



Effect of Bio-fertilization and Nano-silica on Maize Plant at New Valley

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A FIELD experiment was carried out on maize at the New Valley to examine its response to some bio-fertilizers applied separately or with spray with Nano-silica K. The three bio-fertilizers are *Azospirillum brasilense*, *Azospirillum lipoferum*, and mycorrhiza, in addition to their interactions and a control treatment (without biofertilizer). All 16-combination treatments were arranged in split plot technique in three randomized complete blocks. The objective of this work was to examine the mutual influences of all applied treatments on some maize growth parameters. The treatment comprised of inoculation with $\frac{1}{2}$ *Azospirillum brasilense* + $\frac{1}{2}$ *Azospirillum lipoferum* + mycorrhiza + spraying of Nano silica—K proliferated the highest significant total bacterial counts, total *Azospirillum brasilense*, total *Azospirillum lipoferum*, total mycorrhizal counts, dehydrogenase activity, phosphatase enzyme, and root colonization by mycorrhiza in both years of study. *Azospirillum lipoferum* significantly showed better performance in all measured properties than *Azospirillum brasilense*. Spray of the aerial parts of maize plant with Nano-silica K could indirectly affect counts of biological inoculants in the soil under maize plants at the New Valley in both years of study. It can be recommended to add Nano-silica K to the rhizosphere to practice its direct influence on the activities of soil micro fauna.

Keywords: Arbuscular mycorrhiza, *Azospirillum brasilense*, *Azospirillum lipoferum*, Maize, Nano silica K, The New Valley.

Introduction

Fulchieri et al. (1993) found that maize seedlings were inoculated with three strains of *Azospirillum lipoferum* or cultured in different concentrations of indol-3-acetic acid (IAA) or gibberellin A₃ (GA₃). After 48hrs., root length, root surface area, root dry weight, and shoot dry weight were measured in all treatments. Gibberellin content was evaluated in selected roots of all seedlings. They found that the three strains of *A. lipoferum* significantly enhanced root hair growth and density than IAA and GA₃ soaking treatments. Their finding points to that *Azospirillum lipoferum* significantly contributed to the establishment of a vigorous root growth proliferating for healthy plant growth, thence a greater potential for enhanced grain yield.

Shekh (2006) fertilized maize with various sources of bio-fertilizers including nitrogen fixers, phytostimulators, phosphate solubilizing bacteria, and plant growth promoting rhizobacteria. He reported that all sources were beneficial to attain good plants growth and grain yield. In addition, Hungria et al. (2010) stated that using an inoculant containing bacteria that promote plant growth is likely to increase in the coming years due to higher costs of fertilizers, concerns over pollution and emphasis on sustainable agriculture. They recommended *Azospirillum* strains for maize (*Zea mays* L.) fertilization. They evaluated nine *Azospirillum* strains being applied to seeds as peat-based inoculants. Some *A. brasilense* strains increased grain yields of maize by 24–30% in relation to non-inoculated controls. And that, two *A. lipoferum* strains were tested in two separate

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experiments and promising results were obtained. They attributed their findings to general increases in the uptake of several macro and micronutrients and not specifically to biological nitrogen fixation. All experiments on maize received only a low starter dose of N-fertilizer at sowing of 24kg of N ha⁻¹. This result points to a large saving in the amount of N-fertilizers; i.e. big drop in fertilizer cost and lowering the environmental pollution. They also stated that the obtained yields were compatible with Brazilian mean yields. And that, they could identify the first *Azospirillum* strains that are authorized for the production of commercial inoculants in Brazil.

Ferreira et al. (2013) testified the combination of nitrogen and *Azospirillum brasilense* in sandy soils of the Brazilian Cerrado on maize yield and shoot dry weight (SDW). They reported that inoculation with *A. brasilense* gave comparable yield to the nitrogen treatment. And that, the grain production was increased by 29% in the treatment of *A. brasilense* together with mineral nitrogen fertilization as compared to nitrogen fertilization alone.

In the same respect, Morais et al. (2016) applied diazotrophic microorganism of *Azospirillum brasilense* to the seed in the furrow when planting maize at the doses of 0, 100, 200, 300 and 400mL ha⁻¹ in combination with nitrogen fertilizer at the rates of 40, 100, 200 and 300kg ha⁻¹. They found that the dose of 200mL ha⁻¹ *Azospirillum* was noteworthy for grain production at the Cerrado region of Brazil irrespective of nitrogen fertilizer application level. They recommended that the lower the level of N fertilizer application, the greater the benefit obtained from the bio-fertilizer; let's say 40-100kg ha⁻¹.

Rossel & Tarradellas (1991) stated that the inhibition of dehydrogenase activity (DHA) correlated with depression of ATP content ($r=0.82$). Air-drying, remoistening, and substrate addition had little influence on the depression of DHA and of the ATP content. In other words, irrigation and drying of plants does not affect the depression of DHA and of the ATP content. In addition, short-term DHA, as a substrate-induced maximum initial activity, appears mainly to reflect the biomass of soil microflora. The measurement of DHA appears to be a suitable low-cost and sensitive tool for assessing the biomass size in response to the surrounding effects in the

environmental conditions, such as pollutants and other chemicals.

With regard to mycorrhizal influence on plant growth, Zhang et al. (2013) showed that the mean value of soil CO₂ fluxes from 08:00 to 10:00am could represent its daily mean value in summer period (June–August) and that from 09:00am to 12:00pm for the rest seasons of a year. Annual cumulative soil CO₂ fluxes were significantly higher than those in the treatments with non-manure addition. However, the treatments with manure applications represented a carbon sink in the soil (carbon output/input ratio < 1.0), which demonstrated potential for carbon sequestration. They also emphasized the role played by arbuscular mycorrhiza in controlling the fluxes of CO₂ between the aerial and underground parts of maize.

Radwan & Nassar (2011) found that VA-mycorrhizal combined with bio-fertilizer cerealen and 105 kg N/ha was the best treatment to obtain the highest growth attributes, yield, and yield components. Mohammed (2012) showed that maize plants exhibited the highest significant plant height, LAI, 500 kernel weight, biological yield, yield, harvest index (HI), and root-shoot ratio in response to phosphorus bio-fertilizer in the presence of different doses of nitrogen and P₂O₅.

As long as mycorrhiza is a symbiotic association between a fungus and the roots of a vascular plant, Muthukumar (2017) studied the influence of arbuscular mycorrhizal (AM) fungus *Scutellospora calospora* on root architecture, growth, nutrient uptake, root phosphatase activity and mycorrhizal dependency of maize in 0-5% rock phosphate (RP) amended phosphorus (P) deficient soil. RP amendment significantly increased total root length, number of roots in different orders, and root hair diameter of AM plants. The AM fungus positively enhanced maize growth and nutrient uptake. Acid and alkaline phosphatase activities were higher for AM plants in RP amended soils. They stated that AM fungus inoculation along with RP amendment could substitute chemical fertilizers and rendered the P in RP available to the plants.

