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Effect of Inoculation with Diazotrophic Bacteria on 'Solo' Papaya Fruit Quality

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Abstract: A field experiment was conducted during 2022 and 2023 aimed to declare the response of 'Solo' papaya trees productivity and fruit quality to inoculation with *Azospirillum* and *Azotobacter* as a diazotrophic bacteria. It is clay from the obtained results that, under clay loam soil under El-Minia Governorate conditions that inoculated 'Solo' papaya trees with diazotrophic bacteria (*Azospirillum* and *Azotobacter spp*.) significantly improved yield and its components as well as fruit physicochemical properties. However, *Azospirillum* inoculation shows more effective rather than *Azotobacter* inoculation, on all studied properties. Furthermore, increasing the doses from 50 to 150 ml significantly improved all studied parameters. In addition, the companied inoculation with both examined micro-organisms at higher dose (150 ml) produced the best yield, fruit number/tree, fruit weight (g) as well as all physical and chemical properties.

Key words: Solo Papaya, diazotrophic bacteria, Azospirillum, Azotobacter, yield fruit quality.

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1. Introduction

Papaya trees are a member of family *Papayaceae*. It is a tropical evergreen fruit trees. Mexico and the West Indies are considered as a place of origin. In Egypt and many other Arab countries, papaya fruit was considered as a secondary fruit crop that was not widespread, perhaps because consumers were not accustomed to it taste (**Ibrahim, 2011**). However, in the current period, it has become increasing popular as a result of its intensive medical uses and fresh consumption. In contrast, in tropical countries, papaya fruit is one of the most farms and economical fruit. The stage of papaya fruit ripeness used depended on fruit uses (**Quintana, 1991**). Papaya fruits contain high levels of the enzyme papain which is similar in its effect of pepsin and trypsin enzymes. The world interesting of this plant has greatly increased, especially in the pharmaceutical industry and in preparations that treat digestive illnesses whose rates have risen recently. Furthermore, it considered as one of the higher nutritional value plants, it is rich in protein, carbohydrates, vitamins and mineral elements.

Inoculation of papaya trees with diazotrophic bacteria serve as alternatives to inorganic fertilizers. The utilization of bio-inoculants in papaya trees cultivation accelerates papaya tree growth, can improve soil quality and increase crop yield also, and an increase in soil organic matter was observed. Furthermore, the nutrient content and water retention capacity of the soil were improved (**Jadia *et al.*, 2019**). Diazotrophic bacteria inoculation can also supplement a considerable quantity of micronutrients such as N, P, and K, and enhance the accessibility of applied and native soil nutrients (**Jadia *et al.*, 2019**). *Azosprillum* and *Azotobacter* are diazotrophic bacteria frequently employed in agriculture sector as fixing nitrogen biofertilizers. These two micro-organisms were capable to not only fixing nitrogen but also secreting phytohormones such gibberellinic and indolic varieties, which facilitated nutrient assimilation, photosynthesis, and plant growth absorption of nutrients and photosynthesis process (**Fayze *et al.*, 1985; Ibrahim *et al.*, 2020 and Ipek & Esitken2022**).

The overall aim of this experiment is to improve understanding of the influence of inoculate 'Solo' papaya trees with diazotrophic bacteria (*Azospirillum* or/and *Azotobacter*) on yield and its component and fruit physical and chemical properties.

2. Materials and Methods

The present investigation was carried out during two seasons (2022 and 2023), on 'Solo' papaya trees cultivated in the Horticulture department nursery, Faculty of Agriculture, Minia University, Minia Governorate - Egypt, where the soil texture was clay loam and surface irrigation system using Nile water was adapted. Thirty uniforms in vaguer, three years old female Solo papaya trees (*Carica papaya L.*), planted at 1.5 X 2 meters apart, were selected for achieving this experiment. The chosen female trees are subjected to regular horticulture practices that were commonly applied in papaya orchards: fertilization, surface irrigation, hoeing and pest management.

