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Flame Seedless Grapevines Productivity and Fruit Quality in Relation to Mycorrhizal Fungi and Phosphate Dissolving Bacteria Inoculation

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Abstract: With an overall aims to study the effect of inoculation with *Arbuscular Mmycorrhizal* fungi (AMF) and phosphate dissolving bacteria "PDB" (*Bacillus megatherium var. phosphaticum*) on 'Flame Seedless' grapevines productivity and berries physicochemical properties grown under loamy clay soil at El-Minia Governorate conditions - Egypt. A field investigation included 10 treatments were achieved: Control (untreated vines), Inoculation with AMF at 50 g/vine, Inoculation with AMF at 100 g/vine, Inoculation with AMF at 150 g/vine, Inoculation with PDB at 50 ml/vine, Inoculation with PDB at 100 ml/vine, Inoculation with PDB at 150 ml/vine, Inoculation with AMF at 50 g/vine + 50 ml/vine PDB, Inoculation with AMF at 100 g/vine + 100 ml/vine PDB, Inoculation with AMF at 150 g/vine + 150 ml/vine PDB. The obtained results confirmed that Inoculation 'Flame Seedless' grapevines with PDB and AMF at different concentration cane significantly improved the productivity and berries quality. However, the combined inoculation with AMF + PDB shows more effective rather than using each one alone. Furthermore, the vines inoculated with AMF (at 150 g/vine) combined with PDF (at 150 ml/vine) present the best yield and berries physical and chemical properties.

Key words: Flame Seedless, grapevines, *Arbuscular Mmycorrhizal* fungi, dissolving bacteria, yield fruit quality.

1. Introduction

Grapes are suggested to be one of the most important fruit crops for local consumption and export. It is grown extensively in Europe, Africa and other region all over the world **(Weaver, 1976 and Reynier 2000, and Anastasiadi *et al.*, 2010)**. In Egypt, it occupies the third position after citrus and mango according to the cultivated area and the magnitude of fruit production. However, El-Minia Governorate occupied the second position in grapevines cultivation and production. Grape berries are used in different industrial purposes such as making juice, raisins and other preservatives. The grapes have higher nutritional value due to its higher content from sugars, vitamins, antioxidants, organic acids, minerals and essential amino acid **(Weaver, 1976;**

Coombe and Dry 1992; Passingham 2004; Anastasiadi *et al.*, 2010 and Hammad *et al.*, 2020).

Fertilizer play pivotal role in the agriculture production up to 35 to 40% of the productivity. To enhance nutrient use efficiency and overcome the chronic problem of eutrophication, biofertilizers might be a best alternative. Attempts have been made to synthesize bio-fertilizers in order to regulate the release of nutrients depending on the requirements of the crops, and it is also reported that the bio-fertilizers are cheap, environmentally safe, it has no deleterious effect and its effect is extended in soil **(Abd El-Hamed 2002; Abdel-Hamid *et al.*, 2004; Ibrahim *et al.*, 2020 and Metawie 2020)**.

Flame Seedless considered is one of the popular grape cultivar in Egypt, successfully grown under different soil and climate conditions. This cultivar is one of the early ripens cultivars. It has an opportunity for export to foreign markets, due to its early ripening and favorable taste **(Ibrahim *et al.*, 2020 and Ibrahim *et al.*, 2022)**. Under El-Minia conditions, it faces some problems such as poor yield and poor berries coloration. Therefore, many trials were made for finding out the nontraditional methods for overcoming these problems and at the same time protecting our environment from pollution **(Farag, 2006 and Metawie, 2020)**. The efficacy of bio-fertilizers as a cost effective crop input under differing climactic and geographic conditions and on a wide variety of horticulture crops has been proven in the many field trail results that have shown significant improvements in overall yield and quality of fruits.

Research Aims: The overall aims of this research is to study the effect of inoculation with Arbuscular Mmycorrhizal fungi (AMF) and phosphate dissolving bacteria "PDB" (*Bacillus megatherium var. phosphaticum*) on 'Flame Seedless' grapevines productivity and berries physicochemical properties under loamy clay at El-Minia Governorate.