Salgado et al. (2017) measured shoots dry matter (SDM), roots dry matter (RDM), mycorrhizal colonization and accumulation of calcium, zinc

and phosphorus in the SDM at maize flowering in response to inoculation with five different arbuscular mycorrhizal fungi at Cerrado, Brazil. They concluded that inoculation with mycorrhizal fungi demonstrated different effects for the various parameters evaluated in maize.

Shamsul et al. (2012) suggested a positive correlation between proline accumulation and plant stress, where proline plays a highly beneficial role in plants exposed to various stress conditions. They also stated that proline acts as a metal chelator, an antioxidative defense molecule and a signaling molecule. Therefore, a stressful environment results in an overproduction of proline in plants.

Yuvakkumar et al. (2011) studied the effect of Nano-silica on maize crop improvement. They mixed Nano-silica powders with soil at different concentrations along with control and conventional silica under *in vitro* and *in vivo* conditions. In *in vitro*, the Nano-silica increases seed germination (2–11%), water usage efficiency (up to 53%), and total chlorophyll content (13–17%) of maize crop. In *in vivo*, influence of Nano-silica was analyzed on basic parameters such as stem height, stem width, number of leaves, and silica content. The effect of Nano-silica on maize crop was found to be enhanced in all aspects. Also, Amer & El- Emary (2018) reported that Nano-fertilizers (different concentrations with Nano-silica) can significantly improve soil productivity, enhance nutrition use efficiency, and protect plants from environmental stress.

With respect to Nano-K silica spray on maize plants, Guntzer et al. (2012) reported that silicon (Si) has been found in significant concentrations in plants, but it is generally not considered as an essential element. Silicon can mitigate environmental stresses and soil nutrient depletion and as a consequence is an alternative to the extensive use of phytosanitary and NPK fertilizers for maintaining sustainable agriculture. In other words, N, P, and K can be impregnated on Nano silica and sprayed on to the aerial parts of the plants.

Laane (2018) stated that foliar sprays with silicates increase growth and yield and decrease biotic and abiotic stresses. He also added that despite being limited the available data on foliar silica-Nano sprays show a tendency to decrease biotic stress and to stimulate a limited increase in growth and yield.

With respect to phosphatase enzyme activity, Machado & Furlani (2004) reported that it is a physiological characteristic related to plant efficiency in relation to P acquisition and utilization. They pointed to finding positive and/or negative correlations between phosphatase activity and P-efficiency characteristics, specific for the genotypes, not allowing inference on a general and clear association between root-secreted phosphatase and dry matter production or P acquisition under low P conditions.

Materials and Methods

Agricultural experiment

A field experiment was conducted in newly reclaimed sandy soils at El-Monira village, El-Kharga Oasis of the GIS indices of 30.53 longitude, 25.45 latitude and 78.8m altitude at the New Valley Governorate during two successive cropping seasons of 2016 and 2017. The major objective of the current research was to study the response of maize plants to bio fertilizers which included inoculation with *Azospirillum brasilense*, *Azospirillum lipoferum*, mycorrhiza, and their mixtures, in addition to a control without bio inoculation, as well. All bio-fertilizer treatments were applied either separately or with Nano silica spraying.

Microorganisms

Bacterial isolates recruited in the current experiment were isolated from the experimental soil at newly reclaimed sandy areas that was previously mentioned. The isolated bacteria were identified as being *Azospirillum brasilense*, *Azospirillum lipoferum* according to Krieg & Holt (1984). Bacterial concentration of the applied suspensions was adjusted to 10^8 CFU/ml for the two microbial treatments of *Azospirillum brasilense*, *Azospirillum lipoferum* prior to application to the treated grains. With respect to mycorrhiza, spores were collected from the zero-to-30cm soil layer. The obtained soil samples were exposed to wet sieving and decanting technique according to the method described by Gerdemann & Nicolson (1963) and Faramawy (2013). This technique preludes to suspend 100g of soil into a 2L container and add 1.5L of water. Vigorously mix the suspension to free the spores from the soil and roots. For fungal colonization in roots, clean root sample was blended for 1min in 300mL of water to free the spores from roots. Next, the supernatant solution containing the spores was decanted through standard sieves. A

425µm pore size over a 45µm pore size sieves was used. The content of the top sieve is examined for sporocarps that may be up to 1 mm in diameter. For clay soils, it is advisable to repeat the decanting and sieving procedure with the settled soil. Roots were collected from the larger mesh sieve for evaluation of internal colonization. The sieving's retained on the other different sieves were washed into separate petri dishes for further observations or purification by sucrose centrifugation. Thus, it could be possible to obtain a mycorrhizal suspension that can be recruited as a source for inoculation of maize grains with mycorrhiza. After inoculation of grains with mycorrhiza and cultivation, estimation of mycorrhizal colonization can be achieved by using the method described by Trouvelot et al. (1986). Number of mycorrhizal spores induced per treatment was to be reported as No. of spores/100g soil.

Regarding the Nano-silica used in the current research work, it was provided by National Research Center (NRC) at Giza governorate. It was characterized by specific surface area of 300-330m² g⁻¹, pH 4.0-4.5, and mean diameter 10nm.g⁻¹

Maize grains were to be wetted before planting with bacterial suspensions at the rate of 250mL suspension/5kg grains for three hours before planting. Carboxy methylcellulose 0.5% was used as an adhesive agent; i.e. spreading agent. The previous pre-planting treatment with microbial suspensions represents half dose of the bio-fertilizer treatments. The other half was applied in the form of spray using a back-mounted sprayer to soil down the plants aging one month after seeding.

Regarding to phosphorus fertilizer application, it was applied at the rate of 45kg P/fed with the applied organic manure which was added at the rate 20m³/fed. 18 days prior to seeding. The applied amounts were metered per dripper line and were to be applied in the furrow that was manually dug, then the furrow was filled with the dugout soil. This practice was achieved the same for all treatments.

All plants received solid potassium sulfate (50% K₂O) after 45 days from applied 5-7cm away from the plants' stems to avoid plant burn damage. Half of the plants received the remaining recommended amount of K as potassium sulfate in the previously mentioned way via the soil after 60 days from sowing. At the same time (60 days

from sowing) the other half of the plants received potassium silicate as spray onto the aerial parts of the plants.

Farmyard manure was broadcast applied and incorporated into the soil surface layer by hand-hoeing, and then the dripper lines were straight back to their places. A quick false irrigation was applied on to the experimental dripper lines through the drip irrigation network 18 days before seeding to allow the exposure of weeds that may be existing in the soil and the added farm manure to combat them.

Seeding rate was 5kg maize grains/feddan (1feddan= 0.42ha). On the seeding day, 3-4 grains were to be placed in hills 30cm apart along the dripper lines. After germination, number of plants was thinned to 2 plants per hill to achieve a full 100% stand at the beginning of the cultivation season. Owing to the fine textured soil nature (around 48% as silt + clay), drip irrigation was to be practiced every six-day period with short application period each time to avoid loss of soluble fertilizers with the soil water percolating down the rhizosphere, i.e. beyond the plants' root system.