2.1. Soil analysis

The soil of horticulture nursery, where the present experiment carried out, was clay loam. A composite sample of soil was collected and subjected to physicochemical analysis according to the procedures outlined by **Ward and Johnston (1962) and Walsh and Beaton (1986)**. The data are shown in Table (1).

Table (1). Physicochemical analysis of experimental nursery soil

Physical properties			**Exchangeable nutrients**		
Soil Section	**Surface 0 - 30 cm**	**Subsurface 30 - 60 cm**	**Soil section**	**Surface 0 – 30 cm**	**Subsurface 30 - 60 cm**
Sand (%)	28.91	28.90	**Ca++ (mg/100 g)**	31.12	31.43
Silt (%)	29.89	30.64	**Mg++ (mg/100 g)**	3.51	3.56
Clay (%)	41.20	40.46	**Na+ (mg/100 g)**	2.51	2.50
Soil type	Clay loam	Clay loam	**K+ (mg/100 g)**	2.85	2.64
Chemical properties			**DTPA-Extractable nutrients**		
Soil Section	**Surface 0 - 30 cm**	**Subsurface 30 - 60 cm**	**Soil section**	**Surface 0 – 30 cm**	**Subsurface 30 - 60 cm**
PH (1:2.5)	7.75	7.71	**Fe (ppm)**	8.23	8.11
E.C. (dS/m)	1.08	1.06	**Cu (ppm)**	2.01	2.00
O.M.	1.54	1.59	**Zn (ppm)**	2.87	2.89
Active lime	2.11	2.10	**Mn (ppm)**	8.11	8.15

2.2. Experimental work

This experiment included ten treatments, each one included three replicates. Then, the total number of trees equal thirty female trees.

2.3. Preparation of micro-organisms strains

Under the supervision of Microbiology Department, Faculty of Agriculture - Minia University technical staff. Five soil samples were collected from different locations in Minia for isolation and preparation of *Azospirillum* bacteria (according to (**Dobereiner *et al.*, 1976**) and *Azotobacter* (**Abdel-Malek and Ishac, 1968** and **Dobereiner *et al.*, 1976**) bacteria.

For achieving the female trees pollination, male's trees were used in ratio of one male tree for ten female trees. Only the female trees were inoculated with the two examined microorganisms individually or in combinations as follows: Control without inoculation; 50 ml Azospirillum / tree; 100 ml Azospirillum / tree; 150 ml Azospirillum /tree; 50 ml Azotobacter / tree; 100 ml Azotobacter / tree; 150 ml Azotobacter /tree; 50 ml Azospirillum / tree + 50 ml Azotobacter / tree; 100 ml Azospirillum / tree + 100 ml Azotobacter / tree and 10-150 ml Azospirillum / tree + 150 ml Azotobacter / tree

2.4. Experimental design and statistical analysis

The experiment is designed in the form of complete randomized block design (RCBD). *Azospirillum* and *Azotobacter* bacteria are inoculated three times during the papaya trees vegetative growth (early December, early February and early April). However, each treatment was repeated three times, each one represented by single tree. The obtained data were illustrated in tables, and subjected to statistical analysis. The researchers contrasted the means of the treatments using the new L.S.D. Test as described by **Snedecor and Cochran (1990)**

2.5. Different measurements and analysis conducted

2.5.1. Yield and fruit physical parameters

Under Egyptian environmental conditions, papaya trees produce two main crops; the first one ripens at the beginning of summer and the second one ripens at the autumn. Therefor the two crops were collected and the results concerning the yield and fruit physicochemical properties are the average of these two mains crops. At maturation stage (the fruit reach to standard size of cultivar and begin to turning color from green (initial peel color) to yellow (Final peel color), the mature fruits are harvested from each tree separately. Then a random sample of four mature fruits was taken off from different points of each tree (replicate) at harvest time. The following physical parameters were achieved: Fruits numbers per tree; average fruit weight; yield (kg/tree); Fruit dimensions (fruit length and fruit diameter in cm); pulp weight (g), seeds weight (g) and peel weight (g) and then the pulp/seed ratio was calculated.

