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INSECT PESTS INFESTATION, PRODUCTIVITY AND QUALITY OF SUGAR BEET AS INFLUENCE BY NITROGEN, POTASSIUM AND TRACE ELEMENTS FERTILIZERS

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ABSTRACT

Two field experiments were conducted at Sakha agricultural farm, Kafer El-Sheikh Governorate Egypt, during 2018/2019 and 2019/2020 seasons, to study the impact of nitrogen in three rates 60, 80 and 100 kg N fed^{-1}, potassium with the rate of 24, 36 and 48 kg K_2O fed^{-1} as soil application and, a mixture of three trace nutrients *i.e.* Zinc (1g/L), Manganese (1g/L) and Fe (2g/L) as a foliar application on insect infestation, yield and quality of sugar beet. The obtained results revealed that the infestation by beet fly, tortoise beetles and beet moth increased gradually and significantly by increasing nitrogen rate from 60 to 100 kg N fed^{-1}. Further, increasing potassium fertilization caused significant reduction in insect infestation. Moreover, foliar application of the used mixture of trace elements significantly reduced infestation beet by *P. mixta.* At the same time, insignificant reduction on the other two pests has been detected. However, individual root specification, root yield, sugar yield, sucrose and purity were maximized corresponding to 80 kg N fed^{-1}. More nitrogen application decreased all the studied traits except top yield and TSS. On the other hand, increasing potassium fertilizer from 24 up to 48 kg K_2O fed^{-1} positively enhanced root diameter, root length, root weight, root, top, sugar yields/fed. and TSS. Nevertheless, sucrose and purity were maximized as potassium fertilized added at the rate of 36 Kg K_2O fed^{-1}. Moreover, foliar application of trace elements significantly improved all beet productivity characteristics and quality traits.

To conclude that fertilizing beet plants with 80 kg N fed^{-1}, 36 kg K_2O fed^{-1} with sprayed the mixture of trace elements maximizing yield and quality of sugar beet and had negative impact on pests under study.

Key words: Sugar beet, nitrogen, potassium, microelements, insect pests infestation

INTRODUCTION

Sugar beet growing for sugar in Egypt becomes a successful industry since 1982 besides sugarcane cultivation. Sugar beet cultivation began early in some northern governorates, but nowadays, it spread to all northern (Delta) area and expanded to middle and Upper Egypt. The goal in sugar beet production is the development of a crop yielding high tonnage and sugar content that can economically be processed into sugar, meantime, to cover the gap between sugar production and consumption under Egyptian conditions.

Nitrogen is the most important fertilizer element to be added because it is usually in short supply in different types of soils. Nitrogen has a pronounced impact on the growth and physiological processes of sugar beet, even to the extent of causing large changes in the physiological and chemical features of the crop at harvest. Further, many factors may affect the optimum rate of N fertilizer needed by sugar beet to yield fully, meantime, shortage in nitrogen fertilizer sugar beet could not produce profitable crop. Nevertheless, high nitrogen dressing slightly enhanced root growth but decreased sucrose production due to the increase in top growth at the expense of sugar storage (**Mekdad, 2015 and Ismail *et al.*, 2016)**.

Moreover, under Egyptian ecosystem, sugar beet plants are subjected to be attacked by numerous insect pests during its different growth stages. The key insect pests are sugar beet fly *Pegomyia mixta* (Vill.); tortoise beetle *Cassida vittata* (Vill.) and beet moth *Scrobipalpa ocellatella* (Boyd.) (**El-Dessouki *et al*., 2014 and Abbas, 2018).**

Nitrogen (N) is one of the main limiting factors for the optimal growth of insects. **Rashid *et al.* (2016)** stated that excessive and/or inappropriate use of inorganic fertilizers can cause nutrient imbalances and lower pest resistance, via produce more broad, succulent and fresh leaves which could serve as suitable surfaces for egg-laying, increase herbivore's feeding preference, food consumption, survival, growth, reproduction, and population density and reflected for heavy crop damage by insects **(Mace and Mills, 2015)**. **Shalaby *et al.* (2012)** showed that infestation by *P. mixta* Vill., *S. ocellatella* Boyd. and *C. vittata* Vill. were significantly highest at 90 kg N/fed. as compared with lower doses (60 or 75 kg N/fed.).