Some physical and chemical analyses of both the adopted soil and irrigated water

Some physical and chemical analyses of the experimental field soil were achieved according to Page et al. (1982) and presented in Table 1. This table points to a vigorous salt stress (EC= 8.21dS.m⁻¹) and alkaline reaction (pH = 8.64) with the domination of Na and Cl ions. There is an alkalinity threat to plants grown in such soil. They need enough organic fertilizers to combat such alkalinity hazard and correct for good plant nutrition. Fortunately, the irrigation water does not threaten the grown plants owing to their low pH, EC, high Ca and Mg, low Na and Cl. In addition, chemical analyses of irrigation water were depicted in the same table. The latter analyses exhibited that the irrigation water had a pH 7.5 and an EC 1.46 dS.m⁻¹.

Test plant

Grains of the adopted test plant maize hybrid cultivar, namely, three-way cross 310 (T.W. C. 310) (*Zea mays* L.) were purchased from the Crops Research Institute, Agricultural Research Center, Giza, Egypt.

TABLE 1. Analysis of experimental soil to a 30cm depth and irrigation water

Physical analysis %													
					Sand	Silt	Clay			Soil texture			
					52.95	21.51	25.54			Sandy clay loam			
Chemical analysis													
pH	E.C dS.m ⁻¹	CaCO ₃ %	O.M %	T.N %	Cations meq/L				Anions meq/L				
					Ca ⁺²	Mg ⁺²	Na ⁺	K ⁺	CO ₃ ⁻²	HCO ₃ ⁻	Cl ⁻	SO ₄ ⁻²	
8.64	8.21	4.32	0.59	0.09	25.2	7.9	43.4	5.3	0.9	15.9	50.9	12.2	
Chemical analysis of irrigation water													
pH	E.C dS.m ⁻¹			Ca ⁺²	Mg ⁺²	Na ⁺	K ⁺	CO ₃ ⁻²	HCO ₃ ⁻	Cl ⁻	SO ₄ ⁻²		
7.5	1.46			5.42	3.24	5.43	0.27	1.65	2.18	4.2	6.16		

Plant growth promoting properties of bacterial isolates

Agronomic data recorded

Soil biological activity: Enumeration of microorganisms in soil samples was carried out by the most probable number (MPN) technique. One milliliter successive dilutions of 10⁵ and 10⁴ was attained. Soil samples were to be transferred to test tubes containing semi-solid NFB medium for enumeration *Azospirillum brasilense*, *Azospirillum lipoferum* isolates, respectively. Tubes and plates were then incubated under suitable temperature. Microorganisms were identified based on cultural, morphological and biochemical characteristics as per Bergey's Manual of Systematic Bacteriology.

Bacterial population= (MPN value × middle dilution × middle dilution used)/ (Dry weight of the soil sample)

Mycorrhizal colonization and plant biomass analysis. All roots were thoroughly rinsed with tap water before drying, and weighed subsamples of fresh roots were used for mycorrhizal colonization assessment by the gridline intersect method (Giovannetti & Mosse, 1980) after clearing with 10% (m/m) KOH and staining with acid fuchsine (Phillips & Hayman, 1970).

Determination of microbial activity: Counts of microorganisms were estimated by the dilution plate technique methods (Becky et al., 2001). The following microbial analyses; total microbial count (Counts × 10⁵ CFU g⁻¹ dry soil) and *Azospirilla* densities; *lipoferum* and *brasilense* (Counts × 10⁴ CFU g⁻¹ dry soil) were carried out in all soil samples according to Pious et al. (2015). Total Mycorrhiza (Counts × 10⁴ number of spores

Kg⁻¹ soil) of Arbuscular mycorrhizal fungi (AMF) spores in the soil was determined by wet sieving (Gerdemann & Nicolson, 1963).

Dehydrogenase activity (µg TPF g⁻¹ dry soil 24h.) in the rhizosphere soil was determined according to Pramer & Schmidt (1964) and Thalmann (1967). Production of ammonia was determined according to Cappuccino & Sherman (1992).

Phosphatase activity has specified in the soil by using the method according to Tabatabai & Bremner (1969).

Soil analyses

Soil samples were collected from each dripper line at the same time of plant sampling (at what exactly time), air-dried, passed through a 2mm sieve and kept for physical and chemical analyses. Particle size distribution was determined using the pipette method according to Jackson (1973). Electrical conductivity (EC) and soil pH was determined in a 1: 2.5 soil to water extract using conductivity meter and Beckman pH meter, respectively according to Jackson (1973). Organic carbon content was determined by Walkely and Black's wet oxidation method (Walkley & Black, 1984). Available potassium was extracted by neutral normal ammonium acetate method and measured by flame photometer. Available P was extracted using 0.5 M NaHCO₃ at pH 8.5 according to Olsen et al. (1982) and measured calorimetrically using the chlorostannous phosphomolybdic-sulfuric acid method as described by Jackson (1973).

Chemical composition of plants and grains

Grains nitrogen content was determined by

the modified microkjeldahl method as described by Peach & Tracey (1956). Phosphorus percentage was estimated by ascorbic acid according to the method reported by Bender & Wood (2000). Potassium was determined by using the flame photometer method as described by Knudsen et al. (1982).

Yield and yield components

At harvest, plant height (cm), grain yield, and harvest index (1fed.=0.42ha). In addition, oil production (g/plant) was also assessed and calculated as kg/fed. To evaluate effects of the applied treatments on seed quality, seed mineral content of N, P, and K were achieved.

Statistical analysis

All dripper lines were divided into three groups of drippers according to the expected drop in the driving head along the end tail of lines. The three groups were to be sampled for three replicates, respectively. The obtained data were exposed to the analysis of variance (ANoVA) according to the statistical design of split plot technique in randomized complete blocks using SPSS (2014) software package. The Duncan least significant

range (LSR) will be recruited for comparing the mean values of variables and their interactions using alphabetical letters. In other words, any two mean values sharing one letter are to be considered not significantly different at 5% level.

Results and Discussion

In the following, the obtained data will be exhibited and discussed under: 1. Effects of bio-fertilizers on all studied traits will be presented and discussed first, 2. Effects of Nano silica potassium, and 3. Effects of the interaction between bio-fertilizers and Nano silica potassium will follow.

Effects of bio-fertilizers

Table 2 depicts the mean effects of the applied bio-fertilizers treatments as averaged across other variables and the replicates on the total bacterial counts, total *A. lipoferum* counts, total *A. brasilense* counts, total mycorrhiza counts, dehydrogenase activity, phosphatase activity, and root colonization. In other words data in Table 2 tell about the biological situation in the root-zone under maize plants.

