7 | 205.4 | 201.7 | |
| | L.S.D. at 5% | Season 2002 | | Season 2003 | | |
| | VAM isolates | 1.360 | | NS. | | |
| | Treatments | 3.399 | | 2.586 | | |
| | Interaction | 13.596 | | NS. | | |

* VAM [low level] = 10kg/fed; VAM [middle level] = 15kg/fed; VAM [high level] = 20kg/fed, respectively.

Moreover, applying VAM inoculum either alone or combined with N application produced additional significant increases in the TFW/plant when compared with application of P and N fertilizers each alone, respectively. In this respect, the efficacy of applying VAM inoculum alone was significantly increased as its used level increased particularly in 2003 season. Compared with the P fertilizer, the TFW/plant was significantly increased to 211.2, 240.1 and 240.4g in 2002 season and to 179.4, 189.3 and 194.2g in 2003 season when VAM

inoculum was used at the low, middle and high levels, respectively. Compared with the N fertilizer, the TFW/plant was significantly increased to 327.1, 331.0 and 329.7g in 2002 season and to 245.9, 246.6 and 247.9g in 2003 season when N fertilizer was combined with VAM inoculum was used at the low, middle and high levels, respectively.

The TFW/plant was significantly affected by the interaction between treatments and VAM isolates in 2002 season only. The highest values, however, were associated with N + VAM-O at the high and middle levels (261.1and 250.7g), N + VAM-S at the low level (255.7g) and N + VAM-B at the middle level (249.6g) without significant differences between these 4 interactions.

**2.5. Dry weight of leaves/plant:**

Data in **Table (26e)** reveal that, the tested VAM isolates in 2003 season and treatments in both 2002 and 2003 seasons significantly affected the dry weight of leaves/plant (DWL/plant). Concerning isolates, the highest significant values of DWL/plant were produced by VAM-B (15.7g) and VAM-O (15.6g) followed by VAM-S (15.1g) and VAM-M (14.7g), respectively.

As for treatments, applying P and N fertilizers in both 2002 and 2003 seasons showed positive significant effect on the DWL/plant compared with the unfertilized control. However, VAM inoculation in 2002 season only significantly increased the DWL/plant compared with P fertilizer application. The DWL/plant increased proportionally as VAM inoculation level increased. Also, applying N fertilizer combined with VAM inoculation in 2002 season excreted significant increase in the DWL/plant compared with N fertilizer alone. This promising effect was increased significantly with increasing VAM level. Inoculation

with VAM particularly at the low level either alone (compared with P fertilizer) or combined with N fertilization (compared with N fertilizer) had no effect or might significantly decreased DWL/plant in 2003 season.

**Table (26e)**: Effect of different tested treatments on dry weight of leaves (g)/plant of *Zea mays* plant.

| | Treatments | VAM isolates | | | | Mean |
|---|---|---|---|---|---|---|
| | | VAM-O | VAM-B | VAM-S | VAM-M | |
| 2002 season | Control | 22.3 | 22.3 | 22.3 | 22.3 | 22.3 |
| | P fertilization | 23.6 | 23.6 | 23.6 | 23.6 | 23.6 |
| | N fertilization | 39.4 | 39.4 | 39.4 | 39.4 | 39.4 |
| | VAM [low level]* | 26.4 | 27.8 | 25.0 | 24.6 | 26.0 |
| | VAM [middle level] | 31.9 | 30.3 | 30.6 | 27.7 | 30.1 |
| | VAM [high level] | 30.2 | 32.3 | 27.6 | 29.1 | 29.8 |
| | N+VAM [low level] | 40.6 | 38.8 | 42.2 | 45.7 | 41.8 |
| | N+VAM [middle level] | 44.2 | 39.8 | 40.6 | 49.1 | 43.4 |
| | N+VAM [high level] | 47.8 | 38.3 | 40.1 | 43.5 | 42.4 |
| | Mean | 34.1 | 32.5 | 32.4 | 33.9 | |
| 2003 season | Control | 12.9 | 12.9 | 12.9 | 12.9 | 12.9 |
| | P fertilization | 14.6 | 14.6 | 14.6 | 14.6 | 14.6 |
| | N fertilization | 18.0 | 18.0 | 18.0 | 18.0 | 18.0 |
| | VAM [low level] | 13.6 | 13.4 | 11.8 | 12.0 | 12.7 |
| | VAM [middle level] | 14.2 | 14.0 | 13.7 | 12.3 | 13.5 |
| | VAM [high level] | 13.7 | 14.6 | 14.7 | 13.6 | 14.1 |
| | N+VAM [low level] | 16.2 | 16.4 | 17.1 | 15.8 | 16.4 |
| | N+VAM [middle level] | 17.7 | 19.3 | 16.7 | 16.7 | 17.6 |
| | N+VAM [high level] | 19.2 | 18.4 | 16.6 | 17.0 | 17.8 |
| | Mean | 15.6 | 15.7 | 15.1 | 14.7 | |
| | L.S.D. at 5% | Season 2002 | | Season 2003 | | |
| | VAM isolates | NS. | | 0.130 | | |
| | Treatments | 0.913 | | 0.326 | | |
| | Interaction | NS. | | NS. | | |

* VAM [low level] = 10kg/fed; VAM [middle level] = 15kg/fed; VAM [high level] = 20kg/fed, respectively.

### 2.6. Dry weight of stem/plant:

Data in **Table (26f)** reveal that, the tested VAM isolates in 2003 season and treatments in both 2002 and 2003 seasons significantly affected the dry weight of stem/plant (DWS/plant). Concerning isolates,

the highest significant values of DWL/plant were produced by VAM-O (45.0g) followed by VAM-S (44.2g), and VAM-B (43.0g) and VAM-M (41.4g), respectively.

