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Influence of biostimulants supplement on maize yield and agronomic traits

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Supplements that contain nutrients, amino acids and plant extracts, have been called growth promoters or biostimulants. One of them is the growth promoter VIUSID agro, it acts as a natural bioregulator and it composed of amino acids, vitamins and minerals. VIUSID agro would be taken into consideration as an alternative to increase the production of plants. The present investigation was carried out in the experimental field of Agric. Res. Stat. of Fac. of Agric., Cairo Univ., Giza, Egypt in 2015 and 2016 seasons. The objectives were to study the effect of VIUSID agro on maize yield and agronomic traits and to study the relationship among grain yield and the different dosages of VIUSID agro. Five maize cultivars were evaluated under four dosages *i.e*. 0.0, 0.96, 1.44 and 2.0 L/ha of foliar spraying of VIUSID agro. A split-plot design in a randomized complete block arrangement was used with four replications. Grain yield/ha under the dosage of 0.96 L/ha was significantly exceeded the control by 26.0%. Results showed that yield increases for studied cultivars were 81.53 % (SC-30k8), 37.34% (SC-30k9), 28.1% (SC-110), 9.63% (TWC-310) and 7.20% (Cairo-1) by applying the dosage of 0.96 L/ha. The three way cross TWC-310 showed a quadratic relationship with the highest grain yield/ha (8.62 ton/ha) at the dosage of 1.44 L/ha. In contrast, the single cross hybrids SC-30k9, SC-110, SC-30k9 and the open pollinated composite Cairo-1 showed a cubic relationship, with the highest grain yield/ha at the dosage of 0.96 L/ha for SC-30k9 (13.24 ton/ha), Cairo-1 (12.5 ton/ha), SC-110 (8.17 ton/ha) and SC-30k8 (7.37 ton/ha). This study concluded that increasing maize grain yield was obvious for most studied cultivars by applying the dosage of 0.96 L/ha of VIUSID agro than other dosages.

Keywords: Maize, Amino acids, VIUSID agro, Zinc, Relationship.

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal crops worldwide. It cultivated for several purposes such as human nutrition, poultry and animal feed, biofuel production, manufacturing starch and cooking oils as well as fermentation industries. Maize is also grown for green fodder and silage. The total harvested area of maize in Egypt in 2014 was 1,039,241 hectares with a total production about 8,059,906 tons of grains; with an average yield of 7.76 tones/ha (FAOSTAT). However, the local production of maize is not sufficient to ensure the local consumption and Egypt imports every year about six million ton of yellow maize grains for poultry industry. Maximizing total production of maize in Egypt could be achieved through raising productivity per land unit area under the good weather, irrigation system and soil conditions that suit maize crop in Egypt.

It is important to find alternatives to increase the production of maize per land unit area. One of the newly methods should be taken into consideration is the use of growth promoters that do not affect humans or the environment adversely. Supplements that contain nutrients, amino acids and plant extracts have been called "growth promoters" or "biostimulants" (Peña et al. 2017). Using biostimulants to promote plant growth has recently acquired expanding attention worldwide (Ertani et al. 2013). Biostimulants when it applied in small amounts, able to stimulate nutrient uptake and use efficiency by plants and improve crop quality (Calvo et al. 2014). Nardi et al. (2009); Giannattasio et al. (2013) reported that biostimulants can increase the activity of rhizospher microbes and soil enzymes, the production of hormones and/or growth regulators in soil & plants, and the photosynthetic process. The addition of biostimulants to plants also modifies the morphology of plant roots in a similar way to indole acetic acid (IAA), suggesting that they induce a "nutrient addition response" that favors the uptake of nutrients via an increase in the absorptive surface area (Ertani et al. 2012). These effects on growth appear to be featured from the nutritional effect of an additional nitrogen source (Ertani et al. 2009, 2014). The mode of action of biostimulants is often unknown and hard to identify, because they derive mainly from complex sources containing several bioactive components that, together, may contribute to specific effects in plants (Ertani et al. 2011a, b).

One of the alternative to take into consideration to increase the production of plants is the growth promoter VIUSID agro since, according to Catalysis (2014), it acts as a natural bioregulator and is basically composed of amino acids, vitamins and minerals (Peña et al. 2017). In addition, as a relevant aspect, all of its components are subjected to a bio catalytic process of molecular activation that allows the use of low dosages with good results. Experiments were conducted in several crops where VIUSID agro application lead to an increase in production. One was for beans (*Phaseolus vulgaris* L.) (Peña et al. 2015 a). It was also found that it increased the quality of the leaves of the anthurium (*Anthurium andreanum* Lind.) and the start of flowering (Peña et al. 2015 b), as well as the germination of the seed and the production of tomatoes (*Solanum lycopersicum* L.) (Peña et al. 2016). Peña et al. (2017) evaluated the effect of VIUSID agro in the productive performance of lettuce (*Lactuca sativa* L.), Swiss chard (*Beta vulgaris* var. *cicla*.), beetroot (*Beta vulgaris* L.) and radish (*Raphanus sativus* L.) in terms of organoponics or urban agriculture. Yields increased in the most favorable treatments by 30.66% in lettuce, 25.90% in chard and over 50% in beetroot and radish.