TABLE 2. Effect of different bio fertilizers and their interactions on total bacterial and mycorrhizal populations, dehydrogenase activity, phosphatase activity, and root colonization of maize during 2016 and 2017 growth seasons under New Valley conditions

Bio fertilizer	Char.	Total bact. counts	Total <i>A. lipo.</i> counts	Total <i>A. braz.</i> counts	Total mycor. counts	Dehydrogenase activity	Phosphatase activity	Root coloization
Control treatment		14.24H	12.25G	7.81G	0.77F	3.74H	1.17F	45.09H
<i>Azos. brasilienses.</i>		20.63G	15.33F	13.65F	1.17E	5.53G	1.74E	50.15G
<i>Azos. lipoferum</i>		25.72C	19.70C	17.83C	1.90B	6.90C	1.86DE	53.35F
Mycorrhiza		22.54E	16.83E	14.73E	1.49CD	6.00E	2.00CD	60.77D
<i>Azos. bra. + Azos. lipo.</i>		21.59F	15.84F	14.18EF	1.41D	5.72F	1.80E	54.90E
<i>Azos. bra. + Mycor.</i>		23.59D	18.58D	16.00D	1.66C	6.51D	2.05C	62.48C
<i>Azos. lipo. + Mycor.</i>		26.37B	20.77B	18.78B	2.11B	7.56B	2.38B	64.68B
Mixed of the three		29.00A	24.39A	21.33A	2.63A	8.18A	2.57A	70.25A
2017 Season								
Control treatment		19.93G	14.83G	9.90G	0.84G	4.21H	1.32F	50.13H
<i>Azos. brasilienses</i>		26.92F	19.50F	16.03F	1.83F	7.24G	2.28E	69.85G
<i>Azos. lipoferum</i>		31.03C	23.99C	19.52C	2.40C	8.47C	2.41DE	71.61F
Mycorrhiza		28.13E	21.77E	17.31E	2.11E	7.78E	2.49D	73.71C
<i>Azos. bra. + Azos. lipo.</i>		27.28F	21.65E	17.14E	1.94F	7.40F	2.32E	72.36E
<i>Azos. bra. + Mycor.</i>		29.48D	23.18D	18.55D	2.24D	8.15D	2.56C	73.12D
<i>Azos. lipo. + Mycor.</i>		33.64B	26.12B	21.59B	2.69B	9.14B	2.81B	75.83B
Mixed of the three		35.67A	30.21A	25.15A	3v.07A	9.78A	3.07A	79.59A

Total bacterial counts

Data exhibited in Table 2 shows that all inoculation treatments could significantly establish higher bacterial counts in the rhizosphere of maize plants when compared to the control treatment in both seasons of study. *A. lipoferum* could significantly surpass mycorrhiza and *A. brasilense* in proliferating total bacterial count. *A. lipoferum* seems to suit the alkaline pH of the root-zone soil of the New Valley than *A. brasilense*, which prefers lower soil pH values. This is supported by the findings of Hungria et al. (2010) who recommended *Azospirillum brasilense* to be applied to maize as acidic peat-based inoculants. They found *A. lipoferum* promising, but not preferred to *A. brasilense*.

On the other side, mycorrhiza lives on symbiosis to get carbohydrates from the host plant. Therefore, mycorrhiza cannot be considered as a source of carbohydrates of the free living bacteria outside plant root, but rather secretes organic acids that goes out to the root-zone soil solution. These acids solubilize phosphorus from its resources especially mineral ones. Mycorrhiza can thus contribute to the proliferation of total microbial count in the free-living zone.

Inoculation with *A. brasilense* and *A. lipoferum* simultaneously proved to be significantly more effective than inoculation with *A. brasilense* alone, while it was less than *A. lipoferum* applied alone. It is clear that dropping the applied number of each of the two bacteria is to be held responsible for the obtained observation.

In case of mixed application of either *A. brasilense* or *A. lipoferum* with mycorrhiza, the applied number of each of the two bacteria is the same as that applied in the single application of both alone. This observation stands firmly behind the supremacy of the mixed application of *A. brasilense* with mycorrhiza as compared to applying each of them alone. The same held true for the mixed application of *A. lipoferum* with mycorrhiza. Comparing these two treatments that of applying *A. lipoferum* and *A. brasilense* together without inoculation with mycorrhiza; i.e. with initial soil mycorrhizal population, exposes the significant role of mycorrhiza in promoting the establishment of high total bacterial count.

Regarding the 3-microorganism bio-fertilizer, it can be said that despite the application of both

bacteria at half their amount of sole application, the inclusion of mycorrhiza as a third bio-fertilizer could be highly promote the establishment of the highest significant total microbial count. Again, this observation assures the significant role played by mycorrhiza in promoting the establishment of high total bacterial count. All of the abovementioned observations held true in both years of study.

Total *A. lipoferum* counts and Total *A. brasilense* counts mean values depicted in Table 2 show approximately the same trends observed for the total bacterial count in Table 2. The highest significant total *Azospirillum lipoferum* counts were recorded with the 3-bio-fertilizer treatment. It is obvious that this combination treatment could proliferate the topmost promotion to the propagation of *Azospirillum lipoferum* in both years of study.

Total mycorrhizal counts

Total mycorrhizal counts mean values depicted in Table 2 show influences of the applied treatments on total mycorrhizal counts in the first year that were completely different from those observed in the second year of study. In the first year, bio fertilizers treatments were the only to show significant increases on total mycorrhizal counts. The control proliferated for the least total mycorrhizal counts, while the 3—bio-fertilizer treatment proliferated for the highest total mycorrhizal counts. An in-depth sight reveals that, when applied together, *A. lipoferum* was not significantly different from the treatment inoculated with both *A. lipoferum* and mycorrhiza together. Analogically, *A. brasilense* was not significantly different from the treatment inoculated with both *A. brasilense* and mycorrhiza together. In the second year of the trends' observed in Table 5 were, more or less, the same as those observed in Table 2. In 2017, bio-fertilizers showed to be significantly different, and so did the Nano—K and the interaction. The 3-bio-fertilizer treatment exhibited the topmost promotion to the propagation of mycorrhiza.

Dehydrogenase activity

Table 2 reveals that the trends observed on the total bacterial counts in the rhizosphere of maize roots were projected, approximately the same on dehydrogenase activity. This make sense because dehydrogenase activity comes mainly from the physiology practiced by the total bacterial count during their performance of metabolism. The highest significant dehydrogenase activity was

recorded with the combination treatment of applying half the recommended counts per ml of both *A. brasilense* and *A. lipoferum* together with mycorrhiza and sprayed with Nano—K fertilizer.

Phosphatase enzyme:

Phosphatase enzyme (Table 2) showed approximately the same trends observed with dehydrogenase activity. Both records reflect the trends in total bacterial counts in both seasons of study. The highest significant phosphatase enzyme was recorded with the combination treatment of applying half the recommended counts per ml of both *A. brasilense* and *A. lipoferum* together with mycorrhiza and sprayed with Nano—K fertilizer.

Root colonization:

Root colonization (Table 2) showed approximately the same trends observed with total bacterial counts in both seasons of study. The highest significant root colonization was recorded with the combination treatment of applying half the recommended counts per ml of both *A. brasilense* and *A. lipoferum* together with mycorrhiza and sprayed with Nano—K fertilizer.