2.5.2. Chemical properties

The following parameters were achieved: percentages of Total soluble solids in fruit pulp (by using a hand refractometer); reducing, non-reducing and total sugars percentages (using the volumetric techniques described by **Lane and Eynon (1965)** sited in in **A.O.A.C (2000)**; total acidity percentage (by volumetric titration with 0.1 N sodium hydroxide, according to **A.O.A.C, 2000**) and vitamin C contents (by using titration with 2-6 Dichlorophyenol indphynol pigment).

3. Results and Discussion

3.1. Effect of *Azospirillum* and *Azotobacter* inoculations on yield and its components

It is clearly shown from the obtained data in Tables (2) that inoculate 'Solo' papaya trees with *Azospirillum* or/and *Azotobacter* significantly was significantly improved yield (kg / tree), number of fruit/tree and fruit weight in compared to un-inoculated trees (control). The promotion on the yield (kg) per tree, fruit weight, fruit number/tree was in proportional to the increase the doses used from each micro-organism from 50 ml to 150 ml. However, all *Azospirillum* or/and *Azotobacter* inoculation present

higher fruit weight, fruit number per tree and yield per tree in the second season rather than those obtained in the first season.

It is clear from Table (2) that inoculated 'Solo' papaya trees with *Azospirillum* bacteria individually shows more effective in enhancing fruit weight (g), number of fruit per tree and yield (kg/tree) rather than inoculation with *Azotobacter* bacteria, each one individually, these data were true during the two experimental seasons. Moreover, Regardless the doses used, inoculated 'Solo' papaya trees with the two micro-organisms (*Azospirillum* and *Azotobacter*) in combination produced higher and significant yield, fruit weight and fruit number per tree rather than inoculated the trees with each one individually, during the two experimental seasons. Furthermore, the trees inoculated with *Azospirillum* and *Azotobacter* in combination at highest dose (150 ml) present the highest fruit weight, fruit number per tree and highest yield (kg/tree), during the two seasons respectively. In the opposite side, un-inoculated trees present the lowest fruit weight, fruit number / tree and lowest yield (kg/tree). These findings were true during the two experimental seasons respectively.

The impact of enhancing yield kg/tree, fruit number as well as fruit weight (g) was associated with the improvement of leaf stimulatory effect on photosynthetic pigment biosynthesis as well as net photosynthetic rate which significantly improved due to the inoculations with the two growth promoter bacteria such Azospirillum and Azotobacter, as illustrated by some authors such as: **Quintana (1991); Constantino *et al.* (2010); Singh & Varu (2013); Mamta *et al.* (2017); Srinu *et al.* (2017); Shivanan *et al.* (2019); Lanjhiyana *et al.* (2020); Singh and Tripathi (2020); Zhou *et al.* (2020) and Baldev and Sahu (2021)** on different papaya cultivars.

Table (2). Effect of Azospirillum and Azotobacter inoculations on number of fruits/tree, fruit weight (g) and yield (kg/tree) of *Carica papaya* cv. Solo, during 2022 and 2023 seasons

Treatments	Fruit No./tree		Fruit weight (g)		Yield (kg/tree)	
	2022	2023	2022	2023	2022	2023
Control	18	19	422	419	7.60	7.96
AZSB. 50 ml	22	24	439	451	9.66	10.82
AZSB 100 ml	25	26	455	482	11.38	12.53
AZSB 150 ml	32	34	501	522	16.03	17.75
AZB 50 ml	20	22	439	441	8.78	9.70
AZB 100 ml	19	27	477	479	9.06	12.93
AZB 150 ml	20	22	499	511	9.98	11.24
AZSB 50 ml+ AZB 50 ml	30	32	521	554	15.63	17.73
AZSB 100 ml + AZB100 ml	35	40	549	547	19.22	21.88
AZSB 150 ml + AZB 150 ml	38	44	612	662	23.26	29.13
New LSD at 5%	**4**	**6**	**22**	**24**	**1.3**	**2.1**

3.2. Effect of Azospirillum and Azotobacter inoculations on fruit physical parameters

Data illustrated in Tables (3 & 4) shows the response of fruit physical properties of 'Solo' papaya trees grown in clay loam soil under El-Minia Governorate conditions to inoculation with *Azospirillum* and *Azotobacter* at different doses (50, 100 and 150 ml), during 2022 and 2023 seasons.