With regard to potassium fertilizer, sugar beet is classified as a plant that has a high requirement for potassium and recognized as being absolutely indispensable and that it is present in high concentration in plants. Potassium plays an important role in activating the photosynthesis process via activating the enzymes involved in this process. Further, potassium in adequate quantity has a vital role in increase soluble carbohydrates and its translocation to beet root (**Enan, 2016).** Meantime, **Amtmann *et al.* (2008)** illustrated that K elements strongly impact plant susceptibility and attractiveness to insects and diseases. **Zörb *et al.* (2014) and Bala *et al.* (2018)** demonstrated that potassium provides high resistance against insect–pests.

For optimal growth, alongside the macronutrients N, P and K the sugar beet plant need in small quantities from other elements known trace elements (micronutrients) such as B, Zn, Mn, Cl, Cu, and Mo. Experimental result of **Odeley and Animashaun (2007)** showed that foliar application of micronutrients increased plant resistance to pests and diseases and drought stress. Therefore, the trace elements have many contributions in cell wall formation and plant resistance to pests and diseases and environmental stresses **(Ghasemian *et al.*, 2010)**. Meantime, **Shafeek *et al.* (2014)** showed that hot pepper plants sprayed by a mixture of Fe, Mn and Zn gained the lowest insect and mite population besides the best plant growth.

MATERIALS AND METHODS

This investigation is aimed to study the impact of nitrogen, potassium and some trace nutrients on insect infestation, yield and quality of sugar beet (*Beta vulgaris* var. saccharifera, L.). Therefore, two field experiments were conducted at Sakha agricultural farm (latitude of 31.10º N and longitude 30.93º E, and altitude of 14 m above sea level) Kafer El-Sheikh Governorate during 2018/2019 and 2019/2020 seasons.

A split-split plot design with three replications was used, where, nitrogen as urea (46 % N) in three rates 60, 80 and 100 kg N fed^{-1} had occupied the main plots. Potassium in the form of potassium sulfate (48% K_2O) was adapted in sub plots with the rate of 24, 36 and 48 kg K_2O fed^{-1}, while, the mixture of three trace nutrients *i.e.* Zinc (1g/L), Manganese (1g/L) and Fe (2g/L) in the form of sulfate for the three elements were performed in sub-sub plots. The plot area was 36 m^2 consisted of 10 rows 6 m long and 60 apart, spacing within rows 20 cm give target plant population of 35000 hill/ fed. Eighteen treatments were distributed among plots randomly. Sugar beet seed of multi-germ Kawemira cv. was used. The planting dates were precisely on Sept. 15^{th} and 10^{th} 2018 and 2019 seasons, respectively.

Nitrogen fertilizer were applied in two equal split doses, the first being at the full establishment of seedling (thinning for one plant each hill) was after three weeks from sowing and the second was one month later. Potassium fertilizer was applied in two doses at the same time with nitrogen fertilizer. Super phosphate as a source of phosphorus elements was applied in a single dose at land preparation with a rate of 200 kg (15.5% P_2O_5) fed^{-1}. The mixture of trace elements was sprayed after two months from sowing and the other plot (control) was sprayed at the same time using tap water. No chemicals were used for controlling sugar beet insect pests throughout the whole period of the study.