Effect of bio-fertilizers on maize plant height, grain yield, and HI

Plant height (Table 3) shows a continuation of the effects observed in Table 2 in response to the applied bio-fertilizer treatments. In other words, the 3 different bio-fertilizer treatment led to the highest plant height as a translation to its superiority in proliferating the highest biological activities of nitrogen fixing bacteria and phosphate dissolving mycorrhiza (mycorrhiza does not dissolve phosphorus it just increased

the P-uptake by plants through the increasing of absorbing area) in the rhizosphere of maize plant. This treatment showed the same significant superiority with grain yield and harvest index. This agrees with what Hungria et al. (2010) found of that using an inoculant containing bacteria that promote plant growth is likely to decrease costs of fertilizers, help with concerns over pollution and provide emphasis on sustainable agriculture. They recommended *Azospirillum* strains for maize (*Zea mays* L.) fertilization, which may increase grain yields by 24–30% in relation to non-inoculated controls.

In addition, Radwan & Nassar (2011) found that VA-mycorrhizal combined with bio-fertilizer cerealen and 105kg N/ha was the best treatment to obtain the highest growth and grain yield. Also, Mohammed (2012) showed that maize plants exhibited the highest significant plant height, grain yield and harvest index (HI) in response to phosphorus bio-fertilizer in the presence of different doses of nitrogen and P₂O₅.

With respect to grain content of N%, P%, K%, oil%, protein%, total carbohydrate%, and proline (μ mol/g DW), Table 4 reveals the effect of bio-fertilizers, mycorrhiza, and their interactions on these items in the dry matter during 2016 and 2017 growth seasons under New Valley conditions. It can be seen that the 3-bio-fertilizer treatment could show the highest significant accumulation of N, P, and K in grains when compared to other bio-fertilizer treatments in both years of study. It could also perform the highest significant production of oil, protein, and total carbohydrates, but the lowest proline accumulation in the dry matter of maize.

TABLE 3. Effect of different bio fertilizers and their interactions on plant height, grain yield, and harvest index of maize during 2016 and 2017 growth seasons under New Valley conditions

Maize traits Bio fertilizer	Plant height (cm)	Grain yield kg/fed.	Harvest index (%)	Plant height (cm)	Grain yield kg/fed.	Harvest index (%)
	2016 Season			2017 Season		
Control treatment	171F	1918F	34.64E	175F	1960F	35.55G
<i>A. brazilienses</i>	175E	1970E	35.10D	179E	2010E	35.98F
<i>A. lipoferum</i>	186B	2077B	36.03B	189C	2169B	37.19B
Mycorrhiza	180D	2020D	35.52C	184D	2065D	36.58D
<i>A. bra.</i> + <i>A. lipo.</i>	177E	1987E	35.20D	182D	2023E	36.12E
<i>A. bra.</i> + Mycor.	183C	2045CD	35.69C	188C	2122C	36.82C
<i>A. lipo.</i> + Mycor.	188AB	2091B	36.14B	192B	2202A	37.27B
Mixed of the three	190A	2141A	37.06A	195A	2242A	37.91A

TABLE 4. Effect of 3 different bio fertilizers and their interactions on N%, P%, K%, oil%, Protein%, and total carbohydrates% of maize grains and proline content in the dry matter during 2016 and 2017 growth seasons under New Valley conditions

Bio fertilizer	Char.	N	P	K	Oil	Protein	Total carbohydrate	Proline
		%	%	%	%	%	%	(μ mol/g DW)
2016 Season								
Control		1.24F	0.70G	0.68G	3.38F	8.72F	68.25F	8.27A
<i>A. brasiliense</i>		1.27EF	0.73F	0.71FG	3.45E	8.94EF	69.44E	7.91B
<i>A. lipoferum</i>		1.45AB	0.81E	0.82BC	3.63BC	10.08AB	70.20C	7.26EF
Mycorrhiza		1.31DE	0.88C	0.76DE	3.54D	9.16DE	69.72D	7.56CD
<i>A. bra.</i> + <i>A. lipo.</i>		1.34D	0.85D	0.73EF	3.50D	9.38D	69.63D	7.73BC
<i>A. bra.</i> + Mycor.		1.39C	0.75F	0.79CD	3.60C	9.70C	70.07C	7.38DE
<i>A. lipo.</i> + Mycor.		1.42BC	0.95B	0.84AB	3.67B	9.89BC	70.41B	7.15FG
Mixed		1.48A	1.01A	0.87A	3.74A	10.24A	71.58A	7.02G
2017 Season								
Control		1.25F	0.73E	0.75F	3.42F	8.85F	69.32G	8.58A
<i>A. brasiliense</i>		1.29E	0.76DE	0.78E	3.48E	9.07EF	70.27F	8.26B
<i>A. lipoferum</i>		1.47AB	0.84C	0.88BC	3.66BC	10.21B	71.13C	7.72EF
Mycorrhiza		1.32E	0.91B	0.83D	3.58D	9.29DE	70.59E	7.97CD
<i>A. bra.</i> + <i>A. lipo.</i>		1.36D	0.88BC	0.81D	3.52E	9.54D	70.45EF	8.11BC
<i>A. bra.</i> + Mycor.		1.41C	0.78D	0.86C	3.62CD	9.80C	70.99D	7.87DE
<i>A. lipo.</i> + Mycor.		1.44BC	0.99A	0.90B	3.70B	10.02BC	71.54B	7.64F
Mixed		1.49A	1.03A	0.93A	3.77A	10.49A	72.67A	7.53F

The highest N accumulation could be referred to the highest proliferation of largest significant counts of bacteria under this treatment as was declared previously in the current research and consequently the fixation of the largest significant amounts of atmospheric N by the free-living *A. brasiliense* and *A. lipoferum*.

The same treatment could show the highest significant P which can be attributed to the activity played by mycorrhiza which is a P releaser from its mineral or organic sources in the soil. For accumulating the highest significant K in grains owing to solubilizing effects of the bio-fertilizer treatments to K from various micaceous minerals in the soil, soil dressing of K, and/or K spraying with Nano silica, especially considering that the means values of the effects of bio-fertilizer treatments are basically averaged across the sprayed and unsprayed treatments and the replications.

With regard to the superiority of the same treatment in producing the highest significant oil, protein, and carbohydrates in the grains of maize, it can be referred to the highest carbon partitioning

between the root and shoots of maize. This can be supported by what Zhang et al. (2013) emphasized the role played by Arbuscular mycorrhiza in controlling the fluxes of CO₂ between the aerial and underground parts of maize.

Concerning proline accumulation, the 3-bio-fertilizer treatment showed the least significant proline production owing to that the plants with this treatment were facing the least stresses in the ecological system (rhizosphere) or within the plants. This goes on the basis of the lower the stress, the lower the proline accumulation. This observation goes along with what was reported by Shamsul et al. (2012) who stated that a stressful environment results in an overproduction of proline in plants.

In conclusion, the combination treatment of inoculating maize grains with half the full dose of each of *A. lipoferum* and *A. brasiliense* with mycorrhiza could significantly average the highest above all single and double bio-fertilizer treatments in accumulating N, P, and K in grains when compared to other bio-fertilizer treatments in both years of study. It could also

perform the highest significant production of oil, protein, and total carbohydrate, but the lowest proline accumulation in the dry matter of maize.

