Plant Archives Vol. 20 Supplement 1, 2020 pp. 1783-1793 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

INTEGRATED EFFECT OF PLANT GROWTH REGULATORS WITH BORON SOURCES ON SOME BIOLOGICAL PARAMETERS OF SUGAR BEET

Marwa A. Qotob[1*], Mostafa A. Nasef[1], Heba K. A. Elhakim[2], Olfat G. Shaker[3], Nader R. Habashy[1] and Ismail A. Abdelhamid[4]

[1*]Soils, Water and Environment Research Institute, Agriculture Research Center, Giza, Egypt.
[2]Biochemistry department, Faculty of Science, Cairo University, Giza 12613, Egypt.
[3] Department of Biochemistry, Faculty of Medicine, Cairo University, Egypt.
[4] Department of Chemistry, Faculty of Science, Cairo University, Giza12613, Egypt.

Abstract

Any improvement in agricultural systems that results higher production aimed to reduce negative environmental impacts and enhance sustainability plant growth regulators such as gibberellin have similar physiological and biological effects to those of plant hormones and therefore used widely in agriculture to minimize unwanted shoot growth without lowering plant productivity.

An experimental field was conducted at Giza Experimental Station Egypt, on sugar beet plants (*Beta vulgaris* L. *var.* Sara poly) with some plant growth regulators (gibberellin and proline) foliar application at three rates of zero (control), 100 and 200 mg l^{-1} and boron sources (Boric acid and B-NPs) with 75% of macro-nutrients from full dose.

The main target of this study to evaluate another plant growth regulator source like proline which is safer than gibberellin for maximizing sugar beet biological parameters to reduce the gap between sugar consumption and production in presence of boron sources.

Data showed that the foliar applications of gibberellin at rate 100 mg l^{-1} and proline at 200 mg l^{-1} were found to be the more effective without significant differences for plant growth, productivity and quality may be due to increased N use efficiency, especially at sub-optimal macro nutrient fertilizers. Regard to boron sources, B-NPs had positive effect on all biological parameters under study due to sugar transport, cell membrane synthesis, nitrogen fixation, respiration, carbohydrate metabolisms, root growth, functional characteristics and development.

Key words: Proline, GA_3, Boric acid, B-NPs, Macro-nutrient fertilizers, Sucrose quality, sugar beet, Betaine, Choline.

Introduction

Sugar beet (the raw material of the beet sugar factory) composition is important to both the sugar beet farmer and the factory. Sugar (sucrose) and non-sugar (non-sucrose) content determine the quality of the sugar beet where, high sugar and low non-sugar content is desirable. So it is important to evaluate the chemical quality of sugar beet roots in order to evaluate their quality for sugar production. Root yield and technical quality of sugar beet are strongly influenced by weather conditions. The technical quality of sugar beet is essential for economical sugar manufacturing (Asadi, 2006). The wide majority of beets are grown by independent farmers, who are contracted by the factories directly. The industrial demand for sugar beets is increasing, which provides a higher price, incentivizing many farmers to plant more beets. FAS (Foreign Agricultural services) Cairo is increasing sugar beet area harvested in MY 2019/20 to 250,000 ha. Post is revising down last year's harvested area to 225,000 hectares instead of 230,000. With the decreased area harvested, post also revised down MY 2018/19 production to 9.5 MMT, six percent below earlier estimates. Macro-nutrients fertilization is among the vital factors affecting growth, quality and productivity of sugar beet, thus application the suitable rates of nitrogen, phosphorus and potassium one of the favorable factors

***Author for correspondence :** E-mail: marwaaqotob2017@gmail.com

for increasing sugar beet productivity and quality. The proper fertilization reference can be given only based on the soil fertility. It must be determining optimum nitrogen rate, which produce the maximum root, sugar yields and quality parameters (Seadh, 2012).

Plant growth regulators are hormones that widely used in agriculture to increase plant growth and reproduction. The commonly used class of plant growth regulators includes plant growth hormones such as cytokinin and gibberellic acid (Fukao and Bailey-Serres, 2008).

Gibberellins involved in a number of cellular processes that regulate seed germination and growth of aerial plant parts, including floral induction and fruit development (Spaepen, Vanderleyden and Okon, 2009). The effect of spray of gibberellic acid (GA_3) at very low concentrations could be exploited beneficially as its natural occurrence in plants in minute quantities is known to control their development. It is an established phytohormone used commercially for improving the productivity and quality of a number of crop plants (King, R.W. and Evans, 2003). When GA_3 was added to the plant it was effective in enhancing nutrient utilization efficiency of plant and increase the plant quality and productivity (Miceli *et al.*, 2019).

Proline is the most widely distributed metabolite that accumulates under stress conditions (Delauney and Verma, 1993) the significance of this accumulation in osmotic adjustment in plants is still debated and varies from species to species (Hoai *et al.*, 2003). The crystallization of sugar in the industrial processing of beet root in sugar refineries may be jeopardized by accumulation of compounds, such as proline and glucose, because they lead to the formation of coloured components that reduce the quality of beet roots (Monreal *et al.*, 2007).

Boron is one of the important micronutrient among essential elements for plant growth and plays a significant role in the physiological and biochemical processes within plants (Tariq, M. and Mott, 2006). Boron plays a key role in higher plants by facilitating the short-and long-distance transport of sugar via the formation of borate-sugar complexes. In addition, boron may be of importance for maintaining the structural integrity of plasma plant cells membranes. This function is likely related to stabilization of cell membranes by boron association with some membrane constituents (Brown *et al.*, 2002).

Nanotechnology to precisely detects and delivers the correct quantity of nutrients and pesticides and increases the bioavailability (Goudar *et al.*, 2018) which promote productivity while ensuring environmental safety and higher use efficiency. Nano boron has many merits like quick and easy uptake by plants. It has lower tendency to leach *via* soil and appear its impact for shorter times. It improves solubility and dispersion of insoluble nutrients in soil, reduces soil fixation.

The main target of this study using some plant growth regulators *i.e.* gibberellin and proline to increase sugar beet productivity and its biological parameters without hazard effect on human beings and environment in presence of boron sources (Boric acid and Nano boron) with controlled use of macro-nutrient fertilizers.

Materials and Methods

A field experiment was conducted on a clay texture soil at El Giza Agricultural Research Station, Egypt (located between 30° N, 31°: 28 E at an altitude 19 meters above sea level) and cultivated with sugar beet (*Beta vulgaris var.* Sara poly) during winter season of 2018 and 2019. The current study aimed to identify the direct beneficial effects on applying some plant growth regulators as gibberellin and proline at different rates (100, 200 mg l^{-1}) with two boron sources (boric acid and nano boron, B-NPs) at recommended dose for sugar beet (0.48 Kg B $acre^{-1}$) at full dose and 75% from full dose of macro-nutrient fertilizers. The nano boron (B-NPs) analysis of X- ray pattern in (Fig. 1).