2. Material and Methods

2.1. Plant material, location, treatments and statistical design

This current field experiment was conducted over two growing successive seasons 2022 and 2023 on thirty uniform in vigour Flame Seedless grapevines, the chosen vines has ten years old at the beginning of the study. The select vines were growing in private grapevine orchard located at Thala village – Minia district, Minia Governorate, where the soil texture was loamy clay and well drained water. The vines are planted at 2 x 3 meters apart. The vine load was 72 eyes for all choosing vines (on the basis of six fruiting canes X ten eyes plus six renewal spurs X two eyes). Gabel shape supporting system was used. The vines were irrigated through surface irrigation system by using Nile water. Except those dealing with the examined treatments (inoculation with *Arbuscular mycorrhizal* fungi (AMF) and phosphate dissolving bacteria (PDB), all the chosen vines (30 vines) received the usual horticultural practices which are recommended in the vineyard grown in heavy soils. Then, the current investigation was included the following ten treatments categories as following: Control (untreated vines), Inoculation with AMF at 50 g/vine, Inoculation with AMF at 100 g/vine, Inoculation with AMF at 150 g/vine, Inoculation with PDB at 50 ml/vine, Inoculation with PDB at 100 ml/vine, Inoculation with PDB at 150 ml/vine, Inoculation with AMF at 50 g/vine + 50 ml/vine PDB, Inoculation with AMF at 100 g/vine + 100 ml/vine PDB, Inoculation with AMF at 150 g/vine + 150 ml/vine PDB.

Each AMF or/and PDB inoculation as well as control treatment was replicated three times yearly, one vine per each replicate. These treatments were achieved three times yearly; the first one during burst bud stage, the second one during full blooming stage and the third one was achieved at one month later. A Completely Randomized Block design was used to implement this experiment, whereas the present experiment included 10 treatments, each one was replicated three times. Then, the obtained data were tabulated and statistically analyzed and the differences between the means value were compared by using new L.S.D. test (at 5% level of probability) according to **Snedecor and Cochran (1990)**.

2.2. Orchard Soil analysis

Mechanical, physical and chemical analysis of the orchard soil was carried out at the starting of the study according to Chapman and Pratt (1965) and the data are shown in Table (1).

Table (1). Analysis of the tested orchard soil

Constituents	Values
Sand %	10.0
Silt %	33.5
Clay %	57.5
Texture	Loamy Clay
pH (1: 2.5 extract of soil sample)	7.55
E.C. (1: 2.5 extract)	1.13
O.M. %	1.08
$CaCO_3$ %	2.98
Total N %	0.12
Available P (Olsen method, ppm)	1.89
Available K (ammonium acetate, ppm)	450

2.3. Data collection

The following measurements and determinations were achieved during the two seasons:

2.3.1. Yield

The clusters were harvested when TSS/acid ratio in check treatment reached at least 25:1 (at the second week of June during both seasons). Yield per vine expressed in weight (kg), cluster weight (g) and number of clusters / vine were estimated.

2.3.2. Cluster and Berry physical properties

Four clusters from each vine were taken randomly for determination of following cluster and berry physical characteristics. Cluster dimensions (length and width, cm.) by using millimeter vernier caliper. Average berry weight (g.) was recorded by using a calibrated digital balance. Average berry dimensions (longitudinal and equatorial in cm), by using millimeter vernier caliper.

2.3.3. Berry chemical properties

The following chemical parameters were determined: Percentage of total soluble solids (TSS %) in the juice was determined by using handy refractometer, percentage of total acidity (as a tartaric acid/ 100 ml juice) by titration against 0.1N NaOH in presence of phenolphthalein as an indicator **A.O.A.C. (2000)**, percentage of reducing sugars percentage by using volumetric method, as described in **A.O.A.C. (2000)**, berry total anthocyanins were extracted and determined according to **Fulcki & Frabcis (1968)** methods.

3. Results and Discussion

3.1. Yield and its components

Data illustrated in Table (2) shows the effect of inoculation with AMF 50, 100 and 150 g/vine or/and PDB at 50, 100 and 150 ml/vine on cluster numbers/vines, cluster weight (g) and yield kg/vine of ‘Flame Seedless’ grapevines grown in loamy clay soil, under the environmental conditions of El-Minia Governorate, during 2022 and 2023 seasons.