Amino acids is well known biostimulant which has positive effects on plant growth and yield as well as helping the plants to overcome the harmful effect caused by abiotic stress (Kowalezky and Zielong 2008). In addition, amino acids have several other roles in plants *e.g*. they regulate ion transport and stomatal opening and affect the synthesis and activity of enzymes and gene expression (Rai, 2002). Oaks (1994) reported that the amino acids are the first stable products of inorganic N assimilation and are the building blocks for proteins. Changes in the concentration of several amino acids or total amino acids have been shown to be involved in the regulation of many processes related to the nitrogen metabolism of the plant. Bioactive compounds, such as glycyrrhizin is usually produced as a mixture of potassium and calcium salts in plants (Zhang et al. 1995; Paolini et al. 1999) and was identified to be the major active component for its commercial value (Shibata 2000; Liu et al. 2007). In respect to the zinc element, it is a member of more than 300 enzymes in plants and it can be incorporated in the protein solution (Coleman, 1992). There are no references in respect to the use and effect of VIUSID agro on maize production. In this aspect, the present investigation is the first attempt in the use of VIUSID agro on maize especially in Egypt, therefore the objectives of the present study were: (i) to study the effect of VIUSID agro on maize yield and agronomic traits (ii) to determine the optimal dose of VIUSID agro which improve grain yield in maize (iii) to study relationship among grain yield and the different dosages of VIUSID agro for each studied cultivar.

MATERIALS AND METHODS

Two field experiments were carried out at the Agricultural Research and Experiment Station, of Faculty of Agriculture, Cairo University, Giza, Egypt (30°02' N and 31°13' E, with an altitude of 30 meter) during the two successive seasons of 2015 and 2016. The climatic variables in the two successive seasons are presented in Table 1. Soil properties of 2015 and 2016 seasons (Table 2) were analyzed at Reclamation and Development Center Desert Soils, Faculty of Agriculture Research Park, Cairo University.

Table 1. Some climatic variables recorded at Giza location in 2015 and 2016 seasons.

Month	2015		2016	
	Temperature (°C)	Relative humidity (%)	Temperature (°C)	Relative humidity (%)
June	29.1	44.9	29.9	47.4
July	32.2	46.5	28.9	57.5
August	33.2	46.6	29.3	57.9
September	32.8	46.7	27.8	56.2

* Data obtained by the Central Laboratory for Agricultural Climate (CLAC), Agricultural Research Center (ARC), Egypt. Precipitation was not detected in both seasons.

Table 2. Some physical and chemical properties of soil at the experimental site in 2015 and 2016 seasons.

Soil analysis	2015	2016
Physical properties		
Sand (%)	33.3	33.2
Silt (%)	30.2	31.5
Clay (%)	36.5	35.3
Texture class	Clay loam	Clay loam
Chemical properties		
pH $_{(1:1)}$	7.5	7.7
Ec$_{(1:1)}$ (dS m^{-1})	1.9	1.9
Organic matter (%)	2.3	2.2
Total Ca Co_3 (%)	3.4	3.5
Available N (mg kg^{-1})	35.4	40.9
Available P (mg kg^{-1})	9.0	9.9
Available K (mg kg^{-1})	210.0	230.0
Irrigation water analysis		
Ec of Irrigation water (ds/m)	0.78	0.86
pH of Irrigation water	7.02	7.50
Irrigation system	Flooding	Flooding

Table 3. Cultivar name and institution of development of five studied maize cultivars.

Cultivar Name	Institution
SC-30k9	**Pioneer : Pioneer International Company in Egypt**
SC-110	**ARC : Agricultural Research Center**
SC-30k8	**Pioneer**
TWC-310	**ARC**
Cairo-1	**Local open-pollinated composite developed at Agronomy Department, Faculty of Agriculture, Cairo university.**

Plant material

The genetic materials used in this investigation included five maize cultivars, namely the single cross hybrids SC-30k9, SC-110, SC-30k8, , the three way cross hybrid TWC-310 and the open-pollinated composite Cairo-1 (Table 3).