The experiment was laid-out in split-split plot design with three replicates as follows:

a. The main plots were 75% from full dose. Calcium super phosphate (15.5% P_2O_5) was added at rate 112.5 P_2O_5 Kg $acre^{-1}$ during the soil preparation. Nitrogen was applied at rate of 56.5 Kg N $acre^{-1}$ as urea (46.5% N) in three equal doses after 21, 45 and 60 days from planting. Potassium sulphate (50%

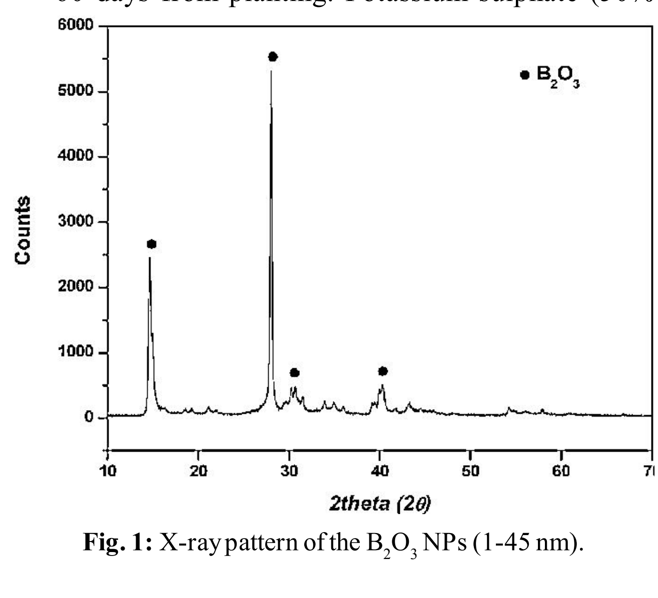

Fig. 1: X-ray pattern of the B_2O_3 NPs (1-45 nm).

K_2O) at rate of 37.5 Kg K_2O acre^{-1} was added in two equal doses after 30 and 50 days from planting. Foliar applications of both plant growth regulators and boron were applied after 45 and 60 days from sowing. All cultural practices for growing sugar beet were done as recommended.

b. The sub plots were plant growth regulators *i.e.* GA_3 (Natural Enterprise Co.) and proline (Alfa Aesar Co.) at three rates as a foliar application (Zero, 100 and 200 mg l^{-1}).

c. The sub-sub plots were applied foliar with two boron sources boric acid (Aldrich Co.) and B-NPs (Yara Fertiliser Co.) at the recommended dose for sugar beet (0.48 Kg B acre^{-1}).

An agricultural soil sample (0-30 cm depth) was used for the study. It was air-dried, ground and sieved with a 2 mm sieve. Some of its properties were estimated according to (Page, Miller and Keeney, 1982). The total N was determined by distillation in a Macro-Kjeldahl (Gerhardt model VAP 30 S). Total P was estimated colorimetrically using stannous chloride mixture and measured by UV/Vis spectrophotometer (JENWAY model 6705 UV/Vis), while K^+ and Na^+ concentrations were measured by flame photometer (JENWAY model PFP7). The concentrations of Ca^{+2}, Mg^{+2}, Fe, Mn, Zn, Cu and B were measured by ICP-AAS spectrophotometer (Agilent Technologies model 8800) (Jackson, 1959), (Cottenie *et al.*, 1982). Tabulated in (Table 1).

Chemical analyses of sugar beet plants were carried out on the samples to determine Chlorophyll pigment contents in leaves of sugar beet according to (Sumanta *et al.*, 2014), determination of boron by ICP (Inductively coupled plasma) spectrometry (model, Ultima 2 JY Plasma) (Jackson, 1959), (Cottenie *et al.*, 1982), total sugar in were determined in sugar beet roots calorimetrically with the picric acid method as described by (Thomas and Dutcher, 1924), betaine was determined by (Focht, Schmidt and Dowling, 1956), choline was determined according to (Gimesi and Szász, 1974), proline was investigated by (Carillo and Gibon, 2011) by the absorbance of the extract measured Spectrophotometer using by JENWAY 6705 UV/Vis., gibberellin was determined using gas spectroscopy model Trace 1310 GC as described by (Moritz and Monteiro, 1994), total soluble solids was determined by (Mariani *et al.*, 2014) using refractometer (model J57HA), determination of α-Amino nitrogen by (Shtanheev *et al.*, 1998), purity was measured by (Guyot, 1967).

Data statistically analyzed by the analysis of variance (ANOVA) was carried out to determine the statistical significance using the least significant difference at level at 0.05 (Gomez and Gomez, 1984).

Results and Discussion

The aim of this study to reduce the consumption of mineral fertilizers through using plant growth regulators

Table 1: Chemical and physical characteristics of initial soil under investigation.

Soil characteristics	Value	Soil characteristics	Value
Particle size distribution%:		Soluble cations (soil paste, $mmol_c l^{-1}$):	
Sand	26.2	Ca^{+2}	2.35
Silt	29.3	Mg^{+2}	1.20
Clay	44.5	Na^+	6.85
Soil textural class	Clay*	K^+	5.13
Soil chemical properties:		Soluble anions (soil paste, $mmol_c l^{-1}$):	
pH (1:2.5 soil water suspension)	8.95	CO_3^{-2}	0.00
$CaCO_3$ %	4.82	HCO^{-3}	3.15
Organic matter %	1.53	Cl^-	6.40
EC_e (dS m^{-1}, soil past)	1.69	SO_4^{-2}	5.95
Soil physical properties:		Available macro- and micronutrients mg kg^{-1}	
Bulk density, g cm^{-3}	1.20	N	46.34
Sodium adsorption ratio (SAR)	5.15	P	18.56
Exchangeable sodium (ESP)	4.50	K	349.1
Saturation (SP)	70.3	Fe	41.2
CEC** $cmol_c$ kg^{-1}	53.2	Mn	26.1
Moisture content %:		Zn	2.43
Field capacity	27	B	1.13
Wilting point	16		
Available water	11		

* Using USAD Soil Texture Triangle, after (Twarakavi, N. K. C., Šimůnek, J. and Schaap, 2010). ** CEC= Cation exchange capacity.

(gibberellin or proline) at the same time evaluate possibility replace the gibberellin by proline which showed its harmful effect on animal and human cells according to (Wang, L., Liu, J., Li, X., Shi, J., Hu, J., Cui, R., Zhang, Z. L., Pang, D.W. and Chen, 2011) who stated that the present study clearly demonstrated that PGRs including gibberellin and cytokinin may cause acute toxicity and teratogenic effect in both neonate and embryo cells.

The obtained data of both successive seasons were not significantly different, their average was taken into consideration.