**Table (26f)**: Effect of different tested treatments on dry weight of stem (g)/plant of *Zea mays* plant.

| | Treatments | VAM isolates | | | | Mean |
|---|---|---|---|---|---|---|
| | | VAM-O | VAM-B | VAM-S | VAM-M | |
| 2002 season | Control | 41.9 | 41.9 | 41.9 | 41.9 | 41.9 |
| | P fertilization | 42.7 | 42.7 | 42.7 | 42.7 | 42.7 |
| | N fertilization | 71.1 | 71.1 | 71.1 | 71.1 | 71.1 |
| | VAM [low level]* | 46.8 | 47.9 | 47.0 | 42.2 | 46.0 |
| | VAM [middle level] | 52.7 | 49.6 | 51.2 | 42.8 | 49.1 |
| | VAM [high level] | 52.1 | 50.7 | 50.8 | 45.5 | 49.8 |
| | N+VAM [low level] | 73.2 | 67.3 | 82.7 | 78.8 | 75.5 |
| | N+VAM [middle level] | 79.1 | 78.5 | 78.1 | 83.1 | 79.7 |
| | N+VAM [high level] | 80.0 | 75.1 | 77.6 | 79.4 | 78.0 |
| | Mean | 59.9 | 58.3 | 60.3 | 58.6 | |
| 2003 season | Control | 31.2 | 31.2 | 31.2 | 31.2 | 31.2 |
| | P fertilization | 38.6 | 38.6 | 38.6 | 38.6 | 38.6 |
| | N fertilization | 46.0 | 46.0 | 46.0 | 46.0 | 46.0 |
| | VAM [low level] | 42.4 | 40.5 | 36.3 | 35.3 | 38.6 |
| | VAM [middle level] | 47.4 | 43.4 | 41.9 | 34.9 | 41.9 |
| | VAM [high level] | 43.8 | 43.6 | 42.8 | 43.0 | 43.3 |
| | N+VAM [low level] | 50.2 | 46.4 | 55.5 | 46.9 | 49.7 |
| | N+VAM [middle level] | 51.1 | 49.1 | 53.5 | 48.7 | 50.6 |
| | N+VAM [high level] | 54.6 | 48.4 | 52.2 | 47.8 | 50.7 |
| | Mean | 45.0 | 43.0 | 44.2 | 41.4 | |
| | L.S.D. at 5% | Season 2002 | | Season 2003 | | |
| | VAM isolates | NS. | | 0.407 | | |
| | Treatments | 1.726 | | 1.018 | | |
| | Interaction | NS. | | NS. | | |

* VAM [low level] = 10kg/fed; VAM [middle level] = 15kg/fed; VAM [high level] = 20kg/fed, respectively.

As for treatments, applying P fertilizer in 2003 season and N fertilizer in both 2002 and 2003 seasons significantly increased DWS/plant compared with the unfertilized control. VAM inoculation in both seasons was significantly better than P fertilizer application for increasing DWS/plant. The DWS/plant increased proportionally as

VAM inoculation level increased particularly in 2002 season. Combining VAM inoculation with N fertilization resulted in significant increase in the DWS/plant compared with N fertilizer alone. This promising effect was increased significantly with increasing VAM level particularly in 2002 season.

**2.7. Total dry weight/plant:**

The data in **Table (26g)** illustrate that the total dry weight (TDW/plant) of maize plant was responded significantly against tested VAM isolates in 2003 season only. VAM-O recorded the highest TDW/plant (60.6g) followed by VAM-S (59.3g), VAM-B (58.8g) and VAM-M (56.1g), respectively. The 4 VAM isolates were significantly equal in this respect in 2002 season. Also, TDW/plant responded differently against tested treatments during both seasons. Compared with the control (untreated), application of P fertilizer in 2003 season only and N fertilizer in both seasons significantly increased the TDW/plant compared with the unfertilized control. As previously mentioned in the TFW/plant (**Table, 57**), application of N was significantly better than P for increasing the TDW/plant in both seasons.

Compared with P and N fertilization, the TDW/plant was significantly increased by VAM inoculation alone or combined with N application, respectively. In this respect, the efficacy of applying VAM inoculum alone, in general, was significantly increased as its used level increased particularly in 2003 season. Applying the high level of VAM inoculation particularly in 2003 season resulted in the highest values of TDW/plant compared with the other tested VAM levels. The N "fertilizer" combined with VAM inoculation produced appreciable

significant increases in the TDW/plant compared with N fertilizer alone. In this regard, the highest increase in the TDW/plant was produced by N fertilization combined with the middle or the high levels of VAM inoculation without significant differences between both levels. This trend was true in both 2002 and 2003 seasons.