Experimental design and treatments

A split-plot design in a randomized complete block arrangement was used with four replications. The main plots were allotted to the four foliar spraying doses of VIUSID agro and genotypes were devoted to sub-plot. Each sub-plot consists of 20 ridges of 0.70 m in width and 4.0 m in length, i.e. the experimental plot area was 56 m^2. Each main plot was surrounded with a wide ridge (1.5 m) to avoid interference of the four doses of VIUSID agro. The composition of VIUSID agro is presented in Table 4. The four doses of VIUSID agro were applied by foliar spraying after ten days from sowing date as presented in Table 5.

Cultural practices

The preceding crop was wheat (*Triticum aestivum* L.) in both seasons. Sowing dates were on June 3 and 6 in 2015 and 2016 seasons, respectively. Seeds were sown in hills at 25 cm apart by hand, thereafter (before the 1st irrigation) were thinned to one plant per hill. Calcium super phosphate fertilizer (15.5% P_2O_5) at the rate of 60 kg P_2O_5/hectare was applied uniformly before sowing. Ammonium nitrate (33.5% N) at the rate of 240 kg N/hectare was added in two equal doses before the first and second irrigations. Standard agricultural practices were followed throughout the growing seasons. The weed management was carried out during the growing season by hoeing twice times, before the 1st and the 2nd irrigations and the pest control, if necessary, was done according to practices used at the experimental station. The other cultural practices were applied as recommended by the Agricultural Research Center (ARC), Giza, Egypt.

Data collection

At harvest, 50 guarded plants were randomly sampled from each plot to determine plant height in cm, measured from soil surface up to point of flag leaf, ears/plant and number of leaves/plant. Shelling%, calculated by dividing grain weight on ear weight and multiplied by 100, ear diameter (mm) and 100-kernel weight (g) were determined on 50 random ears from each plot. Grain yield in kg was weighed from whole area of each experimental unit (sub-plot) and then adjusted into ton per hectare (ton/ha). The grain yield per hectare was adjusted on the basis of 15.5% grain moisture content.

Statistical analysis

Test of normality distribution was carried out according to Shapiro and Wilk, method (1965), by using SPSS v. 17.0 (2008) computer package. Also, data were tested for violation of assumptions underlying the combined analysis of variance by separately analyzing of each season and then combined analysis across the two seasons was performed if homogeneity (Bartlet test) was insignificant. Estimates of LSD were calculated to test the significance of differences among means according to Snedecor and Cochran (1994). Relationship among grain yield and the different dosages of VIUSID agro was done according to Steel et al. (1997). The trend analysis was used to identify the treatments showing optimum value for each cultivar by using SPSS v. 17.0 (2008) computer package.

Table 4. Components % of VIUSID agro used in 2015 and 2016 seasons.

Components	%
Potassium phosphate	5.00
Malic acid	4.60
Glucosamine	4.60
Arginine	4.15
Glycine	2.35
Ascorbic acid	1.15
Calcium pantothenate	0.115
Pyridoxal	0.225
Folic acid	0.05
Cyanocobalamin	0.0005
Monoammonium glycyrrizinate	0.23
Zinc sulphate	0.115

All these compounds subjected to a molecular activation process, according to the manufactures.

Table 5. Characterization of VIUSID agro treatments

Treatments	Dose per application (L/ha)	Interval of applications (days)	Number of applications	Total dose (L/ha)
Control	0	0	0	0
Low	0.192	14	5	0.96
Medium	0.206	10	7	1.44
High	0.200	7	10	2.00

RESULTS

Basic statistical estimates

The data recorded on seven traits were subjected to descriptive statistics of studied traits such as mean, and measures of dispersion (Range, standard deviation, standard error and coefficient of variation). The descriptive statistics of the seven studied traits is presented in Table 6. Variability measures including range, standard deviation, standard error and coefficient of variation. In plant breeding, these measures are commonly used for the assessment of variability. Data showed that the coefficient of variation was lowest for all traits, except grain yield. Low values of C.V were recorded for 100- kernel weight (14.61 %), shelling % (6.69%), ear diameter (13.76%), number of leaves/plant (8.63%) and plant height (8.10%). On the other hand, a wide range of 11.42, 16.70, 23.26, 28.50, 4.25 and 68.00 for grain yield/ha, 100-kernel weight, shelling%, ear diameter, number of leaves/plant and plant height revealing a high level of diversity among the cultivars for these traits.