Pigment content in sugar beet

The obtained data in table 2 revealed that the foliar application of plant growth regulators (gibberellin and proline) increased the pigment content *i.e*. chlorophyll-a, chlorophyll-b and carotenoids where the mean values at rate 100 mg l^{-1} gibberellin and 200 mg l^{-1} proline were 6.15 and 5.44 g100 g^{-1} FW for chlorophyll-a, 3.39 and 2.99 g100 g^{-1} FW for chlorophyll-b, 0.916 and 0.887 g100 g^{-1} FW, respectively. Exogenous application of gibberellins (GAs) has shown enhanced activities of carbonic anhydrase, nitrate reductase (Afroz, S., Mohammad, F., Hayat, S. and Siddiqui, 2005), CO_2 fixation, stomatal conductance (Bishnoi and Krishnamoorthy, 1991) and ribulose-1,5-biphosphate carboxylase /oxygenase (Yuan and Xu, 2001). GAs alters membrane permeability to ions (Gilroy, S. and Jones, 1992) and improves translocation potential to the sink (Peretó and Beltrán, 1987). The physiological and biochemical modes of action of GA_3 is likely responsible for increasing shoot dry biomass plants. Generally, lower concentrations of plant growth regulators are biochemically more active with higher concentrations becoming toxic (Kulkarni *et al*., 2013). Proline, a multifunctional amino acid, besides acting as an excellent osmolyte is also known for stabilizing subcellular structures such as proteins and cell membranes, scavenging free radicals, balancing cellular homeostasis and signaling events and buffering redox potential under stress conditions (Hayat *et al*., 2012). It could be reflecting on maintaining the nutrient status in roots.

This report is in conformity with the increased nitrate content of roots by exogenous application of proline (Alyemeni *et al*., 2016). exogenous application of proline mitigated the decreased plant growth caused by stress is through increasing antioxidant system, relieving oxidative damage, improving the synthesis of compatible solutes and accelerating proline accumulation, which reflected on enhancing photosynthesis (Anjum *et al*., 2011). Also, the chlorophyll molecules are the membrane bound structures whose stability depends highly on the integrity of the membrane structure which is possibly maintained by proline as it acts as a membrane stabilizer (Ashraf, M. and Foolad, 2007).

Table 2: Integrated effect of plant growth regulators and mineral fertilizer rates with different boron sources on sugar beet pigments.

Boron sources (B)	Control	Gibberellin (mg l^{-1})			Proline (mg l^{-1})		
		100	200	Mean	100	200	Mean
Chlorophyll-a (g 100g^{-1} FW)							
Contr.	3.14	5.59	4.99	4.57	4.10	5.12	4.12
Boric acid	3.23	6.18	5.49	4.96	4.83	5.25	4.44
B-NPs	3.46	6.67	5.70	5.28	4.90	5.94	4.77
Mean	3.28	6.15	5.39	4.94	4.61	5.44	4.44
Chlorophyll-b (g 100g^{-1} FW)							
Contr.	1.33	2.71	2.68	2.24	2.45	2.70	2.16
Boric acid	1.59	3.65	3.22	2.82	2.60	2.92	2.37
B-NPs	1.72	3.80	3.50	3.01	2.73	3.35	2.60
Mean	1.55	3.39	3.13	2.69	2.59	2.99	2.38
Carotenoids (g 100g^{-1} FW)							
Control	0.673	0.831	0.728	0.744	0.731	0.802	0.735
Boric acid	0.685	0.937	0.746	0.789	0.769	0.892	0.782
B-NPs	0.708	0.981	0.771	0.820	0.824	0.978	0.837
Mean	0.689	0.916	0.748	0.784	0.775	0.881	0.783
L.S.D. at 0.05							
	B	G	R	B × G	B × R	G × R	B × G × R
Chlorophyll-a	0.61	1.01	0.55	0.57	0.56	0.70	0.50
Chlorophyll-b	0.37	0.85	0.45	0.51	0.11	0.30	0.35
Carotenoids	0.02	0.03	0.10	0.09	0.04	0.15	0.02

B=Boron sources, G=Plant growth regulator sources and R=Rate of Plant growth regulator.

Regard to boron sources, data showed that foliar application of nano boron on sugar beet plants was more respond than boric acid where the chlorophyll-a, chlorophyll-b and carotenoids contents were 3.13, 1.58 and 0.695 g100 g^{-1} FW for nano boron and 3.06, 1.40 and 0.662 g100 g^{-1} FW for boric acid, respectively. This result was in agreement with (Hassan, Ahmad and Mohi-ud-din, 2013) who reported that application of boron increase net photosynthetic rate which may be attributed to the increase in chlorophylls content of leaves. Furthermore, application of boron increased the activity of catalase and glutathione reductase, which act as antioxidants thus saving the electron transport mechanism of plant from getting oxidized by free radicals like superoxide radicals, singlet oxygen radicals (Wojcik, V.A., Frankie, G.W., Thorp, R.W. and Hernandez, 2008). Also, (Davarpanah *et al*., 2016) indicated that the foliar application of nano-B fertilizers in plant increased the leaf concentrations of both microelements, reflecting the improvements in nutrient status.

The interaction between gibberellin and nano boron give the highest response for all parameters under study this may be due to GAs oxidation and activation seems to be regulated sequentially by the boron status, probably *via* suppression of GA_{20}-oxidase by KNOX homeodomain protein (Chen, Banerjee and Hannapel, 2004). Moreover, rapid conversion to a bioactive form of GAs may be favourable especially under high boron supply to prevent overgrowth and stabilize plant development (Eggert and von Wirén, 2017).

In general, it could be noted that the interaction between foliar application of plant growth regulators accompanied with boron sources used give more respond than plant growth regulators or boron sources sole and the more effective treatment were 100 mg l^{-1} gibberellin and 200 mg l^{-1} proline with nano boron without any significant differences.

Residual content of applied plant growth regulators and boron sources used in sugar beet roots

Data showed in table 3 that the foliar application of plant growth regulators (Gibberellin or Proline) at two rates 100 and 200 mg kg^{-1} on sugar beet roots residual content increased by application of gibberellin. The obtained data was in agreement with (Kim *et al.*, 2008) who reported that GA_3 applications significantly increased endogenous GA_3 content in the plants. On contrast, proline application did not affect the residual content of gibberellin when applied at both rate compared to control treatment. According to (Osman, 2015) exogenous application of proline might be not only accelerated the translocation process of amino acids from source to sink, but also suppressed the conversion process from amino acids to proteins.

Also, data showed that the residual content of proline and boron increased by application rates of gibberellin, this may be due to that the gibberellic acid may stimulated plant on building protein and the optimum transform of nutrients although the unavailability of moisture in the plant to a certain level (Al-Shaheen and Soh, 2016). Regard to the application of proline at 100 and 200 mg kg^{-1} proline and boron content were increased by increasing proline concentration. According to (Kahlaoui, B., Hachicha, M., Rejeb, S., Rejeb, M.N., Hanchi, B. and Misle, 2014) the exogenous application of proline leads to a significant increase in the proline accumulation of both organs (leaves and roots) in plant.

Further study showed that amino acids such as proline have a chelating effect on micronutrients when applied together, the absorption and transportation of micronutrients inside the plant is easier, this effect is due to the chelating action, the effect of cell membrane permeability and low molecular weight (Westwood, 1993).