Effect of nano silica K

With regard to the effect of Nano silica K application, Table 5 clearly shows that using the Nano silica was steadily superior to non-spraying. This held true for all applied bio-fertilizers and the control, too. Nano silica contained potassium, which seems to be delivered to plant tissues with the rapid diffusion of Nano silica. This statistically significant observation points to an actual physical contribution of Nano silica K spray through dropping of spray solution onto the soil surface and reaching the soil solution. Therefore, it is believed that spraying procedure efficiency was supposed to be measured. This reasoning can be supported by the finding of Yuvakkumar et al. (2011) who mixed Nano-silica K powders with the soil and achieved vigorous root and vegetative growth of maize plants. Also, Amer & El- Emary (2018) reported that soil applied Nano-fertilizers can significantly improve soil productivity, enhance nutrients use efficiency, and protect plants from environmental stress. Spray solution dripping onto the soil surface can be understood to reach soil solution at the rhizosphere and contribute to the biological activities there. So, it is still needed to run more

experimental work to emphasize the previous explanation. In addition, the efficiency of spraying process still also needs to be measured and verified.

It can be seen in Table 6 that spraying Nano-silica K was always superior to non-spraying in both years of study regarding all studied plant traits. The obtained results make sense where there is a direct physical access of potassium carried on and delivered by Nano-silica to aerial parts of maize plants. This observation goes along with that mentioned by Laane (2018) who stated that foliar sprays with silicates increases maize growth and yield. From another point of view, Guntzer et al. (2012) reported that silicon (Si) can mitigate environmental stresses and soil nutrient depletion and as a consequence is an alternative to the extensive use of phytosanitary and NPK fertilizers for maintaining sustainable agriculture. In other words, N, P, and K can be impregnated on Nano silica and sprayed on to the aerial parts of the plants. As so described, silicon is used as reservoir for N, P, and K when used as spray. In addition, Laane (2018) stated that foliar sprays with silicates increases vegetative growth and yield, while decreases biotic and abiotic stresses. He also added that despite being limited the available data on foliar Nano silica sprays show a tendency to decrease biotic stress and stimulate a limited increase in growth and yield.

TABLE 5. Effect of nano silica spraying on chemical composition of maize during 2016 and 2017 growing seasons under New Valley condition

Nano silica spraying	Char.	Total bact. counts	Total <i>A. lipo.</i> counts	Total <i>A. braz.</i> counts	Total mycor. counts	Dehydr-ogenase activity	Phosph- atase activity	Root coloniz- ation
2016 Season								
Control		20.59B	15.35B	13.99B	1.37IB	5.22B	1.61B	55.67B
Nano silica		25.33A	20.58A	17.09A	1.91A	7.32A	2.28A	59.75A
2017 Season								
Control		26.10B	20.94B	16.84B	1.84B	6.74B	2.11B	68.89B
Nano silica		31.92A	24.37A	19.46A	2.44A	8.80A	2.70A	72.66A

TABLE 6. Effect of nano silica spraying on yield and its components of maize during 2016 and 2017 under the New Valley conditions

Nano silica K	Trait	Plant height (cm)	Grain yield (kg/fed.)	Harvest index (%)	Plant height (cm)	Grain yield (kg/fed.)	Harvest index (%)
2016				2017			
Control		175B	1947B	34.86B	179B	2025B	36.94B
Nano silica		187A	2115A	36.48A	192A	2172A	40.12A

In conclusion, spraying Nano-silica K is eventually beneficial for the physiology taking place in the aerial parts of maize plants and indirectly in the rhizosphere.

With respect to grain content of N%, P%, K%, oil%, protein%, total carbohydrate%, and proline (μ mol/g DW), Table 7 reveals the effect of potassium Nano-silica spray on these items in the dry matter during 2016 and 2017 growth seasons under New Valley conditions. It can be observed that there is a straight forward superiority of spray on non-spray regarding accumulating N, P, K, oil, protein, and total carbohydrates, but the inverse regarding proline accumulation. Again, this makes sense owing to the direct connection with the physiology taking place in the aerial parts of maize plants. This observation goes along with that by Laane (2018) who stated that foliar sprays with silicates increase growth and yield.

Effect of the interaction between bio-fertilizer and Nano-K

Table 8 depicts the mean values of the effects of the interaction between bio-fertilizers treatments and spray with potassium Nano-silica averaged across the replicates on the total bacterial counts, total *A. lipoferum* counts, total *A. brasilense* counts, total mycorrhiza counts, dehydrogenase activity, phosphatase activity, and root colonization. The interaction between bio-fertilizers and spray with Nano silica K proved to be significant for plants receiving bio-fertilizers and sprayed with Nano than those not receiving Nano. This was evident for all measured biological activities in the rhizosphere, but for two activities; total *A. lipoferum* counts and mycorrhizal counts. The significance of those two interactions may have been mimicked by the vigorous effects of

bio-fertilizers. Again, the compound treatment of the mixed three bio-fertilizers and spray with Nano silica K on the aerial parts of maize plants in both seasons of study.

Table 9 exhibits the effects of the interaction between bio fertilizers and spray with potassium Nano-silica on plant height, grain yield, and harvest index of maize during 2016 and 2017 under New Valley conditions. For maize plant height in table 9, the combination treatment composed of inoculation with half dose of both *A. brasilense* and *A. lipoferum* in addition to mycorrhiza at full dose with spraying the aerial parts of the plants with potassium Nano-silica proved to be superior to all other treatments in effecting for the highest significant maize plant height. This influence deems necessarily logic because plant height is a result of nutrition coming from the root system or from the shoots. Analogously, the same combination treatment could prove to be the topmost effective in producing the highest significant grain yield and harvest index in both years of study. All maize plant traits in table 9. The obtained results held true in both years of study.

With regard to the effect of the interaction between Nano silica spraying and bio fertilizers on the chemical composition of maize during 2016 and 2017 growing seasons under New Valley condition. Table 10 exhibits that the combination treatment composed of inoculation with half dose of both *A. brasilense* and *A. lipoferum* in addition to mycorrhiza at full dose with spraying the aerial parts of the plants with potassium Nano-silica proved to be superior to non-sprayed treatments in effecting for the highest significant accumulation of N, P, and K nutrients and the highest significant production of oil and protein, but insignificant in the accumulation of carbohydrates.