3.1.1. Effect on cluster number per vine

The obtained data illustrated in Table (2) displayed that, regardless the dose of inoculation, inoculated the vines with both micro-organisms each one individually or in both combinations hasn’t any significant effect on cluster numbers/vine during the first season. This seems logical as the flower bud’s differentiations were already done during the previous summer. Contrary, in the second seasons all treatments were capable to increase the cluster numbers rather than control. Regarding the doses of each micro-organism, during the second season inoculated 'Flame Seedless' grapevine with AMF significantly was accompanied with improving the number of cluster / vine rather than those inoculated with PDB. The promotion on cluster number/vine was in proportional to increasing the dose of each micro-organism from 50 ml to 150 ml/vine. Furthermore, the 'Flame Seedless' vines inoculated with PDB at 150 ml and AMF at 150 g/vine in combination produced the highest number of clusters per vine during the second season (34 clusters). On the opposite side un-inoculated 'Flame Seedless' vines present the lowest number of clusters per vine (27 clusters), during the second season.

3.1.2. Effect on cluster weight (g)

The obtained data shows that inoculate the vines with the PDB at the low doses (50 or 100 ml/vine) failed to varied the cluster weight (g) significantly. These findings were true during the two experimental seasons (2022 and 2023). On the other hand, inoculated the vines with the higher dose of PDB (150 ml/vine) was capable to enhanced the cluster weight (g) compared to un-treated vines. However, all AMF inoculation doses lead to significantly increment in cluster weight during the both experimental seasons. Furthermore, all combined applications of the two micro-organisms (PDB and AMF) shows more effective rather than using each one alone, these findings were true during the two experimental seasons. Under such promised treatment, cluster weight (g) reached 352 g and 372 g during the two experimental seasons, 2022 and 2023 respectively. Contrary, untreated vines (control) produced the lowest cluster weight (280 g & 277 g) during both seasons respectively.

3.1.3. Effect on yield (kg/vine)

Change in yield (kg/vine) of 'Flame Seedless' grapevines in 2022 and 2023 seasons as a response of 'Flame Seedless' productivity to inoculation with PDB (at 50 to 150 ml/vine) or/and AMF (at 50 to 150 g/vine) are shown in Table (2). It is clear from these table that, inoculate 'Flame Seedless' grapevines with AMF or/and AMF individually or in combination at different doses significantly was very effective in enhancing yield (kg/vine) over the check treatments (un-treated vines). Then, all PDB or/and AMF was capable to increase the yield of vines (kg/vine) during the two experimental seasons. The obtained data shows that, even although the number of clusters per vine didn't increased significantly during the first season as a result of vines inoculations with PDB or/and AMF, the yield (kg/vine) exhibited significantly during the same season. It can be explained by the positive role of PDB or/and AMF in significantly improving the weight of cluster (g) during the first season. The data also shows that, regarding the dose of each micro-organism the vines received AMF present superiority in yield (kg/vine) rather than those received PDB individually, these data were true during the tow experimental seasons. Furthermore, using the two micro-organisms in combination shows more effective than using each one individually regardless the dose of inoculation. The data illustrate that the vines inoculated with PDB (at 150 ml/vine) and AMF (at 150 g/vine) produced the highest cluster weight (10.2 & 12.3 kg/vine), during the two seasons respectively. On the opposite side, un-inoculated vines present the lowest yield (7.5 & 7.5 kg/vine), during 2022 and 2023 seasons respectively.

The promoting effect of AMF inoculation on the productivity of 'Flame Seedless' grapevines in terms of cluster weight (g) and yield (kg/vine) as well as cluster numbers/vine may be due to positive effect of mycrrohiza on enhancing mineral elements volubility and absorption **(Sadhana 2014 and Sun *et al.*, 2018)**, water absorption **(Sadhana 2014 and Begum *et al.*, 2019)**, and growths promoter production **(Rouphail *et al.*, 2015; Begum *et al.*, 2019 and Farag, 2006)**.

Similar results were obtained by: **Ibrahim (2015)** on 'Superior' and 'Early Superior' grapevines *cvs.*; **Zaid *et al.* (2021)** on three pomegranate cultivars namely; Wonderful, H116 and Manfalouty; **Vijayalakshmi *et al.* (2022)** on 'Muscat Hamburg' grapevines.