Regard to the foliar application of boron on plants of sugar beet (*Beta vulgaris* L.) in the form of boric acid or B-NPs, the obtained data showed that the mean values of proline content were 2.45, 2.17, 2.62 and 2.35 µmol g^{-1} FW, gibberellin content 13.07, 13.02, 13.15 and 13.09 mg kg^{-1} and boron content 49.82, 45.98, 52.45 and 49.75 mg kg^{-1}, respectively. According to (Nilanjan, 2013) stated that compared to the conventional boric acid or Borax fertilizers, all of which are on the macro scale (on the order of micrometers) (macro boric acid"), the boron nanofertilizers of embodiments herein (on the order of nanometers) shows a sharp increase in crop yield (increased biomass, potato tuber yield and plant weight) and

Table 3: Residual content of plant growth regulators applied with different boron sources on sugar beet roots.

Boron sources (B)	Control	Gibberellin (mg l^{-1})			Proline (mg l^{-1})		
		100	200	Mean	100	200	Mean
Proline (µmol g^{-1} FW)							
Contr.	2.16	2.39	2.16	2.28	2.25	2.45	2.33
Boric acid	2.29	3.06	2.74	2.75	2.69	2.78	2.64
B-NPs	2.41	3.11	2.85	2.86	2.84	3.01	2.82
Mean	2.45	2.85	2.58	2.63	2.59	2.75	2.60
Gibberellin (mg kg^{-1})							
Contr.	13.05	15.68	14.70	14.48	13.46	13.61	13.37
Boric acid	13.07	16.25	15.54	14.95	13.62	13.89	13.53
B-NPs	13.15	16.75	15.80	15.23	13.80	14.15	13.70
Mean	13.09	16.23	15.35	14.89	13.63	13.88	13.53
Boron (mg kg^{-1})							
Control	46.21	65.82	60.45	56.97	61.09	67.38	57.71
Boric acid	49.82	78.64	66.12	63.58	65.62	70.53	60.71
B-NPs	52.45	84.35	72.30	68.80	73.86	78.81	67.47
Mean	49.49	76.27	66.29	63.12	66.86	72.24	61.96
L.S.D. 0.05							
	B	G	R	B × G	B × R	G × R	B × G × R
Proline	0.08	0.15	0.11	0.10	0.11	0.12	0.05
Gibberellin	0.15	1.20	0.50	0.21	0.11	0.20	1.40
Boron	2.01	3.10	4.71	4.55	5.09	4.85	1.25

B=Boron sources, G=Plant growth regulator sources and R=Rate of Plant growth regulator.

crop quality (less reducing sugar and increased starch content).

Finally, the interaction analysis for 75% NPK from the recommended dose accompanied with foliar application of gibberellin at rate 100 mg l^{-1} and nano boron (NPs) was the most effective treatment than the same interaction with boric acid.

Sugar extraction and quality parameters

Data obtained in (Table 4) revealed that the foliar application of plant growth regulator as a gibberellin at rate 100 mg l^{-1} give the highest values for sucrose, purity and total soluble solids whereby increase the rate of gibberellin at rate of 200 mg l^{-1} the was observed that decreased in all pervious parameters. In contrast, the results showed that the foliar application of proline gave higher response at 200 mg l^{-1} than 100 mg l^{-1} as application rates where, proline, a multifunctional amino acid, besides acting as an excellent osmolyte is also known for stabilizing subcellular structures such as proteins and cell membranes, scavenging free radicals, balancing cellular homeostasis and signaling events and buffering redox potential under stress conditions (Hayat *et al.*, 2012).

Also, (Asil, Roein and Abbasi, 2011) who indicated drenching with gibberellin increased the floral stalk height as compared to the control. It may be attributed to the effect of gibberellin in stimulating and accelerating cell division, increasing cell elongation and enlargement, or both (Hartmann and Kester, 1963).

Regard to data in (Table 4) the foliar application of boric acid and B-NPs as a boron sources on sugar beet plants observed that nano boron source was more effective than boric acid for sucrose, purity, α- amino nitrogen and total soluble solids with values (16.48, 16.32 and 16.69, 16.41%), (80.47, 80.25 and 80.62, 80.31%), (1.15, 1.37 and 1.32, 1.21%) and (19.4, 18.4 and 19.8, 18.7 Brix<”), respectively. These results were in agreement with (Naderi, Danesh Shahraki and Naderi, 2011) who dedicated that application of nanofertilizers instead of common fertilizers, where nutrients are provided to plants gradually and in a controlled manner. Meanwhile, the nanotechnology increases the application efficiency of fertilizers, decreases pollution and risks of chemical fertilization. Also, (Zahedi, Karimi and Teixeira da Silva, 2019) reported that nanofertilizers when sprayed at very low concentrations on plants showed a direct effect by increasing the growth, final products and quality of plants.

Finally, the interaction analysis for 75% NPK from the recommended dose accompanied with foliar application of gibberellin at rate 100 mg l^{-1} and proline at rate 200 mg l^{-1} with nano boron was the most effective treatment than the same interaction with boric acid.

Some bio-chemical components of sugar beet

The represented data in table 5, showed that the foliar application of gibberellin at 100 mg l^{-1} was the most effective treatment followed by proline at 200 mg l^{-1} as in betaine content 0.172 and 0.171 g 100 g^{-1}, choline content 8.40 and 7.93 mg 100 g^{-1} FW and total carbohydrate content 14.8 and 14.3 g 100g^{-1}). These results in harmony with (El-Sherbeny and Da Silva, 2013) who reported that proline proved to be successful agents in improving growth

Table 4: Integrated effect of plant growth regulators and macro-nutrients fertilizer rates with different boron sources on Sugar content and quality.

Boron sources (B)	Control	Gibberellin (mg l^{-1})			Proline (mg l^{-1})		
		100	200	Mean	100	200	Mean
Sucrose (%)							
Control	16.09	17.65	16.81	16,82	16.95	17.48	16.84
Boric acid	16.48	18.30	16.90	17.23	17.10	17.70	17.09
B-NPs	16.69	18.90	17.60	17.79	17.84	18.65	17.73
Mean	16.42	18.28	17.10	17.24	17.30	17.94	17.22
Purity (%)							
Control	80.42	82.80	81.89	81.60	82.07	82.43	81.54
Boric acid	80.47	83.57	82.21	82.01	82.71	82.75	81.90
B-NPs	80.62	84.51	82.85	82.56	82.80	83.99	82.47
Mean	80.50	83.63	82.32	82.01	82.53	83.06	81.97
á- Amino nitrogen (%)							
Control	1.24	1.12	1.27	1.14	1.23	1.12	1.13
Boric acid	1.15	1.17	1.17	1.24	1.08	1.22	1.22
B-NPs	1.32	1.02	1.19	1.14	1.28	1.26	1.25
Mean	1.24	1.10	1.21	1.17	1.20	1.20	1.20
Total Soluble Solids (Brix<”)							
Control	18.2	21.9	20.8	20.3	21.4	21.9	20.4
Boric acid	19.4	23.8	22.1	21.4	22.6	23.3	21.4
B-NPs	19.8	25.3	23.5	22.5	23.4	24.2	21.9
Mean	19.1	23.7	22.1	21.5	22.5	23.1	21.4
L.S.D. 0.05							
	B	G	R	B×G	B×R	G×R	B×G×R
Sucrose	0.11	0.65	0.30	0.49	0.51	0.60	0.05
Purity	0.08	0.70	0.25	0.25	0.80	0.42	0.10
á-Amino N	0.10	0.18	0.09	0.11	0.21	0.09	0.08
TSS	0.25	1.15	0.35	0.40	0.75	0.58	0.15