The target insects under study are beet fly, *Pegomia mixta* larvae, beet moth, *Scrobipalpa ocellatella* larvae and tortoise beetle, *Cassida vittata* larvae and adults, when the sugar beet plants aged 120 days, 60 plants were taken from each treatment (as 20 plants x 3 replicate). Each sampled, plant was completely introduced into a plastic bag. The confined plants were transferred to the laboratory. To avoid the escape of insects during inspection, a piece of cotton saturated with chloroform was introduced into the bag for 15 minutes to anaesthetize the mobile insect stages. The plants were visually examined and insect pests were counted and recorded fortnight, and continued up to harvest on selected randomly to determine the egg masses No., blotches No. and larvae No. of *P. mixta*; No. of *C. vittata* larvae & adults and No. of *S. ocellatella* larvae

Harvest was carried out after 210 days from planting date, a sample of ten guarded sugar beet plants were taken randomly from the four middle rows of each plot to determine the following characteristics:
Root attributes and yield *i.e.* root diameter (cm), root length (cm) and Root weight (kg). Roots and green tops were separated and each was weighed in kg per each plot and used to calculate Root yield (t/fed.) and Top yield (t/fed.).

Quality traits:

1. Total Soluble Solids percentage (TSS) was determined in fresh roots by using hand refractometer.
2. Sucrose percentage was estimated polarimetrically on lead acetate extract of fresh macerated root according to the methods of **Le Docte (1927).**
3. Purity percentage was calculated by dividing Sucrose% X 100 / TSS% according to the methods of **Carruthers *et al.* (1962).**

Sugar yield per Fadden was calculated according the following equation:

Sugar yield (t/fed.) = Root yield (t/fed.) × Sucrose % × purity%

Statistical analysis: Percentage data were transformed to arc-sine before statistical analysis. The proper statistical analysis of the recorded data was carried out according to **Steel and Torrie (1980)** using “MSTAT” computer software package. The differences between means of the treatments were compared using the least significant difference (LSD) at 5% level of probability.
In all tables *, **, N.S. indicate significant, highly significant and not significant, respectively.

RESULTS AND DISCUSSIONS

Influence of nitrogen, potassium and mixture of microelements on the infestation level with main insect pests:

1. Beet Fly, *Pegomya mixta*:

Average data Tables (1 and 2) revealed that increasing nitrogen rates application from 60 up to 80 and 100 kg N fed^{-1} exhibited significant and gradual increase in beet fly egg masses number, blotches number and larvae number / 20 plants in the two seasons. Such effect may be due to that nitrogen on the higher rates encourages greatly vegetative growth which reflected on top yield as mentioned later. These results are in harmony with those of **Zafar *et al.* (2010), Shalaby *et al.* (2012) and Bala *et al.* (2018).**

Results in the same Tables indicated that increasing potassium levels from 24 up to 36 and 48 kg K_2O fed^{-1} significantly and gradually decreased beet fly, *P. mixta* infestation measured as egg masses, blotches and larvae numbers per 20 plants in both seasons. It is well known that potassium has an effective role in regulating cell leaf thickness. The findings are corroborated with those reviewed by **Rashid *et al.* (2016) and Singh and Sood (2017).**

Table (1): Effect of nitrogen, potassium fertilization and mixture foliar spray on *P. mixta* infestation of sugar beet plants in 2018/2019 season