**Table (26g)**: Effect of different tested treatments on the total dry weight of the aboveground parts of *Zea mays* plant (g).

| | Treatments | VAM isolates | | | | Mean |
|---|---|---|---|---|---|---|
| | | VAM-O | VAM-B | VAM-S | VAM-M | |
| 2002 season | Control | 64.1 | 64.1 | 64.1 | 64.1 | 64.1 |
| | P fertilization | 66.3 | 66.3 | 66.3 | 66.3 | 66.3 |
| | N fertilization | 110.4 | 110.4 | 110.4 | 110.4 | 110.4 |
| | VAM [low level]* | 73.2 | 75.7 | 72.1 | 66.8 | 72.0 |
| | VAM [middle level] | 84.6 | 79.9 | 81.8 | 70.4 | 79.2 |
| | VAM [high level] | 82.3 | 83.0 | 78.4 | 74.6 | 79.6 |
| | N+VAM [low level] | 113.8 | 124.5 | 127.8 | 106.1 | 118.1 |
| | N+VAM [middle level] | 123.3 | 124.9 | 118.7 | 118.3 | 121.3 |
| | N+VAM [high level] | 132.2 | 122.9 | 117.6 | 113.4 | 121.5 |
| | Mean | 94.5 | 94.6 | 93.0 | 87.8 | |
| 2003 season | Control | 44.1 | 44.1 | 44.1 | 44.1 | 44.1 |
| | P fertilization | 53.2 | 53.2 | 53.2 | 53.2 | 53.2 |
| | N fertilization | 64.0 | 64.0 | 64.0 | 64.0 | 64.0 |
| | VAM [low level] | 56.0 | 53.9 | 48.1 | 47.2 | 51.3 |
| | VAM [middle level] | 61.5 | 57.4 | 55.6 | 47.2 | 55.4 |
| | VAM [high level] | 57.5 | 58.2 | 57.5 | 56.6 | 57.4 |
| | N+VAM [low level] | 66.4 | 62.9 | 72.5 | 62.7 | 66.1 |
| | N+VAM [middle level] | 68.8 | 68.4 | 70.2 | 65.4 | 68.2 |
| | N+VAM [high level] | 73.8 | 66.9 | 68.8 | 64.7 | 68.5 |
| | Mean | 60.6 | 58.8 | 59.3 | 56.1 | |
| | L.S.D. at 5% | Season 2002 | | Season 2003 | | |
| | VAM isolates | NS. | | 0.498 | | |
| | Treatments | 2.368 | | 1.245 | | |
| | Interaction | NS. | | 4.352 | | |

* VAM [low level] = 10kg/fed; VAM [middle level] = 15kg/fed; VAM [high level] = 20kg/fed, respectively.

The interaction between treatments and VAM isolates had no significant effect on the TDW/plant in 2002 season. While, in 2003 season the highest significant increases were induced by N "fertilizer"

combined with VAM-O at the high level (73.8g), VAM-S at the low and middle levels (72.5 and 70.2g) without significant differences between the three interactions.

**2.8. Fresh weight of roots/plant:**

The fresh weight of roots (g)/plant (FWR) was significantly affected by source of VAM isolate and tested treatments but not with the interaction in between **(Table, 26h)**. In 2002 season, VAM-O and VAM-M were the most effective for increasing the FWR/plant (131.6 and 130.9g) while, VAM-B and VAM-S were the least effective in this respect (124.7 and 124.2g). No significant differences were found between VAM isolates in 2003 season.

As for treatments, applying the P and N chemical fertilizers each alone significantly increased FWR/plant compared with the unfertilized control. In this respect, the N fertilizer was significantly better than the P one. Inoculation with VAM particularly at the middle level in 2002 and high level in 2003 seasons significantly increased the FWR/plant compared with P fertilizer. Also, N "fertilizer" + VAM inoculation was significantly better in this respect than N "fertilizer" alone. The 3 used VAM levels, however, were significantly equal when combined with N fertilization particularly in 2002 season. The interaction between VAM isolates and treatments did not significantly affect the FWR/plant in both seasons.

**Table (26h)**: Effect of different tested treatments on the fresh weight of root of *Zea mays* plant (g).

| | Treatments | VAM isolates | | | | Mean |
|---|---|---|---|---|---|---|
| | | VAM-O | VAM-B | VAM-S | VAM-M | |
| 2002 season | Control | 84.4 | 84.4 | 84.4 | 84.4 | 84.4 |
| | P fertilization | 106.7 | 106.7 | 106.7 | 106.7 | 106.7 |
| | N fertilization | 157.8 | 157.8 | 157.8 | 157.8 | 157.8 |
| | VAM [low level]* | 115.6 | 102.2 | 94.4 | 114.4 | 106.7 |
| | VAM [middle level] | 118.9 | 103.3 | 108.3 | 115.6 | 111.5 |
| | VAM [high level] | 117.8 | 105.0 | 100.0 | 116.7 | 109.9 |
| | N+VAM [low level] | 158.9 | 153.6 | 161.1 | 158.3 | 158.0 |
| | N+VAM [middle level] | 160.0 | 156.7 | 153.3 | 164.4 | 158.6 |
| | N+VAM [high level] | 164.5 | 152.2 | 151.7 | 160.0 | 157.1 |
| | Mean | 131.6 | 124.7 | 124.2 | 130.9 | |
| 2003 season | Control | 31.0 | 31.0 | 31.0 | 31.0 | 31.0 |
| | P fertilization | 46.4 | 46.4 | 46.4 | 46.4 | 46.4 |
| | N fertilization | 76.3 | 76.3 | 76.3 | 76.3 | 76.3 |
| | VAM [low level] | 50.1 | 50.0 | 52.1 | 44.1 | 49.1 |
| | VAM [middle level] | 56.0 | 50.6 | 52.2 | 47.9 | 51.7 |
| | VAM [high level] | 55.6 | 51.4 | 54.0 | 51.2 | 53.1 |
| | N+VAM [low level] | 77.9 | 75.2 | 80.1 | 76.7 | 77.5 |
| | N+VAM [middle level] | 80.2 | 79.4 | 78.2 | 77.6 | 78.9 |
| | N+VAM [high level] | 83.3 | 77.4 | 76.9 | 76.0 | 78.4 |
| | Mean | 61.9 | 59.8 | 60.8 | 58.6 | |
| | L.S.D. at 5% | Season 2002 | | Season 2003 | | |
| | VAM isolates | 0.897 | | NS. | | |
| | Treatments | 2.243 | | 1.156 | | |
| | Interaction | NS. | | NS. | | |

* VAM [low level] = 10kg/fed; VAM [middle level] = 15kg/fed; VAM [high level] = 20kg/fed, respectively.