TABLE 7. Effect of Nano silica spraying on chemical composition of maize during 2016 and 2017 growing seasons under New Valley condition

Nano silica spraying	Char.	N	P	K	Oil	Protein	Total Carbo.	Proline
		%	%	%	%	%	%	μ mol/g DW
2016 Season								
Control		1.26B	0.69B	0.72B	3.47B	9.35B	68.37B	8.41A
Nano silica		1.46A	0.98A	0.83A	3.65A	9.67A	71.45A	6.67B
2017 Season								
Control		1.27B	0.73B	0.78B	3.50B	9.49B	69.61B	8.93A
Nano silica		1.48A	1.01A	0.89A	3.68A	9.83A	72.13A	6.99B

TABLE 8. Effect of the interaction between Nano silica spraying and bio fertilizers on chemical composition of maize during 2016 and 2017 growing seasons under New Valley condition

Nano silica X Bio		Char.	Total bact. counts	Total <i>A. lipo.</i> counts	Total <i>A. braz.</i> counts	Total mycor. counts	Dehydro- genase activity	Phosph- atase activity	Root colonization
2016 Season									
Without Nano silica	Cont.		13.05j	10.73	7.05k	0.73	3.37o	1.05h	41.95m
	<i>A. braz.</i>		18.63h	12.35	11.93i	0.92	4.72m	1.48fg	47.81l
	<i>A. lipo.</i>		22.77e	17.27	16.32de	1.62	5.61i	1.51fg	50.58k
	Mycor.		20.47g	13.88	13.25h	1.26	5.11k	1.65f	60.12f
	<i>A. braz.</i> + <i>A. lipo.</i>		20.42g	13.28	12.20i	1.12	4.90l	1.53f	51.95j
	<i>A. braz.</i> + Mycor.		21.55f	15.60	14.82g	1.35	5.38j	1.69f	61.72e
	<i>A. lipo.</i> + Mycor.		23.23e	18.30	17.03de	1.75	6.09h	1.91e	62.83d
	Mixed		24.60d	21.35	19.33c	2.22	6.55f	2.06de	68.38b
With Nano silica	Cont.		15.43i	13.77	8.57j	0.81	4.11n	1.29g	48.23l
	<i>A. braz.</i>		22.63e	18.32	15.37fg	1.42	6.35g	1.99e	52.48i
	<i>A. lipo.</i>		28.67b	22.13	19.33c	2.18	8.19c	2.22cd	56.12h
	Mycor.		24.62d	19.77	16.22ef	1.72	6.88e	2.36c	61.42e
	<i>A. braz.</i> + <i>A. lipo.</i>		22.77e	18.40	16.17ef	1.70	6.54f	2.06de	57.85g
	<i>A. braz.</i> + Mycor.		25.63c	21.57	17.18d	1.97	7.64d	2.40c	63.23d
	<i>A. lipo.</i> + Mycor.		29.50b	23.23	20.53b	2.47	9.03b	2.84b	66.52c
	Mixed		33.40a	27.43	23.33a	3.05	9.80a	3.09a	72.12a
2017 Season									
Without Nano silica	Cont.		17.38	13.63k	10.32	0.78l	3.81o	1.19k	46.15n
	<i>A. braz.</i>		24.40	17.85i	14.13	1.50k	6.35m	1.99i	68.61l
	<i>A. lipo.</i>		28.30	21.80f	18.43	2.07h	7.33i	2.16ghi	70.44k
	Mycor.		25.55	20.17h	15.83	1.74ij	6.90k	2.26fg	73.33g
	<i>A. braz.</i> + <i>A. lipo.</i>		24.70	20.58gh	15.55	1.62jk	6.54l	2.06hi	71.17j
	<i>A. braz.</i> + Mycor.		27.35	20.90gh	17.38	1.87i	7.11j	2.23fgh	71.48i
	<i>A. lipo.</i> + Mycor.		29.43	24.17d	20.25	2.43ef	7.64h	2.40ef	73.87f
	Mixed		31.67	28.42b	22.78	2.75c	8.25f	2.59de	76.07c
With Nano silica	Cont.		22.48	16.02j	9.48	0.90l	4.61n	1.45j	54.12m
	<i>A. braz.</i>		29.43	21.15fg	17.93	2.15gh	8.14g	2.56de	71.10j
	<i>A. lipo.</i>		33.77	26.18c	20.60	2.73c	9.61c	2.65d	72.78h
	Mycor.		30.70	23.37e	18.78	2.48de	8.66e	2.72cd	74.08e
	<i>A. braz.</i> + <i>A. lipo.</i>		29.85	22.72e	18.73	2.27fg	8.25f	2.59d	73.55g
	<i>A. braz.</i> + Mycor.		31.62	25.47c	19.72	2.62cd	9.19d	2.89c	74.75d
	<i>A. lipo.</i> + Mycor.		37.85	28.07b	22.93	2.95b	10.63b	3.21b	77.80b
	Mixed		39.67	32.00a	27.52	3.38a	11.31a	3.55a	83.12a

TABLE 9. Effect of the interaction between Nano silica spraying and bio fertilizers on yield and its components of maize during 2016 and 2017 growing seasons under New Valley condition

Nano	Bio-fertilizer	Plant height (cm)	Grain yield kg/fed.	Harvest index (%)	Plant height (cm)	Grain yield kg/fed.	Harvest index (%)
without Nano silica	Cont.	166o	1834n	33.83o	168n	1886o	34.75o
	<i>A. braz.</i>	169n	1886m	34.29n	173m	1936n	35.18n
	<i>A. lipo.</i>	180j	1993i	35.22j	182i	2095h	36.39j
	Mycor.	174l	1936k	34.71l	177k	1991l	35.78l
	<i>A. braz.</i> + <i>A. lipo.</i>	171m	1903l	34.39m	175l	1949m	35.32m
	<i>A. braz.</i> + Mycor.	177k	1961j	34.88k	181j	2048j	36.02k
	<i>A. lipo</i> + Mycor.	182h	2007h	35.33i	185h	2128g	36.47i
	Mixed	184f	2057g	36.25e	188f	2168e	37.11f
With Nano silica	Cont.	177k	2002hi	35.45h	181j	2033k	36.34j
	<i>A. braz.</i>	181i	2054g	35.91g	186g	2084i	36.77h
	<i>A. lipo.</i>	192c	2161c	36.84c	196c	2243c	37.98c
	Mycor.	186e	2104e	36.32e	191e	2139f	37.37e
	<i>A. braz.</i> + <i>A. lipo.</i>	183g	2071f	36.00f	188f	2096h	36.91g
	<i>A. braz.</i> + Mycor.	189d	2129d	36.50d	195d	2196d	37.61d
	<i>A. lipo</i> + Mycor.	194b	2175b	36.95b	199b	2275b	38.06b
	Mixed	196a	2225a	37.86a	202a	2315a	38.70a

Also from table 10, this combination treatment produced the least amount of proline as compared with all other treatments and the control without or with potassium Nano-silica spray. This is accepted where proline accumulation takes place when plants suffer from adverse factors like drought and salt stress. It seems that the combination treatment has the plants not suffering from such stresses. This can stand a reason behind the production of the least amount of proline in the dry matter of maize plant. This finding stems from that observed by Shamsul et al. (2012) who reported that there was a positive correlation between proline accumulation and plant stress. They also stated that a stressful environment results in an overproduction of proline in plants. This explanation reveals that plants under the control treatment and all other applied treatments suffer from adverse effects at varying degrees relative to under the combination treatment.

Conclusion

In conclusion, the combination treatment composed of inoculation with half dose of both *A. brasilense* and *A. lipoferum* in addition to

mycorrhiza at full dose with spraying the aerial parts of the plants with potassium Nano-silica proved to be superior to all other treatments in effecting for the highest significant accumulation of N, P, and K nutrients and the highest significant production of oil and protein, but insignificant in the accumulation of carbohydrates. The same treatment produced the least proline in the dry matter of maize plants.