B=Boron sources, G=Plant growth regulator sources and R=Rate of Plant growth regulator.

and yield characters of beet plants, especially at 100mg·L^{-1} and 200mg·L^{-1} also, GA_3 increases the chlorophyll concentrations in leaves by increasing the numbers and sizes of chloroplasts and enhances the ultra-structural morphogenesis of plastids (Richard, N.A., 1996). In general, photosynthetic efficiency increases along with the chlorophyll concentration. Thus, exogenous GA_3 indirectly causes the increase in chlorophyll (Ashraf, Karim and Rasul, 2002) that resulted in the accumulation of more dry mass (Khan, 1996). High concentration of endogenous GA_3 by increasing the gibberellin concentration treatment (Wang *et al.*, 2015). In addition, GA_3 caused the increase in the endogenous Indole acetic acid contents (Reid and Davies, 1992). The harmonization treatment had an adverse effect on some biochemical content of plant (Kaplan *et al.*, 2019).

The previous studies have illustrated that the exogenous application of proline mitigated the decreased plant growth caused by stress is through increasing antioxidant system, relieving oxidative damage, improving the synthesis of compatible solutes and accelerating proline accumulation, which reflected on enhancing photosynthesis (58,35). Also, Sun Physiologically, a major function of GAs in higher plants can be generalized as stimulating organ growth through enhancement of cell elongation and in some cases, cell division. In addition, GAs promotes certain developmental switches, such as between seed dormancy and germination, juvenile and adult growth phases and vegetative and reproductive development. Foliar application of gibberellin with low NPK treatment significantly improved fiber diameter, fiber elongation and breaking strength compared to both NPK alone and control treatment (Ullah *et al.*, 2017).

Table 5, showed the foliar application of nano boron give higher results for betaine, choline and total carbohydrate than boric acid foliar application this may due to (Nilanjan, 2013) who stated that, one benefit of the boron nanofertilizer described in embodiments may be extremely low cost and high efficiency. Some embodiments described herein provide a highly effective means of nano-fertilization by administration of boric acid nanoparticles to plants. Nano scale boric acid released from the surface of metal nanoparticles of embodiments herein can be a highly efficient boron fertilizer. Other benefits of the boron coated metal nanoparticles described herein include increased boron content in plants resulting in increased chlorophyll content, number of leaves, total biomass, total yield and lowered soluble and reducing sugars. Also this results was in agreement with (Dewdar *et al.*, 2018) who reported that nanofertilizer can either provide nutrients for the plant or aid in the transport or absorption of available nutrients resulting in better crop growth. Further, boron nutrition favourable affected yield parameters, synthesis and transport of carbohydrates, boron contributed to a substantial increase in the curd marketable yield curd weight and increase in the content of dry matter, total sugars and L-Ascorbic acid in plant tissues in comparison to that after mineral fertilization without the addition of boron (Rosa, Franczuk and A-HAJKO, 2019).

Finally, the interaction between the foliar application of gibberellin at 100 mg l^{-1} and proline at 200 mg l^{-1} with nano boron with 75% of recommended dose give the highest response for most parameter under study of sugar beet plant these results was in agreement with (Seadh and El-Metwally, 2015) who reported that adding of plant growth regulators with addition mineral fertilizers with 80% of recommended dose in order to maintain high productivity and quality of plant at the same time reduce production costs and environmental

Table 5: Integrated effect of plant growth regulators and macro-nutrient fertilizer rates with different boron sources on biochemical contents.

Boron sources (B)	**Control**	**Gibberellin (mg l^{-1})**			**Proline (mg l^{-1})**		
		100	**200**	**Mean**	**100**	**200**	**Mean**
Betaine (g 100 g^{-1} root FW)							
Control	0.162	0.172	0.160	0.162	0.160	0.171	0.161
Boric acid	0.168	0.194	0.166	0.174	0.174	0.180	0.172
B-NPs	0.173	0.208	0.172	0.185	0.187	0.198	0.187
Mean	0.168	0.191	0.166	0.174	0.174	0.183	0.173
Choline (mg 100 g^{-1} root FW)							
Control	7.45	8.40	7.75	7.81	7.78	7.93	7.72
Boric acid	7.51	8.68	7.91	7.95	7.81	8.15	7.74
B-NPs	7.58	8.82	7.90	8.10	7.95	8.32	7.84
Mean	7.51	8.63	7.98	7.92	7.85	8.14	7.80
Total Carbohydrate (g 100g^{-1})							
Control	13.1	14.8	14.0	13.9	13.5	14.3	13.6
Boric acid	13.7	15.6	14.7	14.4	13.9	14.8	13.8
B-NPs	13.9	15.9	15.0	14.9	14.1	15.5	14.2
Mean	13.6	15.4	14.6	14.5	13.8	14.9	14.0
L.SD. 0.05							
	B	G	R	B × G	B × R	G × R	B × G × R
Betaine	0.001	0.005	0.01	0.002	0.01	0.05	0.001
Choline	0.05	0.30	0.50	0.09	0.10	0.15	0.20
T. Carb.	0.10	1.00	0.75	0.25	0.11	0.31	0.90

B=Boron sources, G=Plant growth regulator sources and R=Rate of Plant growth regulator.

pollution under the environmental condition in Egypt.

On the other side, GA_3 showed remarked increase in the quality and productivity in sugar beet plants was observed that gibberellin has undesirable effect on human cells as reported by Hassan (Hassan *et al.*, 2019) who noticed that the GA_3 has harmful effects on the histological development of the renal cortex so, it should be used cautionary. Moreover, when human cells exposed to different concentrations of gibberellin increase levels of reactive oxygen species and protein levels of apoptosis markers, GA_3 inhibit the activity of Na^{+}"K^{+} adenosine triphosphatase (ATPase) and Ca^{2+}-ATPase, which maintain the stability of ion inside and outside the cell membrane (Xu *et al.*, 2019). GA_3 can induce liver impairment and clarify the antioxidant and anti-apoptotic ameliorating impacts on hepatic cytoarchitecture and immune-histochemical and biochemical effects (Alsemeh, Moawad and Abdelfattah, 2019).

Conclusions

From previously data obtained could be concluded that the using of plant growth regulators as a proline or gibberellin reduced the consumption of mineral fertilizers and possibility of replacing the gibberellin by proline. The application of nanotechnology in agriculture as using nano boron (B-NPs) increased the application efficiency, decreased pollution and risk of fertilizers used and increased plant quality.