Analysis of variance

Combined analysis of variance (Table 7) showed that highly significant differences existed among all cultivars for all studied traits, except ears/plant. Mean squares due to doses of VIUSID agro were also highly significant for all studied traits, except ears/plant. Mean squares due to years were highly significant only for one trait, namely plant height. Significant or highly significant mean squares due to doses × years interaction were observed for all studied traits, except ears/plant and shelling%. Mean squares due to cultivars × years interaction were significant or highly significant for all traits, except grain yield/ha, ears/plant and shelling%. In addition, mean squares due to cultivars x doses interaction were highly significant for all traits, except ears/plant. Mean squares due to cultivars x years × doses interaction were also highly significant for all traits, except ears/plant

Effect of VIUSID agro

The effect of different doses of VIUSID agro on studied traits is presented in Fig. (1). Grain yield/ha under the dose of 0.96 L/ha of VIUSID agro was significantly exceeded the control by 26.0%. Yield increasing due to 0.96 L/ha of VIUSID agro was accompanied by significant increasing in 100-kernel weight (6.0%), ear diameter (25.0%) and number of leaves/plant (4.0%) compared with control. On the other hand, grain yield/ha was significantly decreased due to the doses of 1.44 and 2.0 L/ha of VIUSID agro compared to control by 6.0 and 21.0%, respectively. Yield reductions due to the doses of 1.44 and 2.0 L/ha were accompanied by reductions in 100-kernel weight (5.0 and 21.0%, respectively) and shelling% (3.0 and 9.0%, respectively) compared with control (Fig. 1). In contrast, significant increasing was observed in ear diameter (30.0%), number of leaves/plant (10.0 and 17.0%) and plant height (6.0 and 2.0%) due to 1.44 and 2.0 L/ha of VIUSID agro. It is interesting to note that number of ears/plant did not affected by applying different doses of VIUSID agro.

It was cleared that the dosage of 0.96 L/ha of VIUSID agro had significant effect on increasing grain yield/ha as well as increasing 100-kernel weight, ear diameter and number of leaves/plant. Therefore, the dosage of 0.96 L/ha of VIUSID agro could be recommended for increasing maize grain yield in the present investigation. On the other hand, the dosages of 1.44 and 2.0 L/ha of VIUSID agro had significant effect on increasing number of leaves/plant, plant height and ear diameter. In contrast, these two dosages (1.44 and 2.0 L/ha) had significant reductions on maize grain yield. Therefore, the dosages of 1.44 as well as 2.0 L/ha could be used for increasing number of leaves/plant and plant height that would be taken into consideration for increasing maize fodder yield for animal feeding.

Table 6. Mean, range, standard deviation, standard error and coefficient of variation for studied traits across 2015 and 2016 seasons.

Trait	Mean	Range	Std. Deviation	Std. Error	C.V%
Grain yield (ton/ha)	7.53	11.42	2.81	0.31	37.32
100- kernel weight (g)	30.72	16.70	4.49	0.50	14.61
Ears / plant	1.00	0.00	0.00	0.00	0.00
Shelling %	78.45	23.26	5.24	0.59	6.69
Ear diameter (mm)	43.56	28.50	5.99	0.67	13.76
Number of leaves/ plant	12.30	4.25	1.06	0.12	8.63
Plant height (cm)	189.09	68.00	15.31	1.71	8.10

Table 7. Combined analysis of variance of a split plot design for all traits of five maize cultivars evaluated under spraying four doses of VIUSID agro across 2015 and 2016 seasons

S.O.V	d.f	Grain yield	100- Kernel weight	Ears/plant	Shelling %	Ear diameter	Number of leaves/ plant	Plant height
Years (Y)	1	0.14	0.69	0.00	11.56	7.23	0.40	1050.63**
R(Y)	6	0.67	0.24	0.00	3.61	4.45	0.42	10.27
Doses (A)	3	96.08**	579.05**	0.00	544.66**	1061.49**	29.92**	889.29**
YA	3	0.88*	2.81**	0.00	1.51	22.49**	0.88**	345.09**
$Error_{(a)}$	18	0.25	0.29	0.00	4.85	2.90	0.17	8.39
Cultivars (B)	4	163.71**	250.74**	0.00	257.17**	95.50**	6.19**	5425.41**
YB	4	0.26	1.88**	0.00	6.88	10.60*	2.60**	183.94**
AB	12	15.82**	35.07**	0.00	117.16**	156.37**	4.34**	974.73**
YAB	12	1.38**	0.87**	0.00	17.32**	22.70**	1.25**	248.65**
$Error_{(b)}$	96	0.53	0.33	0.00	4.20	3.78	0.16	14.73