## 2.9. Dry weight of roots/plant:

The dry weight of roots (g)/plant (DWR) was significantly affected also by source of VAM isolate and tested treatments but not with the interaction in between **(Table, 26i)**. In 2003 season, VAM-O and VAM-S were the most effective for increasing the DWR/plant (27.3 and 26.9g) while, VAM-B and VAM-M were the least effective in this respect (25.5 and 25.2g).

**Table (26i)**: Effect of different tested treatments on the dry weight of root of *Zea mays* plant (g).

| | Treatments | VAM isolates | | | | Mean |
|---|---|---|---|---|---|---|
| | | VAM-O | VAM-B | VAM-S | VAM-M | |
| 2002 season | Control | 32.3 | 32.3 | 32.3 | 32.3 | 32.3 |
| | P fertilization | 44.7 | 44.7 | 44.7 | 44.7 | 44.7 |
| | N fertilization | 60.8 | 60.8 | 60.8 | 60.8 | 60.8 |
| | VAM [low level]* | 43.3 | 41.9 | 41.6 | 42.8 | 42.4 |
| | VAM [middle level] | 46.0 | 43.4 | 45.3 | 44.8 | 44.8 |
| | VAM [high level] | 44.6 | 44.0 | 42.9 | 45.0 | 44.1 |
| | N+VAM [low level] | 61.0 | 58.3 | 60.3 | 59.9 | 59.9 |
| | N+VAM [middle level] | 62.9 | 60.9 | 59.8 | 63.8 | 61.8 |
| | N+VAM [high level] | 63.7 | 57.9 | 58.3 | 63.1 | 60.7 |
| | Mean | 51.0 | 49.3 | 49.5 | 50.8 | |
| 2003 season | Control | 11.9 | 11.9 | 11.9 | 11.9 | 11.9 |
| | P fertilization | 19.7 | 19.7 | 19.7 | 19.7 | 19.7 |
| | N fertilization | 36.2 | 36.2 | 36.2 | 36.2 | 36.2 |
| | VAM [low level] | 18.5 | 18.9 | 19.0 | 16.3 | 18.2 |
| | VAM [middle level] | 22.3 | 20.1 | 21.8 | 19.4 | 20.9 |
| | VAM [high level] | 21.6 | 20.9 | 22.5 | 20.2 | 21.3 |
| | N+VAM [low level] | 35.1 | 27.7 | 38.0 | 33.9 | 33.7 |
| | N+VAM [middle level] | 39.5 | 39.2 | 36.7 | 35.0 | 37.6 |
| | N+VAM [high level] | 41.3 | 35.1 | 36.0 | 34.4 | 36.7 |
| | Mean | 27.3 | 25.5 | 26.9 | 25.2 | |
| | L.S.D. at 5% | Season 2002 | | Season 2003 | | |
| | VAM isolates | NS. | | 0.266 | | |
| | Treatments | 1.145 | | 0.665 | | |
| | Interaction | NS. | | NS. | | |

* VAM [low level] = 10kg/fed; VAM [middle level] = 15kg/fed; VAM [high level] = 20kg/fed, respectively.

However, the 4 VAM isolates were significantly equal in 2003 season. The FWR/plant was significantly increased in 2002 and 2003 seasons by applying the P fertilizer (44.7 and 19.7g) and N fertilizer (60.8 and 36.2g) compared with the unfertilized control (32.3 and 11.9g). In this respect, the N fertilizer was significantly better than the P one. Inoculation with VAM at the low, middle and high levels, respectively in 2003 significantly increased DWR/plant to 18.2, 20.9 and 21.3g compared with P fertilizer (11.9). The combination between

N fertilization and VAM inoculation in most cases had no significant effect in this respect compared with N "fertilizer" alone particulary in 2003 season. The interaction between VAM isolates and treatments did not significantly affect the DWR/plant in both seasons.

**3. Effect on some yield parameters:**

**3.1. Ear weight:**

The data in **(Table, 27a)** illustrate that the VAM-O was the most effective and recorded the highest significant increases in ear weight in 2003 season (139.1g) followed by VAM-S (131.2g) and VAM-B (127.3g) and VAM-M (116.0g), respectively. No significant differences, however, were detected between the four VAM isolates tested in 2002 season. As for treatments, the same results reveal that the ear weight was significantly higher in P and N fertilizers than the unfertilized control in both seasons. In this respect, applying N fertilization was significantly better than P fertilization.

The ear weight was significantly increased by applying VAM inoculation alone (compared with P fertilizer) or combined with N fertilization (compared with N fertilizer alone). This trend was holds true in both seasons. Regarding VAM inoculation alone, the ear weight was significantly increased as VAM inoculum level increased. Applying VAM inoculum at the low, middle and high levels, respectively increased the ear weight to 153.9, 155.0 and 161.8g in 2002 season and to 113.4, 128.7 and 141.7g in 2003 season. However, applying the same inoculum levels, in respective combined with N fertilization increased the ear weight to 197.8, 197.9 and 186.0g in 2002 season and 156.3, 161.0 and 156.5g in 2003 season. The same results

stated also that the ear weight, in both seasons, was not significantly affected by the interaction between VAM isolates and treatments tested.