References

Afroz, S., F. Mohammad, S. Hayat and M.H. Siddiqui (2005). 'Exogenous Application of Gibberellic Acid Counteracts the Ill Effect of Sodium Chloride in Mustard', *Turkish Journal of Biology.*, **29:** 233-236.

Al-Shaheen, M.R. and A. Soh (2016). 'Effect of proline and Gibberellic Acid on the qualities and qualitative of Corn (*Zea maize* L.) under the influence of different levels of the water stress.' *International Journal of Scientific and Research Publications.*, **6(5):** 752-756. Available at: www.ijsrp.org.

Alsemeh, A.E., R.S. Moawad and E.R. Abdelfattah (2019). 'Histological and biochemical changes induced by gibberellic acid in the livers of pregnant albino rats and their offspring: ameliorative effect of Nigella sativa', *Anatomical Science International*. Springer Tokyo., **94(4):** 307-323. doi: 10.1007/s12565-019-00488-0.

Alyemeni, M.N., Q. Hayat, S. Hayat, M. Faizan and A. Faraz (2016). 'Exogenous proline application enhances the efficiency of nitrogen fixation and assimilation in chickpea plants exposed to cadmium.'*An International Journal, Legume Research.,* Agricultural Research Communication Centre, **39(2):** 221-227. doi: 10.18805/lr.v0iOF.9291.

Anjum, S.A., X.Y. Xie, L.C. Wang, M.F. Saleem, C. Man and W. Lei (2011). 'Morphological, physiological and biochemical responses of plants to drought stress.' *African journal of agricultural research.*, **6(9):** 2026-2032. doi: 10.5897/AJAR10.027.

Asadi, M. (2006). *Beet-Sugar Handbook*, *John Wiley & Sons*. John Wiley & Sons. Available at: https://books.google.com.eg/books?hl=en&lr=&id=ssltAbEO4kkC&oi=fnd&pg=PR9&dq=Beet-Sugar+Handbook&ots=rkgDOq0fVo&sig=i7YQ7k4CnFdK7BIcwLsM_ef3FU8&redir_esc=y#v=onepage&q=Beet-Sugar Handbook&f=false.

Ashraf, M. and M.R. Foolad (2007). 'Roles of glycine betaine and proline in improving plant abiotic stress resistance'. *Environmental and Experimental Botany.*, **59(2):** 206-216. doi: 10.1016/j.envexpbot.2005.12.006.

Ashraf, M., F. Karim and E. Rasul (2002). 'Interactive effects of gibberellic acid (GA 3) and salt stress on growth, ion accumulation and photosynthetic capacity of two spring wheat (*Triticum aestivum* L.) cultivars differing in salt tolerance.' *Plant Growth Regulation.*, **36(1):** 49-59. doi: 10.1023/A:1014780630479.

Asil, M.H., Z. Roein and J. Abbasi (2011). 'Response of tuberose (*Polianthes tuberose* L.) to gibberellic acid and benzyladenine.' *Horticulture, Environment and Biotechnology.*, **52(1):** 46-51. doi: 10.1007/s13580-011-0073-0.

Bishnoi, N.R. and H.N. Krishnamoorthy (1991). 'Effect of waterlogging and gibberellic acid on leaf gas exchange in peanut (*Arachis hypogaea* L.).' *Journal of Plant Physiology.*, **139(4):** 503-505. doi: 10.1016/S0176-1617(11)80502-X.

Brown, P. H., N. Bellaloui, M.A. Wimmer, E.S. Bassil, J. Ruiz, H. Hu and V. Römheld (2002). 'Boron in plant biology.' *Plant Biology.*, 205-223. doi: 10.1055/s-2002-25740.

Carillo, P. and Y. Gibon (2011). 'Protocol: extraction and determination of proline.' *Prometheus Wiki*, 1-5. Available at: https://www.researchgate.net/publication/211353600 (Accessed: 3 September 2019).

Chen, H., A.K. Banerjee and D.J. Hannapel (2004). 'The tandem complex of BEL and KNOX partners is required for transcriptional repression of ga20ox1', *Plant Journal.*, **38(2):** 276-284. doi: 10.1111/j.1365-313X.2004.02048.x.

Cottenie, A., G. Velghe, M. Verloo and L. Kiekens (1982). *Biological and analytical aspects of soil pollution.*, *Lab. Of Analytical Agro. State Univ. of Calif. Division of Agric. Sci.*

Davarpanah, S., A. Tehranifar, G. Davarynejad, J. Abadía and R. Khorasani (2016). 'Effects of foliar applications of zinc and boron nano-fertilizers on pomegranate (Punica granatum *cv.* Ardestani) fruit yield and quality.' *Scientia Horticulturae*. *Elsevier B.V.*, **210:** 57-64. doi: 10.1016/j.scienta.2016.07.003.

Delauney, A.J. and D.P.S. Verma (1993). 'Proline biosynthesis and osmoregulation in plants.' *The plant journal.* Blackwell Publishing Ltd., **4(2):** 215-223. doi: 10.1046/j.1365-313X. 1993.04020215.x.

Dewdar, M.D., M.S. Abbas, A.S. El-Hassanin and H.A.A. El-Aleem (2018). 'Effect of Nano Micronutrients and Nitrogen Foliar Applications on Sugar Beet (*Beta vulgaris* L.) of Quantity and Quality Traits in Marginal Soils in Egypt. **7(8):** 4490-4498.' *Int. J. Curr. Microbiol. App. Sci.*, **7(8):** 4490-4498. doi: 10.20546/ijcmas.2018.708.475.

Eggert, K. and N. von Wirén (2017). 'Response of the plant hormone network to boron deficiency.' *The New phytologist.*, **216(3):** 868-881. doi: 10.1111/nph.14731.

El-Sherbeny, M.R. and J.A.T. Da Silva (2013). 'Foliar treatment with proline and tyrosine affect the growth and yield of beetroot and some pigments in beetroot leaves.' *Horticultural Research.*, **21(2):** 95-99. doi: 10.2478/johr-2013-0027.

Focht, R.L., F.H. Schmidt and B.B. Dowling (1956). 'Sugar Beet Processing, Colorimetric Determination of Betaine in Glutamate Process End Liquor.' *Journal of Agricultural and Food Chemistry.*, **4(6):** 546-548. doi: 10.1021/jf60 064a007.

Fukao, T. and J. Bailey-Serres (2008). 'Ethylene-a key regulator of submergence responses in rice.' *Plant Science.*, **175 (1-2):** 43-51. doi: 10.1016/j.plantsci.2007.12.002.

Gilroy, S. and R.L. Jones (1992). 'Gibberellic acid and abscisic acid coordinately regulate cytoplasmic calcium and secretory activity in barley aleurone protoplasts.' *Proceedings of the National Academy of Sciences of the United States of America. National Academy of Sciences.*, **89(8):** 3591-3595. doi: 10.1073/pnas.89.8.3591.