3.2.1. Effect on fruit dimensions and fruit shape index

The obtained data in Table (3) shows that inoculated 'Solo' papaya trees with the two examined micro-organisms (*Azospirillum* and *Azotobacter*) individually or in combinations significantly improved the fruit dimensions (length and diameter) in comparison with un-inoculated trees, during both

experimental seasons. It is clear from the obtained data that, the individual inoculations with both examined micro-organisms, regarding the doses used, the trees inoculated with *Azospirillum* bacteria produced higher and significant fruit length and diameter rather than those inoculated with *Azotobacter* bacteria or un-inoculated one. The increment in fruit dimensions was parallel to increasing the dose used from each micro-organism. In the same context the trees inoculated with the two examined micro-organisms (*Azospirillum* and *Azotobacter*) in combination produced highest fruit length and diameter compared to those inoculated with each micro-organism individually. These data were true during both experimental seasons (2022 and 2023).

Furthermore, Table (3) clearly shows that, the trees inoculated with the combined *Azospirillum* and Azotobacter at 150 ml for (each one) produced the highest fruit length (14.0 cm & 14.9 cm) and fruit diameter (7.5 cm & 7.8 cm) during the two experimental seasons respectively. On the other hand, un-inoculated trees (control) produced fruits with lower length (11.2 cm & 11.5 cm) and diameter (5.3 cm & 5.3 cm), in both experimental seasons respectively. On the opposite side, the obtained results as recorded in Table (9) shows that all treatments involve inoculating the trees with the two examined micro-organisms (*Azospirillum* or/and *Azotobacter*) not exert any significant effect on the shape of fruit, neither in the first season nor in the second season. This may have been the response of both fruit length (cm) and fruit diameter (cm) responding to the treatments in an identical manner. Consequently, the fruit retained their usual shape, which tends to elongate shape.

Table (3). Effect of Azospirillum and Azotobacter inoculations on fruit physical properties of *Carica papaya* cv. Solo, during 2022 and 2023 seasons

Treatments	Fruit length (cm)		Fruit diameter (cm)		Fruit shape index	
	2022	2023	2022	2023	2022	2023
Control	11.2	11.5	5.3	5.3	2.11	2.16
AZSB. 50 ml	11.8	11.9	5.6	5.7	2.10	2.08
AZSB 100 ml	12.5	12.9	6.2	6.4	2.01	1.99
AZSB 150 ml	12.9	13.0	6.6	6.8	1.96	1.91
AZB 50 ml	11.6	11.9	5.5	5.8	2.10	2.05
AZB 100 ml	12.3	12.4	6.1	6.2	2.01	2.00
AZB 150 ml	12.5	12.8	6.2	6.4	1.99	2.00
AZSB 50 ml+ AZB 50 ml	12.9	13.1	6.7	6.7	1.93	1.95
AZSB 100 ml + AZB100 ml	13.3	14.0	7.0	7.3	1.90	1.9
AZSB 150 ml + AZB 150 ml	14.0	14.9	7.5	7.8	1.89	1.90
New LSD at 5%	**0.7**	**0.8**	**0.5**	**0.4**	**NS**	**NS**

3.2.2. Effect on fruit pulp weight, peel weight, seed weight and pulp/seeds ratio

The obtained data in Table (4) shows that inoculated 'Solo' papaya trees with the two examined micro-organisms (*Azospirillum* and *Azotobacter*) individually or in combinations significantly improved the fruit pulp weight (g) and pulp weight to seeds ratio rather than un-inoculated trees, during both experimental seasons. it same clear from the obtained data that inoculate the 'Solo' papaya trees with the two examined micro-organisms individually or in combination significantly enhanced fruit pulp weight (g) and fruit pulp to seeds ratio during both experimental seasons (2022 and 2023). Furthermore, inoculation with Azospirillum shows superior rather than inoculation with Azotobacter in the two characters, pulp weight and pulp weight / seeds weight, these findings were true during the both experimental seasons.