It can be seen that the applied treatments did not leave behind significantly different amounts of soil available P, soil available K, soil available N, soil carbon and calculated C/N ratio at harvest time in both years of study, except for significantly different amounts of soil available P and K, only in the first year. Again, the combination treatment mentioned above was the superior to all treatments in leaving behind the highest amounts of soil available P and K. albeit clear, it is essential to mention that the highest left behind P and K were found after the topmost absorption of nutrients and scoring the highest elemental accumulation in maize grains.

TABLE 10. Effect of the interaction between Nano silica spraying and bio fertilizers on the chemical composition of maize during 2016 and 2017 growing seasons under New Valley condition.

Nano silica X Bio		Char.	N	P	K	Oil	Protein	Total	Proline
		%	%	%	%	%	%	carbohydrates	μ mol/g DW
2016 Season									
Without Nano silica	Cont.	1.14n	0.55o	0.63l	3.29l	8.55m	66.71	9.14a	
	<i>A. braz.</i>	1.17m	0.58n	0.65k	3.36k	8.77l	67.90	8.78b	
	<i>A. lipo.</i>	1.35gh	0.66l	0.76g	3.54g	9.91de	68.66	8.13f	
	Mycor.	1.21l	0.73j	0.71i	3.45i	9.00jk	68.18	8.43d	
	<i>A. braz.</i> + <i>A. lipo.</i>	1.24k	0.70k	0.68j	3.41j	9.22hi	68.09	8.60c	
	<i>A. braz.</i> + Mycor.	1.29j	0.60m	0.74h	3.51h	9.53g	68.53	8.25e	
	<i>A. lipo</i> + Mycor.	1.32i	0.80i	0.79f	3.58f	9.72f	68.87	8.02g	
	Mixed	1.38ef	0.86gh	0.81e	3.65e	10.07c	70.04	7.89h	
With Nano silica	Cont.	1.33hi	0.85h	0.73h	3.47i	8.88kl	69.79	7.40i	
	<i>A. braz.</i>	1.37fg	0.87g	0.76g	3.54g	9.10ij	70.98	7.04j	
	<i>A. lipo.</i>	1.55a	0.96e	0.87c	3.72c	10.24b	71.74	6.39n	
	Mycor.	1.40e	1.03c	0.81e	3.63e	9.32h	71.25	6.69l	
	<i>A. braz.</i> + <i>A. lipo.</i>	1.44d	1.00d	0.78f	3.58f	9.54g	71.17	6.86k	
	<i>A. braz.</i> + Mycor.	1.49c	0.90f	0.84d	3.69d	9.86ef	71.60	6.51m	
	<i>A. lipo</i> + Mycor.	1.52b	1.10b	0.89b	3.76b	10.05cd	71.94	6.28o	
	Mixed	1.57a	1.15a	0.92a	3.82a	10.40a	73.11	6.15p	
2017 Season									
Without Nano silica	Cont.	1.15n	0.59p	0.69o	3.33l	8.68n	68.06	9.55a	
	<i>A. braz.</i>	1.18m	0.62o	0.72n	3.39k	8.90m	69.01	9.23b	
	<i>A. lipo.</i>	1.36h	0.7m	0.82j	3.57g	10.04de	69.87	8.69f	
	Mycor.	1.22l	0.77k	0.77l	3.49i	9.12kl	69.33	8.94d	
	<i>A. braz.</i> + <i>A. lipo.</i>	1.25k	0.74l	0.75m	3.43j	9.37ij	69.19	9.08c	
	<i>A. braz.</i> + Mycor.	1.30j	0.64n	0.80k	3.53h	9.63h	69.73	8.84e	
	<i>A. lipo</i> + Mycor.	1.33i	0.85j	0.84h	3.61f	9.85fg	70.28	8.61g	
	Mixed	1.39g	0.89h	0.87f	3.68e	10.32bc	71.41	8.50h	
With Nano silica	Cont.	1.35h	0.87i	0.80k	3.51hi	9.02lm	70.58	7.61i	
	<i>A. braz.</i>	1.39g	0.90g	0.83i	3.57g	9.24jk	71.53	7.29j	
	<i>A. lipo.</i>	1.57b	0.98e	0.93c	3.75c	10.38b	72.39	6.75n	
	Mycor.	1.42f	1.05c	0.88e	3.67e	9.46i	71.85	7.00l	
	<i>A. braz.</i> + <i>A. lipo.</i>	1.46e	1.02d	0.86g	3.61f	9.71gh	71.71	7.14k	
	<i>A. braz.</i> + Mycor.	1.51d	0.92f	0.91d	3.71d	9.97ef	72.25	6.90m	
	<i>A. lipo</i> + Mycor.	1.54c	1.13b	0.95b	3.79b	10.19cd	72.80	6.67o	
	Mixed	1.59a	1.17a	0.98a	3.86a	10.66a	73.93	6.56p	

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تأثير التسميد الحيوي والنانو سيليكات على نبات الذرة بالوادي الجديد

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أقيمت تجربة حقتية بالوادي الجديد لدراسة مدى استجابة نبات الذرة لثلاثة أنواع من الأسمدة الحيوية وهي: الأزوسبيريليم برازيلينس و الأزوسبيريليم ليبوفيروم والميكور هيزا بالإضافة إلى ثلاثة تفاعلات حيوية ثنائية وتفاعل حيوي ثلاثي واحد وذلك مقابل معاملة الكنترول (بدون تسميد حيوي). كل المعاملات الثمانية نفذت إما بمفردها أو مع الرش بسيليكات البوتاسيوم النانوية. وقد نفذت ال 16 معاملة مركبة في تصميم القطع المنشقة مرة واحدة في ثلاثة قطاعات كاملة عشوائية. والهدف الرئيسي من البحث الحالي هو أن نفحص التأثيرات المتصاحبة لكل المعاملات المطبقة على بعض القياسات الحيوية للذرة. وقد أظهرت النتائج المتحصل عليها أن المعاملة المركبة المكونة من تلقيح تقاوي الذرة بنصف العدد الموصى به لكل من الأزوسبيريليم برازيلينس والأزوسبيريليم ليبوفيروم مع الميكور هيزا والرش بسيليكات البوتاسيوم النانوية مهدت معنوياً لأعلى عدد كلي من البكتيريا، والأزوسبيريليم برازيلينس والأزوسبيريليم ليبوفيروم والميكور هيزا، وكذلك أعلى نشاط لإنزيم الديهيدروجينيز، وأنزيم الفوسفاتيز، وأعلى غزو للجذور بالميكور هيزا خلال موسمي الدراسة الحالية. وقد أظهر الأزوسبيريليم ليبوفيروم أداءً معنوياً أفضل من الأزوسبيريليم برازيلينس. وقد أدى الرش بسيليكات البوتاسيوم النانوية إلى تأثير معنوي غير مباشر على أعداد الكائنات الدقيقة في منطقة انتشار الجذور لنبات الذرة في موسمي الدراسة. وينصح بإضافة سيليكات البوتاسيوم النانوية عن طريق التربة في منطقة انتشار الجذور لتمارس دورها مباشرة في انعاش الكائنات الدقيقة بالتربة.