***and** indicate significant at 0.05 and 0.01 levels of probability, respectively.**

Genotypic differences

The studied maize cultivars showed a significant difference in their absolute mean values under different doses of VIUSID agro compared with control for all studied traits, except ears/plant (Table 8). Therefore, ranks of all studied cultivars under the doses of 0.96, 1.44 and 2.0 L/ha of VIUSID agro were different from that under control. The highest mean values of grain yield/ha were achieved by Cairo-1 (11.66 and 12.5 ton/ha) and SC-30k9 (9.64 and 13.24 ton/ha) under control and under the dosage of 0.96 L/ha, respectively. Under the dosages of 1.44 and 2.0 L/ha the single cross hybrid SC-30k9 exhibited the highest mean values of grain yield (9.40 and 8.75 ton/ha, respectively) among studied cultivars. The second best cultivars under the dosage of 1.44 L/ha were TWC-310 (8.62 ton/ha) and Cairo-1 (8.02 ton/ha). Under the dosage of 2.0 L/ha the second best cultivars were TWC-310 (7.72 ton/ha) and Cairo-1 (6.41 ton/ha). It is interesting to mentioned that TWC-310 occupied the 3rd high yielding cultivar under control and the 2nd high yielding cultivar under the dosages of 0.96, 1.44 and 2.0 L/ha of VIUSID agro. In respect to Cairo-1 it occupied the 3rd high yielding cultivar under the dosage of 2.0 L/ha (Table 8).

It is worth noting to note that the dosage of 0.96 L/ha of VIUSID agro increased grain yield compared with control by 81.53 and 37.34% for SC-30k8 and SC-30k9, respectively (Table 8). Also, the dosage of 0.96 L/ha increased grain yield for SC-110, TWC-310 and Cairo-1 by 28.1, 9.63 and 7.20%, respectively. On the other hand, the dosage of 1.44 L/ha increased grain yield compared to control by 14.0% (SC-110) and 16.96% (TWC-310). In contrast, the dosage of

2.0 L/ha of VIUSID agro decreased grain yield/ha for all cultivars compared to control with the exceptions of two cultivars, namely TWC-310 and SC-30k8. These two cultivars slightly increased under the dosage of 2.0 L/ha of VIUSID agro compared to the control for grain yield/ha by 4.8 and 7.4%, respectively.

Superiority of SC-30k9, Cairo-1 and TWC-310 under different dosages of VIUSID agro in the present study were accompanied by superiority of these cultivars in 100-kernel weight, shelling% and ear diameter and by superiority in number of leaves/plant and plant height in some cases (Table 8).

Table 8. Mean performance of all cultivars for all traits under spraying four doses of VIUSID agro 0.0 (control), 0.96, 1.44 and 2.0 L/ha (data are combined across 2015 and 2016 seasons)

VIUSID agro	Cultivar	Grain yield (ton/ha)	100-kernel weight (g)	Ears / plant	Shelling %	Ear diameter (mm)	Number of leaves/ plant	Plant height (cm)
Control	**SC-30k9**	9.64	35.4	1	79.92	22.5	11.5	188.25
	SC-110	6.38	35.2	1	79.61	38.75	10.75	198.25
	SC-30k8	4.06	29.12	1	80.08	34.5	12.25	184.25
	TWC-310	7.37	30.7	1	86.93	42.5	11.5	157.5
	Cairo-1	11.66	31.35	1	76.92	41.5	11	199.5
0.96 L/ha	**SC-30k9**	13.24	36.07	1	83.32	44	12.63	189.5
	SC-110	8.17	34.98	1	80.82	45.25	12.25	220.25
	SC-30k8	7.37	32.13	1	86.93	46.5	11.38	174.75
	TWC-310	8.08	32.52	1	80.9	45.5	11.38	160.5
	Cairo-1	12.5	35.58	1	76.78	43	11.63	186
1.44 L/ha	**SC-30k9**	9.4	32.73	1	84.4	47.75	13	197
	SC-110	7.29	33.67	1	75.28	45.5	11.63	198.75
	SC-30k8	3.5	24.17	1	69.55	47.75	12.5	187.5
	TWC-310	8.62	29	1	81.78	45.75	11.5	177
	Cairo-1	8.02	34.73	1	78.36	47	14.25	219
2.0 L/ha	**SC-30k9**	8.75	30.73	1	78.48	48	14.63	187.5
	SC-110	3.5	23.98	1	72.23	47.25	13.13	188
	SC-30k8	4.36	20.23	1	73.24	46	13.13	186.25
	TWC-310	7.72	26.6	1	75.42	45	13	185
	Cairo-1	6.41	25.48	1	68.09	47.25	13	197
LSD $_{0.05}$		**1.01**	**0.79**	**ns**	**2.88**	**2.73**	**0.56**	**5.38**