**Table (27a):** Effect of different tested treatments on the ear weight (g) of *Zea mays* plants.

| | Treatments | VAM isolates | | | | Mean |
|---|---|---|---|---|---|---|
| | | VAM-O | VAM-B | VAM-S | VAM-M | |
| 2002 season | Control | 109.2 | 109.2 | 109.2 | 109.2 | 109.2 |
| | P fertilization | 133.4 | 133.4 | 133.4 | 133.4 | 133.4 |
| | N fertilization | 144.2 | 144.2 | 144.2 | 144.2 | 144.2 |
| | VAM [low level]* | 153.9 | 155.8 | 152.1 | 153.6 | 153.9 |
| | VAM [middle level] | 158.3 | 156.6 | 151.1 | 154.2 | 155.0 |
| | VAM [high level] | 155.8 | 172.2 | 164.8 | 154.2 | 161.8 |
| | N+VAM [low level] | 191.7 | 199.4 | 216.5 | 183.6 | 197.8 |
| | N+VAM [middle level] | 193.4 | 198.1 | 193.3 | 206.7 | 197.9 |
| | N+VAM [high level] | 193.7 | 186.3 | 182.9 | 181.1 | 186.0 |
| | Mean | 159.3 | 161.7 | 160.8 | 157.8 | |
| 2003 season | Control | 91.7 | 91.7 | 91.7 | 91.7 | 91.7 |
| | P fertilization | 99.4 | 99.4 | 99.4 | 99.4 | 99.4 |
| | N fertilization | 107.0 | 107.0 | 107.0 | 107.0 | 107.0 |
| | VAM [low level] | 123.3 | 115.6 | 128.6 | 86.1 | 113.4 |
| | VAM [middle level] | 155.8 | 125.6 | 128.7 | 104.5 | 128.7 |
| | VAM [high level] | 154.2 | 139.7 | 136.7 | 136.1 | 141.7 |
| | N+VAM [low level] | 167.0 | 151.7 | 164.4 | 141.9 | 156.3 |
| | N+VAM [middle level] | 176.7 | 163.3 | 164.4 | 139.7 | 161.0 |
| | N+VAM [high level] | 177.2 | 151.4 | 159.7 | 137.8 | 156.5 |
| | Mean | 139.1 | 127.3 | 131.2 | 116.0 | |
| | L.S.D. at 5% | Season 2002 | | Season 2003 | | |
| | VAM isolates | NS. | | 1.78 | | |
| | Treatments | 5.80 | | 4.46 | | |
| | Interaction | NS. | | NS. | | |

* VAM [low level] = 10kg/fed; VAM [middle level] = 15kg/fed; VAM [high level] = 20kg/fed, respectively.

### 3.2. Grain yield/plant:

The data in **(Table, 27b)** illustrate that the grain yield/plant was significantly affected by source of VAM isolate in 2003 season and tested treatments in booth 2002 and 2003 seasons. VAM-S was the most effective and recorded the highest significant increases in the grain yield/plant (75.3g) followed by VAM-O (73.1g) and VAM-B (66.5g)

and VAM-M (52.6g), respectively. No significant differences, however, were detected between the four VAM isolates tested in 2002 season. The grain yield/plant was significantly affected by the tested treatments in both seasons. It was significantly higher in P and N fertilizers than the unfertilized control. The N fertilization was significantly better in this respect than P fertilization in 2002 season. The grain yield/plant was significantly increased by using VAM inoculation either alone (compared with P fertilizer) or combined with N fertilization (compared with N fertilizer alone). This trend was holds true in both seasons.

**Table (27b):** Effect of different tested treatments on the grain yield/plant (g) of *Zea mays* plants.

| | Treatments | VAM isolates | | | | Mean |
|---|---|---|---|---|---|---|
| | | VAM-O | VAM-B | VAM-S | VAM-M | |
| 2002 season | Control | 37.7 | 37.7 | 37.7 | 37.7 | 37.7 |
| | P fertilization | 50.1 | 50.1 | 50.1 | 50.1 | 50.1 |
| | N fertilization | 61.1 | 61.1 | 61.1 | 61.1 | 61.1 |
| | VAM [low level]* | 58.2 | 70.0 | 54.2 | 58.3 | 60.2 |
| | VAM [middle level] | 64.3 | 74.5 | 73.6 | 61.2 | 68.4 |
| | VAM [high level] | 57.3 | 80.6 | 75.5 | 60.4 | 68.5 |
| | N+VAM [low level] | 102.3 | 125.6 | 123.9 | 103.5 | 113.8 |
| | N+VAM [middle level] | 119.8 | 121.2 | 106.8 | 111.7 | 114.9 |
| | N+VAM [high level] | 122.5 | 97.6 | 104.0 | 103.8 | 107.0 |
| | Mean | 74.8 | 79.8 | 76.3 | 72.0 | |
| 2003 season | Control | 34.8 | 34.8 | 34.8 | 34.8 | 34.8 |
| | P fertilization | 35.1 | 35.1 | 35.1 | 35.1 | 35.1 |
| | N fertilization | 54.7 | 54.7 | 54.7 | 54.7 | 54.7 |
| | VAM [low level] | 58.5 | 61.5 | 76.4 | 29.6 | 56.5 |
| | VAM [middle level] | 84.0 | 65.4 | 79.7 | 37.9 | 66.8 |
| | VAM [high level] | 80.4 | 73.1 | 87.0 | 59.8 | 75.1 |
| | N+VAM [low level] | 94.1 | 78.7 | 105.3 | 81.0 | 89.8 |
| | N+VAM [middle level] | 109.7 | 95.0 | 104.7 | 72.7 | 95.5 |
| | N+VAM [high level] | 106.9 | 99.8 | 100.4 | 68.0 | 93.8 |
| | Mean | 73.1 | 66.5 | 75.3 | 52.6 | |
| | L.S.D. at 5% | Season 2002 | | Season 2003 | | |
| | VAM isolates | NS. | | 1.36 | | |
| | Treatments | 3.76 | | 3.41 | | |
| | Interaction | NS. | | NS. | | |

* VAM [low level] = 10kg/fed; VAM [middle level] = 15kg/fed; VAM [high level] = 20kg/fed, respectively.