Gimesi, O. and G. Szász (1974). 'Determination of choline and trimethylamine in seeds and premixes.' *Periodica Polytechnica Chemical Engineering.*, **18(3):** 203-210.

Gomez, K.A. and A.A. Gomez (1984). *Statistical Procedures for Agricultural Research., John Wiley & Sons, Inc. New York 641.* Available at: https://books.google.com.eg/books?hl=en&lr=&id=PVN7_XRhpdUC&oi=fnd&pg=PA2&dq=Statistical+procedures+for+agricultural+research+(2+ed.)&ots=Hr9c8kqsm4&sig=YUiFBhs0hpj70U2l3ZVnXOBrr_s&redir_esc=y#v=onepage&q=Statistical procedures for agricultural research.

Goudar, K.M., K.N. Geetha, N.N. Lingaraju, A.G. Shankar and R. Raddy (2018). 'Response of sunflower (*Helianthus annuus* L.) to nano boron nitride fertilization.' *International Journal of Chemical Studies.*, **6(5):** 2624-2630.

Guyot, H.M. (1967). 'Process for treating sugar producing plants to effect improved saccharose yield.' *Patent and Trademark Office.*

Hartmann, H.T. and D.E. Kester (1963). 'Plant propagation: principles and practice." Soil Science 95, no. 1 (1963): 89.', *Soil Science.* 5th edn. Prentice-Hall, Englewood Cliffs, NJ.: *Prentice Hall.*, **95(1):** 89.

Hassan, G.A., T.B. Ahmad and R.A. Mohi-ud-din (2013). 'An ethnobotanical study in Budgam district of Kashmir valley: an attempt to explore and document traditional knowledge of the area., 4, 201-204.' *International Research Journal of Pharmacy.*, **4(1):** 201-204.

Hassan, S.A., H.A. Abdel-Aziz, H.K. Mohamed and M.E. Adly (2019). 'Effects of exposure to gibberellic acid during pregnancy and lactation on the postnatal development of the renal cortex in the albino rat.' *Journal of Current Medical Research and Practice. Medknow.*, **4(2):** 121. doi: 10.4103/jcmrp.jcmrp_67_18.

Hayat, S., Q. Hayat, M.N. Alyemeni, A.S. Wani, J. Pichtel and A. Ahmad (2012). 'Role of proline under changing environments: a review.' *Plant signaling & behavior*, 1456-1466. doi: 10.4161/psb.21949.

Hoai, N.T.T., I.S. Shim, K. Kobayashi and U. Kenji (2003). 'Accumulation of some nitrogen compounds in response to salt stress and their relationships with salt tolerance in rice (*Oryza sativa* L.) seedlings.' *Plant Growth Regulation.*, **41(2):** 159-164. doi: 10.1023/A:1027305522741.

Jackson, M.L. (1959). 'Soil Chemical Analysis.' *Journal of Agricultural and Food Chemistry.*, **7(2):** 138. Available at: https://archive.org/details/soilchemicalanal030843mbp/page/n13.

Kahlaoui, B., M. Hachicha, S. Rejeb, M.N. Rejeb, B. Hanchi and E. Misle (2014). 'Response of two tomato cultivars to field-applied proline under irrigation with saline water: Growth, chlorophyll fluorescence and nutritional aspects', *Photosynthetica.* Kluwer Academic Publishers, **52(3):** 421-429. doi: 10.1007/s11099-014-0053-6.

Kaplan, M., A. Najda, K. Klimek and A. Borowy (2019). 'Effect of Gibberellic acid (GA_3) inflorescence application on content of bioactive compounds and antioxidant potential of grape (*Vitis* L.)'Einset Seedless' berries.' *South African Journal of Enology and Viticulture.* South African Society for Enology and Viticulture., **40(1):** 1-10. doi: 10.21548/40-1-3004.

Khan, N.A. (1996). 'Effect of gibberellic acid on carbonic anhydrase, photosynthesis, growth and yield of mustard.', *Biologia Plantarum. Academy of Sciences of the Czech Republic.*, **38(1):** 145-147. doi: 10.1007/BF02879650.

Kim, S.G., A. Lee, H.K. Yoon and C.M. Park (2008). 'A membrane-bound NAC transcription factor NTL8 regulates gibberellic acid-mediated salt signaling in Arabidopsis seed germination.' *Plant Journal.*, **55(1):** 77-88. doi: 10.1111/j.1365-313X.2008.03493.x.

King, R.W. and L.T. Evans (2003). 'Gibberellins and flowering of grasses and cereals/: Prizing Open the Lid of the "Florigen" Black Box', *Annual Review of Plant Biology.* Annual Reviews., **54(1):** 307-328. doi: 10.1146/annurev.arplant.54.031902.135029.

Kulkarni, M.G., W.A. Stirk, C. Southway, H.B. Papenfus, P.A. Swart, A. Lux, M. Vaculík, M. Martinka and J. van Staden (2013). 'Plant growth regulators enhance gold uptake in

Brassica juncea' *International J. of Phytoremediation.*, **15(2):** 117-126. doi: 10.1080/15226514.2012.683207.

Mariani, N., R. Da Costa, K. De Lima, V. Nardini, L. Cunha Júnior and G. Teixeira (2014). 'Predicting soluble solid content in intact jaboticaba (Myrciaria jaboticaba (Vell.) O. Berg) fruit using near-infrared spectroscopy and chemometrics.' *Food Chemistry*. Elsevier Ltd, **159:** 458-462. doi: 10.1016/j.foodchem.2014.03.066.

Miceli, A., F. Vetrano, L. Sabatino, F. D'Anna and A. Moncada (2019). 'Effect of Gibberellic Acid on Growth, Yield and Quality of Leaf Lettuce and Rocket Grown in a Floating System.' *Agronomy.*, **9(7):** 382-404. doi: 10.3390/agronomy 9070382.

Monreal, J.A., F. Vetrano, L. Sabatino, F. D'Anna and A. Moncada (2007) 'Proline content of sugar beet storage roots: Response to water deficit and nitrogen fertilization at field conditions.' *Environmental and Experimental Botany*, **60(2):** 257-267. doi: 10.1016/j.envexpbot. 2006.11.002.

Moritz, T. and A.M. Monteiro (1994). 'Analysis of endogenous gibberellins and gibberellin metabolites from Dalbergia dolichopetala by gas chromatography-mass spectrometry and high-performance liquid chromatography-mass spectrometry.' *Planta*. *Springer-Verlag,* **193(1):** 1-8. doi: 10.1007/BF00191599.

Naderi, M., A.A. Danesh Shahraki and R. Naderi (2011). 'Application of nanotechnology in the optimization of formulation of chemical fertilizers.' *Iranian Journal of Nanotechnology.*, **12:** 16-23.

Nilanjan, D.E.B. (2013). 'Plant nutrient coated nanoparticles and methods for their preparation and use.' World Intellectual Property Organization.