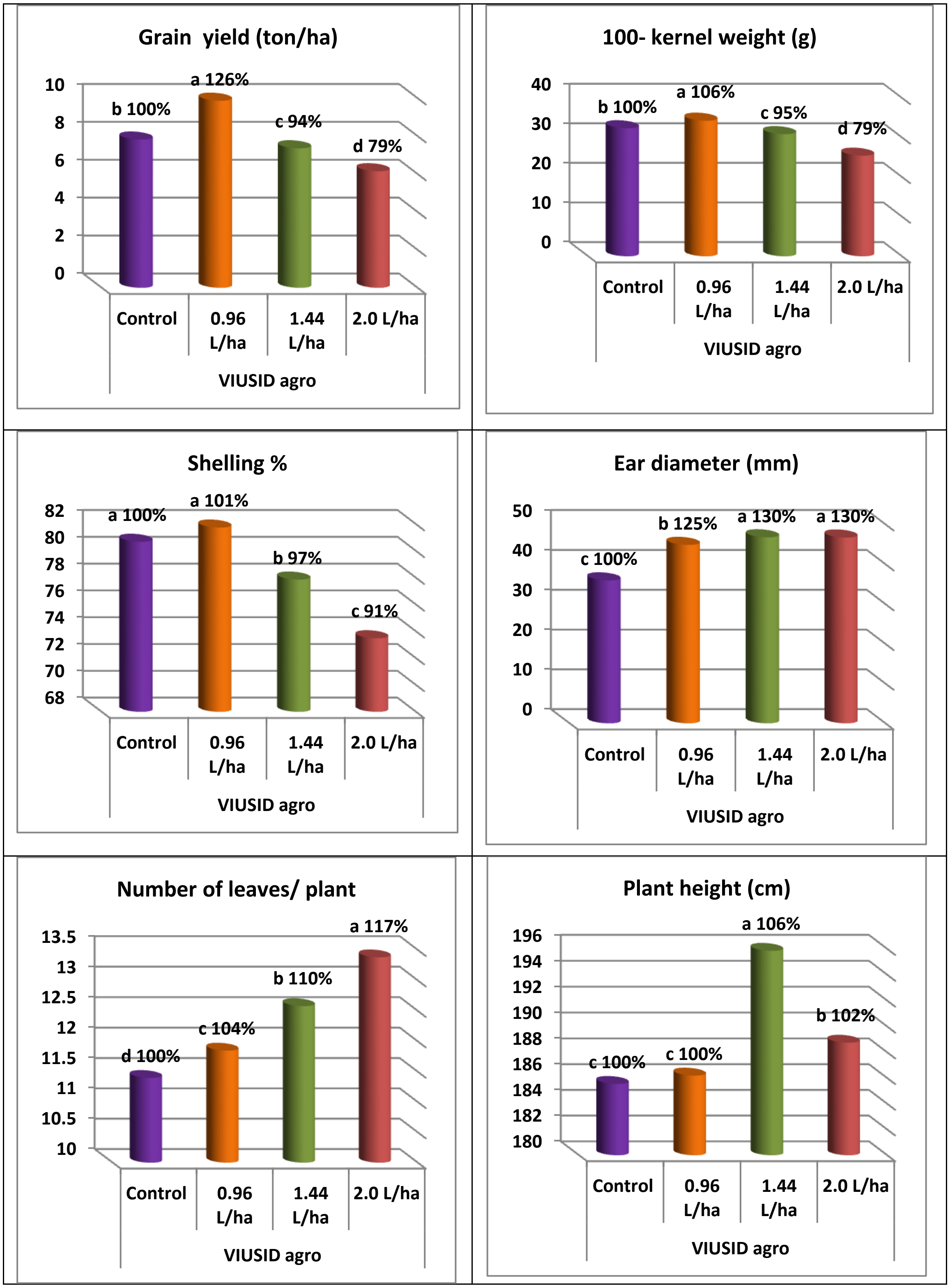

Figure. 1. Relative change of studied traits across all cultivars under spraying four doses of VIUSID agro 0.0 (control), 0.96, 1.44 and 2.0 L/ha (data are combined across 2015 and 2016 seasons). Relative change = ((control – dosage) / control) x 100)