It is clear from the obtained data that inoculate 'Solo' papaya trees with the tow examined micro-organisms (*Azospirillum* and *Azotobacter*) in combinations produced higher and significant fruit pulp weight (g) and pulp weight to seeds weight rather than using each micro-organism individually. In addition, increasing the doses of the two examined micro-organisms (each one single or in combination) was parallel to increasing pulp weight and pulp weight to seeds ratio. The same table shows that the trees inoculated with combined application of the two examined micro-organisms (*Azospirillum* and *Azotobacter*) at highest dose (150 ml) produced the highest pulp weight (540.8 g & 590.9 g) and highest pulp to seeds ratio (22.8 & 24.5), during the both experimental seasons respectively. On other hand, the lowest fruit pulp weight (351.5 g & 348.2 g) and fruit pulp to seeds weight (14.5 & 15.0) of Solo papaya fruits were obtained from un-inoculated trees. These data were true during the two seasons (2021 and 2022) respectively. On the opposite side, regardless the doses used, all inoculation with Azospirillum or/and *Azotobacter* failed to varied significantly the fruit peel weight (g) and seeds weight (g/fruit), neither in the first season nor in the second seasons.

The promotion of fruit physical properties as a result of inoculate 'Solo' papaya trees with *Azospirillum* or/and *Azotobacter* bacteria at different doses (from 50 to 150 ml), which found in the present investigation, may be attributed to the following facts: growth-promoting microorganisms (PGPM) such as *Azospirillum* and *Azotobacter* bacteria have enhance plant mineral nutrients availability and uptick and net photosynthesis activity directly or indirectly by producing different types of phytohormones, iron-binding metabolites and dissolving the nutrients and minerals in soil **(Mahmud and Chong, 2021)**. Biofertilizers inoculation can increase soil fertility, and promote antagonism and biological control of phytopathogenic organisms (**Chirinos & Montilla, 2006 and Corpoica, 2007)** this can reflect the enhancement of fruit physical properties, which found in our investigation. Historically the most studied on plant growth-promoting bacteria are species of *Azospirillum* and *Azotobacter* genus are a typical example of plant-bacteria interactions. These specious were first isolated and evaluated on cereals before being commercialized. This to examined genus (Azospirillum and Azotobacter) can provide fruit physical properties and lead to a decrease the environmental pollution with heavy metals (**Alalaf, 2020)**. **Abobatta and El-Azazy, 2020** confirmed that using biofertilizers lead to increasing soil nutrient availability, improving soil characteristics, and minimizing the destructive repercussions of pathogenic organisms.

Table (4). Effect of Azospirillum and Azotobacter inoculations on fruit physical properties of *Carica papaya* cv. Solo, during 2022 and 2023 seasons

Treatments	Pulp weight (g)		Peel weight (g)		Seeds weight (g)		Pulp/seeds ratio	
	2022	2023	2022	2023	2022	2023	2022	2023
Control	351.5	348.2	48.2	47.9	24.3	23.2	14.5	15.0
AZSB. 50 ml	368.2	378.3	47.7	49.2	23.1	23.5	15.9	16.1
AZSB 100 ml	401.7	409.4	48.1	48.8	23.2	23.8	17.3	17.2
AZSB 150 ml	435.0	450.7	47.5	47.1	23.5	24.2	18.5	19.2
AZB 50 ml	366.0	371.3	49.1	46.8	23.9	22.9	15.3	16.2
AZB 100 ml	395.8	408.2	47.3	47.1	23.9	23.7	16.6	17.2
AZB 150 ml	427.8	440.1	47.1	46.4	24.1	24.5	17.7	17.9
AZSB 50 ml+ AZB 50 ml	446.5	478.2	51.2	52.3	23.3	23.5	19.2	20.3
AZSB 100 ml + AZB100 ml	476.9	475.9	48.9	47.2	23.2	23.9	20.6	19.9
AZSB 150 ml + AZB 150 ml	540.8	590.9	47.5	47.0	23.7	24.1	22.8	24.5
New LSD at 5%	**31.3**	**30.4**	**NS**	**NS**	**NS**	**NS**	**1.4**	**1.3**