Table (2). Effect of mycrrohiza and phosphate dissolving bacteria inoculation on yield and cluster aspects of Flame seedless grapevines, during 2022 and 2023 seasons

Treatments	Cluster weight (g)		No. of clusters/vine		Yield (kg)		Cluster length (cm)		Cluster width (cm)	
	2022	**2023**	**2022**	**2023**	**2022**	**2023**	**2022**	**2023**	**2022**	**2023**
Control	280	277	27	27	7.5	7.5	14.0	14.1	11.4	11.6
PDB 50 ml	287	299	27	29	7.8	8.7	14.3	14.4	11.9	12.1
PDB 100 ml	286	301	28	29	8.0	8.7	14.4	14.5	12.3	12.6
PDB 150 ml	299	308	28	30	8.3	9.2	14.6	14.7	12.7	12.9
AMF 50 g	299	305	28	30	8.1	9.2	15.4	15.5	13.2	13.7
AMF 100 g	309	318	28	31	8.7	9.9	16.9	16.8	13.5	13.7
AMF 150 g	312	326	27	32	8.5	10.4	17.2	17.6	14.1	14.1
PDB 50 ml + AMF 50 g	332	353	28	31	9.3	10.9	17.9	18.1	14.1	14.3
PDB 100 ml + AMF 100 g	349	365	28	33	9.8	12.1	18.1	19.2	14.6	14.4
PDB 150 ml + AMF 150 g	352	372	29	34	10.2	12.3	18.5	19.3	14.7	14.9
New LSD at 5%	**17**	**18**	**NS**	**2**	**1.1**	**1.1**	**1.2**	**1.1**	**0.7**	**0.8**

3.2. Effect of PDB or/and AMF on berry physical properties

Data concerning the effect of PDB (at 50, 100 and 150 ml/vine) or/and AMF inoculations (at 50, 100 and 150 g/vine) on berry physical properties of 'Flame Seedless' grapevines grown in loamy clay soil under El-Minia Governorate conditions, during 2022 and 2023 seasons are illustrated in Table (3).

3.2.1. Berry weight

Concerning the effect of PDB (at 50, 100 and 150 g/vine) or/and AMF (at 50, 100 and 150 g/vine) on 'Flame Seedless' berry weight (g), data illustrate that all PDB and AMF inoculations (individually or in combination) was capable to increase berry weigh (g) of Flame seedless grapevine in comparison with un-inoculated vines, during the two experimental seasons. Furthermore, increasing the doses of each micro-organism from 50 to 150 was parallel to increasing fruit weight (g). Regarding the doses used the vines inoculated with AMF presented higher fruit weight rather than those inoculated with PDB, these findings were true during the two experimental seasons. Furthermore, the vines received PDB (at 150 ml/vine) combined with AMF (at 150 g/vine) present the best berry weight (3.49 & 3.68 g) during 2022 and 2023 respectively. Contrary, un-inoculated vines (control) present the minimized berry weight (2.22 & 2.19 g), during the two experimental seasons respectively.

3.2.2. Berry dimensions and shape index

Concerning the effect of PDB (at 50, 100 and 150 ml/vine) or/and AMF (at 50, 100 and 150 g/vine) on 'Flame Seedless' berry longitudinal and berry equatorial (cm), data illustrated in Table (3) shows that all individual inoculation with PDB or AMF failed to improve the berry longitudinal and equatorial (cm), except the case of inoculate the vine with AMF at higher dose (150 g/vine), these data were true during the two experimental seasons. It is clear from the obtained data that all combined inoculation with PDB and AMF were capable to enhancing the berry dimensions (longitudinal and equatorial) in both experimental seasons 2022 and 2023. However, increasing the doses used of each micro-organism from 50 to 150 g or g/vin or ml/vine (as a combined inoculations) was parallel to increasing berry longitudinal and equatorial (cm). Then the vines inoculated with PDB 150 ml/vine combined with AMF at 150 g/vine produced the maximized berry longitudinal (1.49 & 1.51 cm) and equatorial (1.44 & 1.47 cm), during 2022 and 2023 respectively. In the other side, the vines un-inoculated (control) produced the minimized berry longitudinal (1.19 & 1.22 cm) and berry equatorial (1.18 & 1.19 cm) during both experimental seasons respectively.

It is worth to mention that, regardless the dose of inoculation or type of inoculations (individually or in combinations), treated 'Flame Seedless' grapevine with PDB or/and AMF failed to enhancing berry shape index, as shown in Table (3). These findings were true during the two experimental seasons (2022 and 2023).