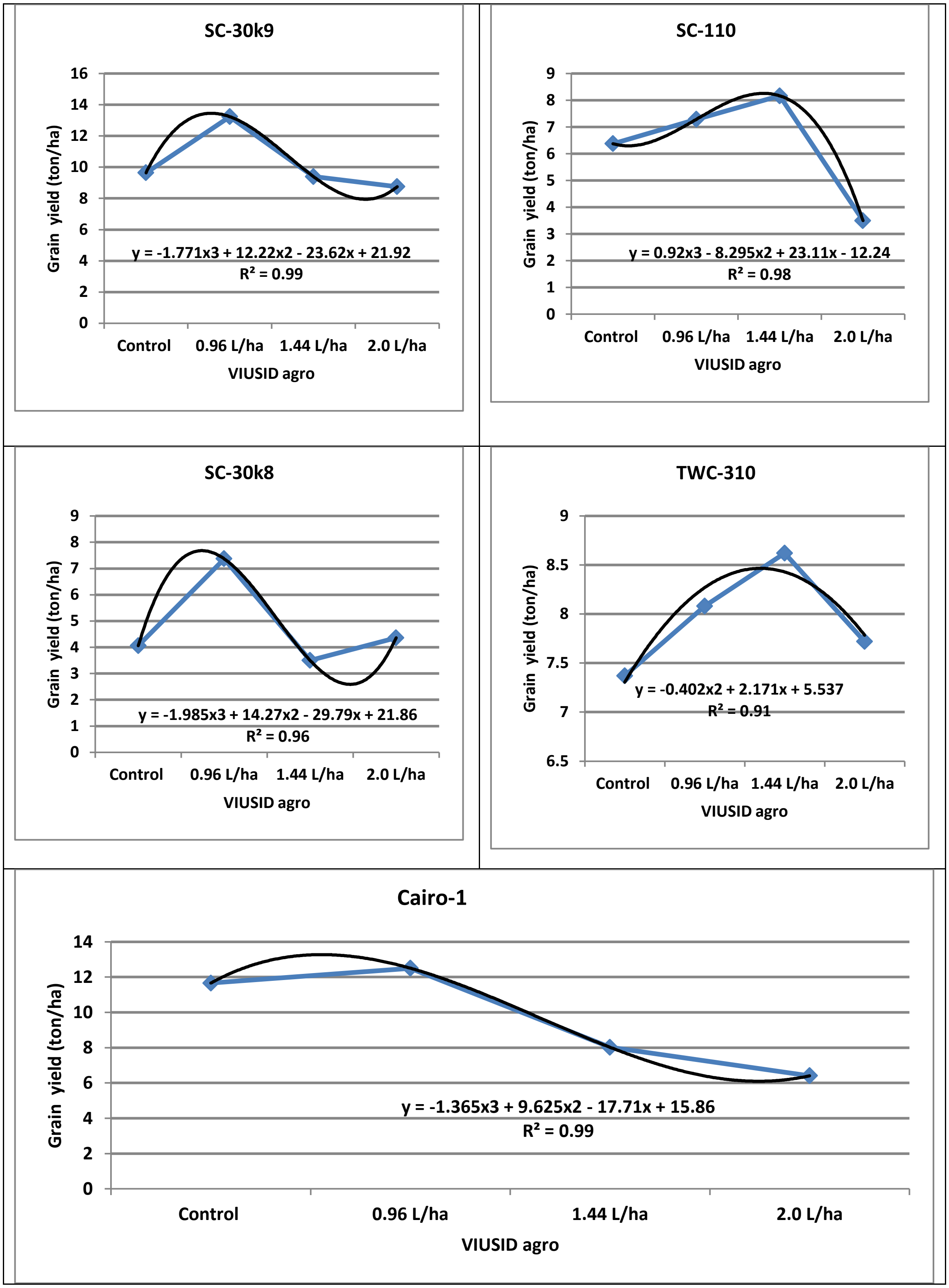

Fig. 2. Relationships between grain yield per hectare (GYPH) of SC-30K9, SC-110, SC-30k8, TWC-310 and Cairo-1 under spraying four doses of VIUSID agro 0.00 (control), 0.96, 1.44 and 2.0 L/ha (data are combined across 2015 and 2016 seasons).

These two cultivars slightly increased under the dosage of 2.0 L/ha of VIUSID agro compared to the control for grain yield/ha by 4.8 and 7.4%, respectively.

Superiority of SC-30k9, Cairo-1 and TWC-310 under different dosages of VIUSID agro in the present study were accompanied by superiority of these cultivars in 100-kernel weight, shelling% and ear diameter and by superiority in number of leaves/plant and plant height in some cases (Table 8).

Relationships among grain yield and the dosages of VIUSID agro

Data of the present investigation were reanalyzed to evaluate grain yield/ha responses of cultivars under different dosages of VIUSID agro. The trend analysis was used to identify the treatments showing optimum value for each cultivar. The relationships among grain yield and the dosages of VIUSID agro are presented in Fig.2. The cultivar TWC-310 showed a quadratic relationship, with the highest grain yield/ha (8.62 ton/ha) at the dosage of 1.44 L/ha of VIUSID agro. In contrast, the cultivars SC-30k9, SC-110, SC-30k8 and Cairo-1 showed a cubic relationship, with the highest grain yield/ha at the dosage of 0.96 L/ha for SC-30k9 (13.24 ton/ha), Cairo-1 (12.5 ton/ha), SC-110 (8.17 ton/ha) and SC-30k8 (7.37 ton/ha).