The grain yield/plant, particularly in 2003 seaso, was proportionally and significantly increased as VAM inoculum level increased. At low, middle and high levels of VAM inoculation, grain yield/plant increased to 60.2, 68.4 and 68.5g in 2002 season and to 56.5, 66.8 and 75.1g, respectively in 2003 season. However, applying N fertilizer combined with the same inoculum levels, in respective increased the grain yield/plant to 113.8, 114.9 and 107.0g in 2002 season and 89.8, 95.5 and 93.8g in 2003 season. The grain yield/plant seems to be not significantly affected, in both seasons, by the interaction between VAM isolates and treatments tested.

### 3.3. Weight of 100-kernels:

Data in **Table (27c)** illustrate that the weight of 100-kernels of corn was significantly affected by VAM isolates and treatments tested in both 2002 and 2003 seasons. In the first season, the highest weight of 100-kernels was produced by VAM-B (27.57g), VAM-S (27.55g) and VAM-O (27.53g) without significant differences between them while, VAM-M was the least effective in this respect (26.04g). However, VAM-B was the most effective in the second season (28.09g) followed by VAM-S (27.56g), VAM-O (27.1g) and VAM-M (26.23g), respectively.

Concerning treatments, the N fertilization in both seasons significantly increased the weight of 100-kernels (26.67g) while P fertilization (25.0g) had no significant effect compared with the untreated control (25.0g). Applying VAM inoculum alone at the low, middle and high levels significantly increased weight of 100-kernels to 26.27, 26.94 and 27.58g in the first season and 26.6, 27.64 and 27.71g, respectively in the 2$^{nd}$ season compared with application of P fertilizer

(25.0g). Applying VAM inoculum at the low, middle and high levels combined with N fertilizer significantly increased the weight of 100-kernels was to 28.83, 29.57 and 28.72g g in the first season and 28.54, 29.31 and 28.75g, respectively in the second season compared with application of N fertilizer alone (26.67g). However, the interaction between VAM isolates and treatments did not significantly affect weight of 100-kernels in both seasons.

**Table (27c):** Effect of different tested treatments on the weight of 100-Kernels (g) of *Zea mays* plants.

| | Treatments | VAM isolates | | | | Mean |
|---|---|---|---|---|---|---|
| | | VAM-O | VAM-B | VAM-S | VAM-M | |
| 2002 season | Control | 25.00 | 25.00 | 25.00 | 25.00 | 25.00 |
| | P fertilization | 25.00 | 25.00 | 25.00 | 25.00 | 25.00 |
| | N fertilization | 26.67 | 26.67 | 26.67 | 26.67 | 26.67 |
| | VAM [low level]* | 26.67 | 26.89 | 26.44 | 25.07 | 26.27 |
| | VAM [middle level] | 27.50 | 28.22 | 26.67 | 25.36 | 26.94 |
| | VAM [high level] | 28.06 | 28.06 | 28.92 | 25.28 | 27.58 |
| | N+VAM [low level] | 29.17 | 29.36 | 29.94 | 26.83 | 28.83 |
| | N+VAM [middle level] | 29.72 | 29.92 | 29.95 | 28.70 | 29.57 |
| | N+VAM [high level] | 30.00 | 29.05 | 29.36 | 26.47 | 28.72 |
| | Mean | 27.53 | 27.57 | 27.55 | 26.04 | |
| 2003 season | Control | 25.00 | 25.00 | 25.00 | 25.00 | 25.00 |
| | P fertilization | 25.00 | 25.00 | 25.00 | 25.00 | 25.00 |
| | N fertilization | 26.67 | 26.67 | 26.67 | 26.67 | 26.67 |
| | VAM [low level] | 26.67 | 27.22 | 28.06 | 24.44 | 26.60 |
| | VAM [middle level] | 27.50 | 28.61 | 28.06 | 26.39 | 27.64 |
| | VAM [high level] | 26.67 | 29.17 | 28.33 | 26.67 | 27.71 |
| | N+VAM [low level] | 27.50 | 30.00 | 29.17 | 27.50 | 28.54 |
| | N+VAM [middle level] | 29.44 | 30.83 | 29.17 | 27.78 | 29.31 |
| | N+VAM [high level] | 29.44 | 30.28 | 28.61 | 26.67 | 28.75 |
| | Mean | 27.10 | 28.09 | 27.56 | 26.23 | |
| | L.S.D. at 5% | Season 2002 | | Season 2003 | | |
| | VAM isolates | 0.153 | | 0.152 | | |
| | Treatments | 0.382 | | 0.381 | | |
| | Interaction | NS. | | NS. | | |

* VAM [low level] = 10kg/fed; VAM [middle level] = 15kg/fed; VAM [high level] = 20kg/fed, respectively.

## 4. Effect on chemical analysis of maize kernels:

### 4.1. Crude protein:

Data in **(Table, 28a)** illustrate that the crude protein (CP) in the maize kernels was significantly affected during both 2002 and 2003 seasons by variations between VAM isolates, treatments and the interaction in between. In 2002 season, VAM-B recorded the highest significant increases in the CP (10.67%) followed by VAM-M (10.46%), VAM-O (9.47%) and VAM-S (9.36%), respectively. While in 2003 season, VAM-B still the best in this respect (7.74%) followed by VAM-O (7.18%), VAM-S (6.84%) and VAM-M (6.53%), respectively.