3.3. Effect of Azospirillum and Azotobacter inoculations on fruit chemical parameters

3.3.1. Effect on TSS% and fruit sugars contents

Data concerning the effect of inoculation 'Solo' papaya trees with *Azospirillum* and *Azotobacter*, individually or in combination, at different doses (50, 100 and 150 ml) on fruit TSS%, reducing sugars %, non-reducing sugars and total sugars % in the pulp of 'Solo' papaya fruit, during 2022 and 2023 seasons are shown in Tables (5). It is clear from the obtained data that inoculate 'Solo' papaya trees with the two examined micro-organisms either individually or in combination significantly was responsible to improving fruit chemical properties (in terms of increasing TSS %, reducing & non-reducing sugars% and total sugars%) rather than un-inoculation trees. these findings were true during the two experimental seasons (2022 and 2023).

It is clear from Tables (5) that, the promotion on TSS% and sugars contents of papaya fruits was associated with increasing the doses of both examined micro-organisms (from 50 ml to 150 ml). however Un-significant effect on the TSS% and Sugars contents were observed due to increasing the doses of *Azospirillum* or/and *Azotobacter* from 100 ml to 150ml. Data in Table (5) also pronounced that, inoculation 'Solo' papaya trees with *Azospirillum* and *Azotobacter*, each one at 150 ml in combination, produced the highest TSS%, reducing sugars, non-reducing sugars and total sugars in fruit pulp. On the opposite side, the lowest total soluble solids %, reducing sugars %, non-reducing % and total sugars % were obtained from un-inoculated trees, these data were true during the two experimental seasons.

Table (5). Effect of Azospirillum and Azotobacter inoculations on TSS%, Reducing sugars% and non-reducing sugars% of *Carica papaya* cv. Solo, during 2022 and 2023 seasons

Treatments	TSS %		Reducing sugars %		Non-reducing sugars %	
	2022	2023	2022	2023	2022	2023
Control	9.7	9.6	6.1	6.0	1.6	1.5
AZSB. 50 ml	10.1	10.1	6.4	6.6	1.9	2.0
AZSB 100 ml	10.4	10.5	6.6	6.7	2.1	2.2
AZSB 150 ml	10.6	10.6	6.8	6.8	2.1	2.1
AZB 50 ml	10.1	10.2	6.2	6.4	1.7	1.7
AZB 100 ml	10.3	10.4	6.4	6.5	1.9	2.0
AZB 150 ml	10.4	10.5	6.7	6.8	2.0	2.1
AZSB 50 ml+ AZB 50 ml	10.7	10.9	7.0	7.1	2.1	2.3
AZSB 100 ml + AZB100 ml	11.0	11.2	7.2	7.3	2.2	2.4
AZSB 150 ml + AZB 150 ml	11.6	11.9	7.4	7.6	2.3	2.5
New LSD at 5%	**0.8**	**0.9**	**0.5**	**0.7**	**0.11**	**0.14**

3.3.2. Effect on fruit total acidity% and vitamin C contents

Data concerning the effect of inoculation 'Solo' papaya trees with *Azospirillum* and *Azotobacter*, individually or in combination, at different doses (50 ml, 100 ml and 150 ml) on fruit pulp total acidity % and vitamin C contents (mg/100g F.W.) of 'Solo' papaya, during 2022 and 2023 seasons are shown in Table (6). It is worth to mention that, regardless the type of micro-organism inoculated (individually or in combination) and the doses used of each micro-organism, during the first season all treatments failed to improve fruit total acidity and vitamin C contents significantly. Contrary to the first season, it is clear from the obtained data during the second season that inoculated 'Solo' papaya trees with *Azospirillum* or/and *Azotobacter* lead to significantly decrease fruit total acidity in comparison with un-inoculated trees (control) during the second experimental season only. While, fruit vitamin C contents (mg/100g F.W.) of 'Solo' papaya significantly increased as a result of inoculate the trees with