DISSCUSSION

Maximizing total production of maize in Egypt could be achieved by raising productivity per land unit area. One of the newly methods should be taken into consideration to increase the production of maize per unit area is the use of biostimulants. Biostimulants are supplements that contain nutrient, amino acids and plant extracts that do not affect humans or the environment adversely (Peña et al. 2017). One alternative would be taken into consideration is the use of VIUSID agro since, according to Catalysis (2014), it acts as a natural bioregulator and it composed of amino acids, vitamins and minerals (Peña et al. 2017). In addition, all of its components are subjected to a biocatalytic process of molecular activation that allows the use of low dosages with good results. The present study indicated that the studied genotypes and dosages of VIUSID agro had a significant effect on all studied traits, except ears/plant. Ranks of maize cultivars differ from one dose of VIUSID agro to another indicating that the studied dosages had significant effect on the studied genotypes, suggesting the possibility of selection for improved performance of such traits under a specific dosage of VIUSID agro.

The obvious increasing in grain yield/ha due to foliar spraying 0.96 L/ha of VIUSID agro indicating that biostimulants when it applied in small amounts, able to stimulate nutrient uptake and use efficiency by plants and improve crop quality as reported by Calvo et al. (2014). Furthermore, biostimulants can increase the activity of rhizospher microbes and soil enzymes, the production of hormones and /or growth regulators in soil and plants, and the photosynthetic process (Nardi et al. 2009; Giannattasio et al. 2013). Ertani et al. (2012) reported that the addition of biostimulants to plants also modifies the morphology of plant roots in a similar way to indole acetic acid (IAA), suggesting that they induce a “nutrient addition response” that favors the uptake of nutrients *via* an increase in the absorptive surface area. It is worth noting that VIUSID agro acts as a natural bioregulator and composed of amino acids, vitamins and minerals and all of its components are subjected to a biocatalytic process of molecular activation that allows the use of low dosage with good result (Peña et al. 2017). Increasing maize yield/ha under the low dosage (0.96 L/ha) of VIUSID agro in the present investigation suggesting that the dosage of 0.96 L/ha could be recommended for maximizing maize grain yield and proved that the biocatalytic process of molecular activation of the components of VIUSID agro allows the use of low dosage with good result.

Amino acids that involved in the components of VIUSID agro have several roles in plants, such as they have positive effects on plant growth and yields as well as helping the plants to overcome the harmful effect caused by abiotic stress (Kowalezky and Zielong, 2008). In addition, they regulate ion transport and stomatal opening and affect the synthesis and activity of enzymes and gene expression (Rai, 2002) as well as they are the first stable products of inorganic N assimilation and are the building blocks for proteins (Oaks, 1994). In respect to glycyrrhizin, it is a bioactive compound and it usually produced as a mixture of potassium and calcium salt in plants (Zhang et al. 1995; Paolini et al. 1999). Glycyrrhizin was identified to be the major active component for its commercial value (Shibata, 2000; Liu et al. 2007). The zinc element has a great importance that is a member of more than 300 enzymes in plants and it can be incorporated in the protein solution (Coleman, 1992). There are no references about the effect of VIUSID agro on maize production. However, some experiments were conducted in several other crops where VIUSID agro application lead to an increase in production. It was found that it increased the quality of the leaves of the anthurium (*A. andreamum*) and the start of flowering (Peña et al. 2015 b), as well as the germination of the seed and production of tomatoes (*S. lycopersicum*) (Peña et al. 2016). In addition, Peña et al. (2017) conducted some experiments aimed to evaluate the effect of VIUSID agro in the productive performance of lettuce (*L. sativa*), Swiss chard (*B. vulgaris* var. *cicala*), beetroot (*B. vulgaris* L.) and radish. Yields increased in the most favorable treatments by 30.66% in lettuce, 25.90% in chard and over 50% in beetroot and radish

Maximum yield increasing was observed by applying the dosage of 0.96 L/ha for SC-30k8, SC-30k9, SC-110 and Cairo-1 in descending order, suggesting that the dosage of 0.96 L/ha of VIUSID agro is suitable for most studied cultivars with the exception of TWC-310 that the dosage of 1.44 L/ha was more suitable for it.

CONCLUSION

Foliar spraying of VIUSID agro increased grain yield and improved performance of maize. Increasing maize grain yield was obvious for most studied cultivars by applying the dosage of 0.96 L/ha of VIUSID agro than other dosages.

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CONFLICT OF INTEREST

The present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

This work was carried out in collaboration between all authors. Author MMM Atta wrote the protocol and wrote the first draft of the manuscript. Authors HM Abdel-Lattif designed and performed data analyses and Ragab Absy managed the literature searches. All authors designed the study, managed the experimental process, read and approved the final manuscript.

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