Nitrogen fertilization level (kg/fed)	Potassium fertilization level (kg/ fed)	Egg masses No./20 plant			Blotches No./20 plant			Larvae No./ 20 plant		
		Trace elements mixture								
		without (control)	With	Mean	without (control)	With	Mean	without (control)	With	Mean
60	24	79.00	70.33	74.67	102.33	87.67	95.00	203.67	181.00	192.34
	36	71.67	64.00	67.84	99.67	85.00	92.34	201.00	178.67	189.84
	48	65.33	57.67	61.50	97.00	83.33	90.17	197.00	174.33	185.67
Mean		72.00	64.00	68.00	99.67	85.33	92.50	200.56	178.00	189.28
80	24	124.00	110.00	117.00	110.67	94.00	102.34	216.00	191.67	203.84
	36	109.00	97.67	103.34	107.33	91.67	99.50	211.67	187.00	199.34
	48	96.33	85.00	90.67	105.00	89.33	97.17	209.00	185.33	197.17
Mean		109.78	97.56	103.67	107.67	91.67	99.67	212.22	188.00	200.11
100	24	127.00	113.67	120.34	126.67	109.33	118.00	232.00	206.33	219.17
	36	119.67	106.33	113.00	123.00	104.67	113.84	226.67	201.00	213.84
	48	114.33	102.00	108.17	114.33	97.67	106.00	221.33	196.67	209.00
Mean		120.33	107.33	113.83	121.33	103.89	112.61	226.67	201.33	214.00
Aver. of K	24	110.00	98.00	104.00	113.22	97.00	105.11	217.22	193.00	205.11
	36	100.11	89.33	94.72	110.00	93.78	101.89	213.11	188.89	201.00
	48	92.00	81.56	86.78	105.44	90.11	97.78	209.11	185.44	197.28
Total Mean		100.70	89.63	95.17	109.55	93.63	101.59	213.15	189.11	201.13

L.S.D 5%:

N	**0.87****	**1.01****	**0.91****
K	**0.72****	**0.90****	**0.96****
T	**1.20****	**1.51****	**1.61****
NK	**0.97****	**0.82****	**0.83***
NT	**1.63***	**1.36***	**1.38***
KT	**N.S.**	**N.S.**	**N.S.**
NKT	**N.S.**	**N.S.**	**N.S.**

Table (2): Effect of nitrogen, potassium fertilization and mixture foliar spray on *P. mixta* infestation of sugar beet plants in 2019/2020 season

Nitrogen fertilization level (kg/fed)	Potassium fertilization level (kg/ fed)	Egg masses No./20 plant			Blotches No./20 plant			Larvae No./ 20 plant		
		Trace elements mixture								
		without (control)	With	Mean	without (control)	with	Mean	without (control)	with	Mean
60	24	73.33	64.67	69.00	90.67	83.33	87.00	197.00	183.67	190.34
	36	66.00	58.33	62.17	87.33	80.67	84.00	191.67	178.33	185.00
	48	60.67	51.00	55.84	84.67	78.00	81.34	187.67	174.00	180.84
Mean		66.67	58.00	62.34	87.56	80.67	84.11	192.11	178.67	185.39
80	24	118.33	103.33	110.83	97.00	89.33	93.17	208.33	193.33	200.83
	36	103.67	91.33	97.50	95.67	87.33	91.50	203.33	189.67	196.50
	48	90.00	78.67	84.34	93.33	85.67	89.50	201.00	186.33	193.67
Mean		104.00	91.11	97.56	95.33	87.44	91.39	204.22	189.78	197.00
100	24	125.67	109.00	117.34	108.33	99.00	103.67	224.00	208.67	216.34
	36	113.33	99.67	106.50	104.00	96.33	100.17	217.33	203.33	210.33
	48	108.00	94.33	101.17	100.33	92.67	96.50	212.67	198.00	205.34
Mean		115.67	101.00	108.34	104.22	96.00	100.11	218.00	203.33	210.67
Mean of K	24	105.78	92.33	99.06	98.67	90.55	94.61	209.78	195.22	202.50
	36	94.33	83.11	88.72	95.67	88.11	91.89	204.11	190.44	197.28
	48	86.22	74.67	80.45	92.78	85.45	89.12	200.45	186.11	193.28
Total Mean		95.44	83.37	89.41	95.71	88.04	91.87	204.78	190.59	197.69

L.S.D 5%:

	Egg masses	Blotches	Larvae
N	**0.57****	**0.63****	**0.40****
K	**0.93****	**1.06****	**0.86****
T	**1.56****	**1.76****	**1.44****
NK	**1.11****	**N.S.**	**0.91***
NT	**1.85****	**N.S.**	**N.S.**
KT	**N.S.**	**N.S.**	**N.S.**
NKT	**N.S.**	**N.S.**	**N.S.**