Applying N fertilization significantly increased the CP in maize-kernels to 10.01 and 6.88% during the two seasons, respectively while, P fertilization (6.26%) had no significant effect compared with the control treatment (6.26%). This trend was true in both seasons. On the other hand, the CP was significantly increased by VAM inoculation at the low (9.27%), middle (10.41%) and high level (10.56%) in 2002 season and at middle level only (6.59%) in 2003 season compared with P application. The CP in 2002 and 2003 seasons was significantly increased by using N fertilizer combined with VAM inoculation at the low (12.26 and 8.49%), middle (14.31 and 8.74%) and high level (12.23 and 8.86%) compared with N fertilizer alone in both seasons (10.01 and 6.88%).

Among all tested interaction (VAM isolates x treatments), the highest CP in maize kernels in 2002 season was produced by using N fertilization combined with VAM-O at the high level (14.1%), VAM-B at the middle level (13.42%) or VAM-M at the low level (13.34%) and

the middle one (13.68%). While, in 2003 season the best value was produced by using N fertilizer combined with VAM-S at the high level (10.39%) and VAM-O (10.09%).

**Table (28a):** Effect of different tested treatments on the crude protein (%) of *Zea mays* kernels.

| | Treatments | VAM isolates | | | | Mean |
|---|---|---|---|---|---|---|
| | | VAM-O | VAM-B | VAM-S | VAM-M | |
| 2002 season | Control | 6.26 | 6.26 | 6.26 | 6.26 | 6.26 |
| | P fertilization | 6.26 | 6.26 | 6.26 | 6.26 | 6.26 |
| | N fertilization | 10.01 | 10.01 | 10.01 | 10.01 | 10.01 |
| | VAM [low level]* | 8.01 | 11.47 | 8.84 | 8.76 | 9.27 |
| | VAM [middle level] | 8.76 | 12.10 | 9.92 | 10.84 | 10.41 |
| | VAM [high level] | 7.76 | 12.10 | 9.89 | 12.51 | 10.56 |
| | N+VAM [low level] | 11.84 | 12.51 | 11.34 | 13.34 | 12.26 |
| | N+VAM [middle level] | 12.26 | 13.42 | 11.26 | 13.68 | 14.31 |
| | N+VAM [high level] | 14.10 | 11.89 | 10.43 | 12.51 | 12.23 |
| | Mean | 9.47 | **10.67** | 9.36 | 10.46 | |
| 2003 season | Control | 6.26 | 6.26 | 6.26 | 6.26 | 6.26 |
| | P fertilization | 6.26 | 6.26 | 6.26 | 6.26 | 6.26 |
| | N fertilization | 6.88 | 6.88 | 6.88 | 6.88 | 6.88 |
| | VAM [low level] | 5.51 | 7.51 | 4.01 | 4.38 | 5.35 |
| | VAM [middle level] | 7.38 | 7.51 | 5.21 | 6.26 | 6.59 |
| | VAM [high level] | 4.69 | 8.34 | 5.26 | 6.67 | 6.24 |
| | N+VAM [low level] | 8.13 | 8.76 | 10.39 | 6.67 | 8.49 |
| | N+VAM [middle level] | 9.43 | 9.43 | 8.80 | 7.30 | 8.74 |
| | N+VAM [high level] | 10.09 | 8.76 | 8.46 | 8.13 | 8.86 |
| | Mean | 7.18 | 7.74 | 6.84 | 6.53 | |
| | L.S.D. at 5% | Season 2002 | | Season 2003 | | |
| | VAM isolates | 0.079 | | 0.043 | | |
| | Treatments | 0.197 | | 0.106 | | |
| | Interaction | 0.789 | | 0.426 | | |

* VAM [low level] = 10kg/fed; VAM [middle level] = 15kg/fed; VAM [high level] = 20kg/fed, respectively.

### 4.2. Phosphorous content:

Data in **Table (28b)** reveal that the tested VAM isolates were not significantly varied concerning their effect on the phosphorous (P) contents in maize kernels in both seasons. Applying the P fertilizer, however, significantly increased P content while N fertilizer

significantly decreased it in 2002 and had no significant effect in 2003 season compared with the untreated controls.