Azospirillum or/and *Azotobacter* rather than those un-inoculated trees. These findings were true only in the second experimental season (2023). Regarding the two examined micro-organisms and the doses used, in the second season, the trees inoculated with *Azospirillum* present lower total acidity % and higher vitamin C contents in their fruits in comparison with those inoculated with *Azotobacter*. Furthermore, increasing the dose used from 50 ml to 150 ml, for each examined micro-organism individually or in combination. was parallel with decreasing total acidity and increasing vitamin C contents in 'Solo' papaya fruit pulp, only during the second seasons (2023). Furthermore, during the second season, the trees received both micro-organisms in combinations present lowest total acidity and higher vitamin C contents in their fruit pulp rather than those inoculated with each micro-organism individually, regardless the dose used. Then, the trees inoculated with 150 ml *Azospirillum* combined with 150 ml *Azotobacter* present the lowest total acidity and highest vitamin C contents. Contrary, un-inoculated trees produced the highest total acidity and lowest vitamin C contents in their fruit pulp. These findings were true during the second season only.

Responses on the chemical properties of papaya fruits to inoculation with *Azospirillum* and *Azotobacter* have been evaluated by some authors on other different papaya cultivars such as: **Reddy *et al.* (2012),** on papaya cv. Surya the authors mentioned that using Implementation of 50% from (Mycorrhiza+ Azospirillum+ vermin-compost + Phosphate solubilizing bacteria) exhibited a high fruit chemical properties; **Singh and Varu (2013)** studied the integrated nutrient management for papaya using (Azotobacter + phosphate solubilizing bacteria + 1/2 recommended mineral fertilizers dose) on papaya trees production and fruit quality, the authors found that that using the bio-fertilizers in combination with half of recommended dose of mineral fertilizers produced the highest fruit physic-chemical properties; in the same context **Baldev and Sahu (2021)** examined the response of 'Red lady' papaya to Azospirillum and phosphate dissolving bacteria inoculations, and the authors concluded the same findings, and the findings of **Mamta *et al.* (2017)** on bio-fertilization (Azotobacter and PSB individually or in combination) on the fruit quality of Red lady papaya.

Table (6). Effect of Azospirillum and Azotobacter inoculations on total sugars%, total acidity % and vitamin C (mg/100g F.W) of *Carica papaya* cv. Solo, during 2022 and 2023 seasons

Treatments	Total sugars %		Total acidity %		Vitamin C (mg/100g)	
	2022	2023	2022	2023	2022	2023
Control	7.6	7.5	0.354	0.346	36.5	31.7
AZSB 50 ml	8.3	8.6	0,336	0,327	37.3	39.5
AZSB 100 ml	8.7	8.9	0.321	0.319	39.5	41.5
AZSB 150 ml	8.9	8.9	0.327	0.316	42.5	44.7
AZB 50 ml	7.4	8.1	0.357	0.334	40.1	37.3
AZB 100 ml	8.3	8.5	0.345	0.339	40.3	41.9
AZB 150 ml	8.7	8.9	0.339	0.337	43.7	42.3
AZSB 50 ml+ AZB 50 ml	9.1	9.4	0.329	0.287	44.7	48.4
AZSB 100 ml + AZB100 ml	9.4	9.7	0.321	0.231	46.9	51.7
AZSB 150 ml + AZB 150 ml	9.7	10.1	0.329	0.211	47.7	52.9
New LSD at 5%	**0.3**	**0.5**	**NS**	**0.022**	**NS**	**5.2**

4. Conclusion

It is clay from the obtained results that, under clay loam soil under El-Minia Governorate conditions that inoculated 'Solo' papaya trees with diazotrophic bacteria (*Azospirillum* and *Azotobacter spp*.) significantly improved yield and its components as well as fruit physicochemical properties. However, *Azospirillum* inoculation shows more effective rather than *Azotobacter* inoculation, on all studied properties. Furthermore, increasing the doses from 50 to 150 ml significantly improved all studied parameters. In addition, the companied inoculation with both examined micro-organisms at higher dose

(150 ml) produced the best yield, fruit number/tree, fruit weight (g) as well as all physical and chemical properties.

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