Table (3). Effect of mycrrohiza and phosphate dissolving bacteria inoculation on berry physical properties of Flame seedless grapevines, during 2022 and 2023 seasons

Treatments	Berry weight (g)		Berry longitudinal (cm)		Berry equatorial (cm)		Shape index	
	2022	2023	2022	2023	2022	2023	2022	2023
Control	2.22	2.19	1.19	1.22	1.18	1.19	1.01	1.04
PDB 50 ml	2.54	2.73	1.24	1.27	1.20	1.25	1.03	1.02
PDB 100 ml	2.75	2.77	1.29	1.32	1.24	1.30	1.04	1.01
PDB 150 ml	2.83	2.92	1.31	1.35	1.28	1.31	1.02	1.03
AMF 50 g	2.87	2.97	1.36	1.39	1.30	1.35	1.04	1.03
AMF 100 g	3.05	3.31	1.42	1.44	1.35	1.41	1.05	1.02
AMF 150 g	3.13	3.37	1.44	1.45	1.41	1.43	1.02	1.01
PDB 50 ml + AMF 50 g	3.37	3.42	1.42	1.46	1.43	1.31	1.02	1.03
PDB 100 ml + AMF 100 g	3.39	3.61	1.47	1.48	1.44	1.46	1.03	1.01
PDB 150 ml + AMF 150 g	3.49	3.68	1.49	1.51	1.44	1.47	1.03	1.03
New LSD at 5%	**0.32**	**0.44**	**0.23**	**0.23**	**0.22**	**0.24**	**NS**	**NS**

The obtained data concerning the effect of PDB or/and AMF inoculations on cluster physical properties were similar with those obtained previously by: **Aslantas *et al.* (2007)** on ‘Granny Smith’ and ‘Stark Spur Golden’ apple cultivars; **Tripathi *et al.* (2014)** on strawberry cv. Chandler; **Cao *et al.* (2021)** on citrus grown in poor soils; **Zaid *et al.* (2021)** on pomegranate trees cultivars Wonderful, H116 and Manfalouty; **Maity *et al.* (2022)** on pomegranate and **Vijayalakshmi *et al.* (2022)** on ‘Muscat Hamburg’ grapevines.

3.3. Effect of PDB or/and AMF on berry chemical properties

Data concerning the effect of single or companied inoculations with PDB and AMF at different doses on berry chemical properties (TSS%, reducing sugars%, total acidity and total anthocyanins) of ‘Flame Seedless’ grapevine grown in loamy clay soil under El-Minia Governorate conditions during 2022 and 2023 seasons are shown in Table (4). It is clear from these table that inoculate ‘Flame Seedless’ grapevines with PDB or/and AMF were capable to cause a significant promotion in berry chemical properties.

3.3.1. Berry Juice TSS, reducing sugars and total acidity

Table (4) shows that, PDB or/and AMF inoculations were capable of causing significant promotion in TSS (%) and reducing sugars contents (%) in berry juice of ‘Flame Seedless’ grapevines over the control vines (un-inoculated vines), during the two experimental seasons. Gradual and significant increment in juices total soluble solids and reducing sugars was parallel to increasing the dose of each micro-organism from 50 to 150 g or ml/vine. The data shows that, the vines received the highest dose of PDB (150 ml/vine) and AMF (150 g/vine) in combination produced the maximized TSS (21.5% & 22.0%) and reducing sugars (19.1% & 19.4%) in their berries, during the two experimental seasons respectively. Contrary, untreated ‘Flame Seedless’ grapevine present the minimized TSS (18.4% & 18.3%) and reducing sugars (16.6% & 16.4%) in their berries, in both experimental seasons respectively.

The same Table declared that, during the two experimental seasons inoculate ‘Flame Seedless’ grapevine with PDB or/and AMF was associated with remarkable and significant decrease in total acidity. This decrement was parallel with increasing the dose of each micro-organism from 50 to 150 g/vine or ml/vine, in both experimental seasons. The obtained data also declared that, all combined inoculation with PDB and AMF shows more effective on total acidity decrement rather than using each micro-organism individually. However, inoculated the vines with AMF individually at different doses was more effective than PDB inoculations. Inoculated the vines with PDB (at 150 ml/vine) and AMF (at 150 g/vine) in combination present the lowest total acidity (0.571% & 0.539%) in berry juice, during the two experimental seasons respectively. In the opposite side, the control vines (un-inoculated vines) present the highest total acidity percentage (0.694% & 0.699%), during the two experimental seasons respectively.

The role of PDB or/and AMF inoculation in improving TSS%, reducing sugars% and decreasing the total acidity % and, which obtained in the present study was in accordance with the results of some other studies carried also on some grapevines cultivars, such as: **Farag, 2006; Sharma & Kumar (2008); Ibrahim *et al.* (2009); Carvajal-Munoz & Carmona-Garcia (2012); Shaheen *et al.* (2013); Ibrahim, 2015; Hammad *et al.* (2020); Swaminathan *et al.* (2020) and Vijayalakshmi *et al.* (2022)**.