**Table (28b):** Effect of different tested treatments on the total phosphorus (%) of *Zea mays* kernels.

| | Treatments | VAM isolates | | | | Mean |
|---|---|---|---|---|---|---|
| | | VAM-O | VAM-B | VAM-S | VAM-M | |
| 2002 season | Control | 0.060 | 0.060 | 0.060 | 0.060 | 0.060 |
| | P fertilization | 0.066 | 0.066 | 0.066 | 0.066 | 0.066 |
| | N fertilization | 0.058 | 0.058 | 0.058 | 0.058 | 0.058 |
| | VAM [low level]* | 0.089 | 0.081 | 0.083 | 0.086 | 0.085 |
| | VAM [middle level] | 0.102 | 0.082 | 0.085 | 0.084 | 0.088 |
| | VAM [high level] | 0.094 | 0.080 | 0.089 | 0.106 | 0.092 |
| | N+VAM [low level] | 0.093 | 0.082 | 0.098 | 0.090 | 0.091 |
| | N+VAM [middle level] | 0.095 | 0.121 | 0.090 | 0.090 | 0.099 |
| | N+VAM [high level] | 0.117 | 0.107 | 0.078 | 0.083 | 0.096 |
| | Mean | 0.086 | 0.082 | 0.079 | 0.080 | |
| 2003 season | Control | 0.058 | 0.058 | 0.058 | 0.058 | 0.058 |
| | P fertilization | 0.061 | 0.061 | 0.061 | 0.061 | 0.061 |
| | N fertilization | 0.057 | 0.057 | 0.057 | 0.057 | 0.057 |
| | VAM [low level] | 0.066 | 0.083 | 0.070 | 0.075 | 0.073 |
| | VAM [middle level] | 0.076 | 0.076 | 0.075 | 0.075 | 0.076 |
| | VAM [high level] | 0.064 | 0.078 | 0.087 | 0.076 | 0.076 |
| | N+VAM [low level] | 0.074 | 0.079 | 0.094 | 0.075 | 0.081 |
| | N+VAM [middle level] | 0.084 | 0.079 | 0.076 | 0.076 | 0.079 |
| | N+VAM [high level] | 0.108 | 0.080 | 0.069 | 0.069 | 0.082 |
| | Mean | 0.072 | 0.072 | 0.072 | 0.069 | |
| | L.S.D. at 5% | Season 2002 | | Season 2003 | | |
| | VAM isolates | NS. | | NS. | | |
| | Treatments | 0.0026 | | 0.0024 | | |
| | Interaction | 0.0103 | | 0.0097 | | |

* VAM [low level] = 10kg/fed; VAM [middle level] = 15kg/fed; VAM [high level] = 20kg/fed, respectively.

VAM inoculation alone at different levels, however, significantly increased the P content in 2002 season (0.085-0.092%) and 2003 season (0.073-0.076%) compared with P fertilizer (0.06 and 0.058%). Similarly the VAM inoculation combined with N fertilizer significantly increased P content in the maize kernels in 2002 season (0.091-0.099%) and 2003 season (0.079-0.082%) compared with N fertilizer alone.

Among tested interactions, the highest P content in the maize kernels was produced by N fertilizer combined with VAM-B at the middle level (0.121%) in 2002 season and VAM-O at the high level (0.108%) in 2003 season in comparison with any other treatment.

**4.2. Potassium content:**

The data in **Table (28c)** prove that the potassium (K) content in maize kernels was significant affected by the tested treatments. The K content was significantly increased by using N fertilizer in seasons 2002 (3.5%) and 2003 (3.08%) while P fertilizer significantly increased the K content in 2002 season only (2.75%).

VAM inoculation was significantly more effective for increasing the K content in the corn kernels than P fertilization. The K content increased proportionally as VAM inoculation level increased. Applying VAM inoculation at the low, middle and high levels increased K content to 3.25, 3.29 and 3.31% in the first season and to 2.73, 2.81 and 2.9%, respectively in the second season. On the contrary, combining any of these VAM levels with N fertilization had no significant effect on K content in the corn kernels compared with N fertilization alone. Also, K content in both seasons was not affected significantly either by source of VAM isolates or the interaction between VAM isolates and tested treatments.

**Table (28c):** Effect of different tested treatments on the total potassium (%/g kernels) of *Zea mays* plants.

| | Treatments | VAM isolates | | | | Mean |
|---|---|---|---|---|---|---|
| | | VAM-O | VAM-B | VAM-S | VAM-M | |
| 2002 season | Control | 2.50 | 2.50 | 2.50 | 2.50 | 2.50 |
| | P fertilization | 2.75 | 2.75 | 2.75 | 2.75 | 2.75 |
| | N fertilization | 3.50 | 3.50 | 3.50 | 3.50 | 3.50 |
| | VAM [low level]* | 3.42 | 2.83 | 3.67 | 3.08 | 3.25 |
| | VAM [middle level] | 3.50 | 3.08 | 3.50 | 3.08 | 3.29 |
| | VAM [high level] | 2.92 | 3.08 | 3.75 | 3.50 | 3.31 |
| | N+VAM [low level] | 3.33 | 3.08 | 3.92 | 3.50 | 3.46 |
| | N+VAM [middle level] | 4.25 | 4.25 | 2.67 | 3.17 | 3.58 |
| | N+VAM [high level] | 4.17 | 3.50 | 2.83 | 3.17 | 3.42 |
| | Mean | 3.37 | 3.18 | 3.23 | 3.14 | |
| 2003 season | Control | 2.50 | 2.50 | 2.50 | 2.50 | 2.50 |
| | P fertilization | 2.42 | 2.42 | 2.42 | 2.42 | 2.42 |
| | N fertilization | 3.08 | 3.08 | 3.08 | 3.08 | 3.08 |
| | VAM [low level] | 2.83 | 2.83 | 2.67 | 2.58 | 2.73 |
| | VAM [middle level] | 2.83 | 2.83 | 2.67 | 2.92 | 2.81 |
| | VAM [high level] | 2.42 | 2.92 | 3.17 | 3.08 | 2.90 |
| | N+VAM [low level] | 3.00 | 2.83 | 3.58 | 3.08 | 3.13 |
| | N+VAM [middle level] | 3.33 | 3.50 | 2.33 | 3.08 | 3.06 |
| | N+VAM [high level] | 3.25 | 3.00 | 2.25 | 3.08 | 2.90 |
| | Mean | 2.85 | 2.88 | 2.74 | 2.87 | |
| | L.S.D. at 5% | Season 2002 | | Season 2003 | | |
| | VAM isolates | NS. | | NS. | | |
| | Treatments | 0.160 | | 0.137 | | |
| | Interaction | NS. | | NS. | | |

* VAM [low level] = 10kg/fed; VAM [middle level] = 15kg/fed; VAM [high level] = 20kg/fed, respectively.