Osman, H.S. (2015). 'Enhancing antioxidant–yield relationship of pea plant under drought at different growth stages by exogenously applied glycine betaine and proline'. *Annals of Agricultural Sciences*. Faculty of Agriculture, Ain-Shams University., **60(2):** 389-402. doi: 10.1016/j.aoas. 2015.10.004.

Page, A.L., R.H. Miller and D.R. Keeney (1982). 'Methods of soil analysis. Part 2. Chemical and microbiological properties', in *American Society of Agronomy, Soil Science Society of America*. Second Edi, 149-223.

Peretó, J.G. and J.P. Beltrán (1987). 'Hormone directed sucrose transport during fruit set induced by gibberellins in Pisum sativum.' *Physiologia Plantarum.*, **69(2):** 356-360. doi: 10.1111/j.1399-3054.1987.tb04300.x.

Reid, J.B. and P.J. Davies (1992). 'The genetics and physiology of gibberellin sensitivity mutants in peas.', in *In Progress in plant growth regulation.* Springer Science & Business Media, Dordrecht., 214-225. doi: 10.1007/978-94-011-2458-4_24.

Richard N.A. (1996). 'Plant Growth Substances: Principles and Applications.' in *Springer Science and Business Media.* Springer Science & Business Media, 332. Available at: https://books.google.com.eg/books?hl=en&lr=&id=tzToBwAAQBAJ&oi=fnd&pg=PR17&dq=Plant+Growth+Substances:+Principles+and+Applications.+New+York&ots=yZ4WeJ17Z8&sig=pz3i_rGULjkHfbkHPjqGofB_5WI&redir_esc=y#v=onepage&q=Plant Growth Substances%3A Principles and A (Accessed: 2 September 2019).

Rosa, R., J. Franczuk and L. A-HAJKO (2019). 'Effects of trichoderma harzianum and boron on spring broccoli.', *Applied ecology and environmental research.*, **17(2):** 4397-4407. doi: 10.15666/aeer/1702_43974407.

Seadh, S.E. (2012). 'Maximizing sugar beet yields with decreasing mineral fertilization pollution.' *International Journal of Agriculture Sciences.*, **4(7):** 293-298. Available at: http://search.proquest.com/openview/e25071b895083e7031a8d2e6aeff8f3d/1.pdf?pq-origsite=gscholar&cbl=616630.

Seadh, S.E. and M.A. El-Metwally (2015). 'Influence of antioxidants on wheat productivity, quality and seed-borne fungi management under NPK fertilization levels.' *Asian Journal of Crop Science*., Asian Network for Scientific Information, **7(2):** 87-112. doi: 10.3923/ajcs.2015.87.112.

Shtanheev, V.O., L.I. Chernyavs'ka, H.O. Petrenko and V.A. Zayets (1998). 'The method for determining the alpha-amino nitrogen content in [sugar] beet.', *FAO (Food and Agriculture Organization)*. State Patent Department of Ukraine, 3.

Spaepen, S., J. Vanderleyden and Y. Okon (2009). 'Plant Growth-Promoting Actions of Rhizobacteria.' *Advances in botanical research.*, **51(C):** 283-320. doi: 10.1016/S0065-2296(09)51007-5.

Sumanta, N., C.I. Haque, J. Nishika and R. Suprakash (2014). 'Spectrophotometric analysis of chlorophylls and carotenoids from commonly grown fern species by using various extracting solvents. Research Journal of Chemical Sciences ISSN,X.', *Research Journal of Chemical Sciences.*, **4(9):** 63-69. doi: 10.1055/s-0033-1340072.

Szabados, L. and A. Savouré (2010). 'Proline: a multifunctional amino acid.', *Trends in plant science.*, 89-97. doi: 10.1016/j.tplants.2009.11.009.

Tariq, M. and C.J.B. Mott (2006). 'Effect of boron supply on the uptake of micronutrients by Radish (Raphanus Sativus l.)', *Journal of Agricultural and Biological Science.*, **1(2):** 1-8. Available at: www.arpnjournals.com.

Thomas, W. and R.A. Dutcher (1924). 'The colorimetric determination of carbohydrates in plants by the picric acid reduction method I. The estimation of reducing sugars and sucrose.' *Journal of the American Chemical Society.*, **46(7):** 1662-1669. doi: 10.1021/ja01672a015.

Twarakavi, N.K.C., J. Šimùnek and M.G. Schaap (2010). 'Can texture-based classification optimally classify soils with respect to soil hydraulics?.' *Water Resources Research.*, **46(1):** 1-11. doi: 10.1029/2009WR007939.

Ullah, S., S. Anwar, M. Rehman, S. Khan, S. Zafar, L. Liu and D.

Peng (2017). 'Interactive effect of gibberellic acid and NPK fertilizer combinations on ramie yield and bast fibre quality.', *Scientific reports.*, **7(1):** 10647. Available at: https://www.nature.com/articles/s41598-017-09584-5.

Wang, L., J. Liu, X. Li, J. Shi, J. Hu, R. Cui, Z.L. Zhang, D.W. Pang and Y. Chen (2011). 'Growth propagation of yeast in linear arrays of microfluidic chambers over many generations' *Biomicrofluidics. American Institute of Physics Inc.*, **5(4):** 1-9. doi: 10.1063/1.3668243.

Wang, J., J. Cang, L. Liu, Y. Zeng, X. Wang, C. Xu and D. Zhang (2015). 'Effects of Exogenous GA3 on Wheat Cold Tolerance.' *Agricultural Science Technology.*, *JKUAT*, **17:** 921-934.

Westwood, M.N. (1993). 'Temperate-zone pomology/: physiology and culture.' in *Timber Press*. 3rd edn, 254-273. Available at: https://trove.nla.gov.au/work/34700157?selectedversion=NBD8875821.

Wojcik, V.A., G.W. Frankie, R.W. Thorp and J.L. Hernandez (2008). 'Seasonality in Bees and Their Floral Resource Plants at a Constructed Urban Bee Habitat in Berkeley, California' *Journal of the Kansas Entomological Society.*, Kansas (Central States) Entomological Society, 15-28. doi: 10.2307/25086414.

Xu, C.S., Y. Zhou, Z. Jiang, L.E. Wang, J.J. Huang, T.Y. Zhang, Y. Zhao, W. Shen, S.H. Zou and L.L. Zang (2019). 'The *in vitro* effects of gibberellin on human sperm motility. *Aging (Albany NY)*, **11(10):** 3080. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6555458/.

Yuan, L. and D. Xu (2001). 'Stimulation effect of gibberellic acid short-term treatment on leaf photosynthesis related to the increase in Rubisco content in broad bean and soybean.' *Photosynthesis Research.*, **68(1):** 39-47. doi: 10.1023/A:1011894912421.

Zahedi, S.M., M. Karimi and J.A. Teixeira da Silva (2019). 'The Use of Nanotechnology to Increase Quality and Yield of Fruit Crops.' *Journal of the Science of Food and Agriculture.*, Wiley, 1-7. doi: 10.1002/jsfa.10004.