3.3.2. Berry total anthocyanins

Data illustrated in Table (4) shows that inoculate 'Flame seedless' grapevines with PDB (at 50, 100 and 150 ml/vine) or/and AMF (at 50, 100 and 150 g/vine) was significantly accompanied with increasing the total anthocyanins contents (mg/100g F.W.) in both experimental seasons. It is worth to mention that, the increment of total anthocyanins was parallel with increasing the dose of PDB or AMF from 50 to 150 ml/vine or g/vine. In this respect regarding the dose of each micro-organism, the vines inoculated with PDB shows more affected than those inoculated with AMF, in both experimental seasons. However, the combined inoculation with PDB and AMF shows more effective in enhancing berry total anthocyanins rather than using each micro-organism alone. These findings were true during the two experimental seasons. Furthermore, the vines received the highest doses of PDB (150 ml/vine) and AMF (at 150 g/vine) in combination present the maximized anthocyanins contents in their berries (149 & 166 mg/100g F.W.), during the experimental seasons respectively. On the opposite side, the minimized total anthocyanins (78 & 76 mg/100g F.W.) were contents obtained from untreated vines during the two seasons respectively.

Table (4). Effect of mycrrohiza and phosphate dissolving bacteria inoculation on berry chemical properties of Flame seedless grapevines, during 2022 and 2023 seasons

Treatments	TSS (%)		Reducing sugars (%)		Total acidity (%)		Total anthocyanins (mg/100g F.W.)	
	2022	2023	2022	2023	2022	2023	2022	2023
Control	18.4	18.3	16.6	16.4	0.694	0.699	78	76
PDB 50 ml	18.9	18.9	17.0	17.1	0.670	0.672	88	92
PDB 100 ml	19.2	20.1	17.2	17.4	0.663	0.642	96	99
PDB 150 ml	19.3	20.4	17.4	17.8	0.659	0.599	102	109
AMF 50 g	19.5	20.5	17.6	17.8	0.661	0.610	81	90
AMF 100 g	19.8	20.9	17.9	18.2	0.648	0.594	90	97
AMF 150 g	20.0	21.3	18.1	18.4	0.631	0.572	101	105
PDB 50 ml + AMF 50 g	20.1	21.4	18.2	18.5	0.633	0.567	122	124
PDB 100 ml + AMF 100 g	21.4	21.9	18.9	19.3	0.577	0.542	139	159
PDB 150 ml + AMF 150 g	21.5	22.0	19.1	19.4	0.571	0.539	149	166
New LSD at 5%	0.5	0.5	0.4	0.5	0.020	0.022	9	8

Zaid *et al.* (2021) mentioned that inoculate pomegranate trees with mycorrhizal fungi (AMF) and phosphorous-dissolving bacteria (PDB) was capable to improving all fruit chemical properties. Furthermore, **Vijayalakshmi *et al.* (2022)** stated that Inoculation 'Muscat of Hamburg' grapevines with PDB and potassium releasing bacteria each one alone or in combination as a shifty replaced for menial fertilizers. The authors found that all chemical quality parameters (TSS, TSS /acid ratio and reducing sugars contents) were significantly improved rather than control treatment. In harmony with our results **Ibrahim (2015)** on ‘Superior’ and ‘Early Superior’ grapevines; **Swaminathan *et al.* (2020)** on fruit quality and nutrient uptake in Purple; **Maity *et al.* (2022)** on pomegranate trees and **Vijayalakshmi *et al.* (2022)** on ‘Muscat Hamburg’ grapevines mentioned similar findings.

The synergistic relationship that was observed between Mycrrohiza and PDB in the present investigation maybe due to involved in providing nutrients **(Ibrahim *et al.*, 2009 and Ibrahim, 2015)**, remove inhibitory products and facilitate this process in plant development as well as regulation the hormones **(Bashan & Holguin, 1997 and Grzyb *et al.*, 2015)**.

4. Conclusion

In order to enhancing yield and fruit physical and chemical properties of ‘Flame Seedless’ grapevines grown under El-Minia Governorate in loamy clay soil and resembling conditions, inoculated the vines with PDB and AMF at different concentration cane significantly improved the productivity and berries quality. However, from the obtained data it is preferable to inoculation ‘Flame Seedless’ grapevines three times yearly with AMF (at 150 g/vine) combined with PDF (at 150 ml/vine).

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