Dealing with the effect of foliar application mixture of trace element (Zn, Mn and Fe), average data in Tables (1 and 2) showed that spraying use of some trace elements significantly reduced the three noticeable sign of beet fly infestation (egg masses, blotches and larvae number /20 plants) measured at harvest time in both first and second seasons. The mixture of foliar application gave the lowest values of egg masses number (89.63 and 83.37 egg masses), blotches number (93.63 and 88.04 blotches) and larvae number (189.11 and 190.59 larvae) / 20 plants as compared with control (without foliar application). These results as similar to those obtained by **Odeley and Animashaun (2007) and Ghasemian *et al.* (2010).**

Interactions effect:

Average data Tables (1 and 2) illustrated that various interaction degrees among the three studied factors have a significant effect on the three noticeable sign of beet fly infestation on beet foliage at harvest time in both seasons except the interaction between potassium + trace elements and among the three factors together in the two seasons. Further, in the second seasons only, insignificant effect of the interaction between nitrogen + potassium on blotches No. and between nitrogen + trace elements mixture on blotches No. and larvae No. In general, the lowest egg masses No. (57.67 and 51.00 egg masses), blotches No. (83.33 and 78.00 blotches) and larvae No. (174.33 and 174.00 larvae) have been detected in the case of using (60 kg N+ 48 kg K +foliar application of Zn+Mn+Fe).

2. Tortoise beetles, *Cassida vittata*:

Appreciated data (Tables 3 and 4) manifested that nitrogen fertilization application at the rates of 60, 80 and 100 kg N fed^{-1} significantly and gradually increased the population density of *C. vittata* in both seasons. However, application of 100 kg N fed^{-1} gave the highest values of tortoise beetles infestation recording 299.72 and 295.67 larvae and adults / 20 plants, otherwise, the lowest population density of tortoise beetles (274.72 and 267.67 larvae and adults / 20 plants) was corresponding to the lowest nitrogen rate (60 kg N fed^{-1}). Such effect may be due to that excess nitrogen promotes leaf number and area which provides a favorable environment for pest infestation. Similar findings are reviewed by **Shalaby *et al.* (2012) and Singh and Sood (2017).**

Increasing potassium rates from 24 up to 36 and 48 kg K_2O fed^{-1} led to a clear gradual decrease in tortoise beetles *C. vittata* density with 291.61, 287.61 and 283.22 larvae and adults / 20 plants in first season, respectively, while, the second one, recorded 286.11, 282.33 and 277.39 larvae and adults / 20 plants, respectively. This result may be due to high levels of potassium enhance secondary compound metabolism, which adversely affects the biology and behavior of insects **(Bala *et al.*, 2018).** These results are in agreement with those of **Amtmann *et al.* (2008) and Sarwar (2012).**

As for the effect of microelements results (Tables 3 and 4) indicated that foliar application of mixture of trace elements *i.e.* Zn, Mn and Fe had insignificant effect on population density of *C. vittata* in both seasons as compared with control (untreated plants). Such effect may be due to that trace element applied early at 60 days from sowing, while, the insect population was counted at the end of the seasons or at harvest time after 210 days from planting. In this connection **Odeley and Animashaun (2007) and Chávez – Dulanto *et al.* (2018)** showed that mix of micronutrients increased plant resistance to pests and diseases.

Interactions effect:

The first and second interaction degrees among the three studies factors insignificantly affected the population density of *C. vittata* in both seasons (Tables 3 and 4) except the interaction between nitrogen + potassium in the second season. These findings give evidence that each factor perform independently under this work.

3. The beet moth, *Scrobipalpa ocellatella*:

Data in Tables (3 and 4) indicated that No. of larvae / 20 plants at harvest time of *S. ocellatella* significantly and gradually increased as nitrogen levels increased from 60 up to 80 and 100 kg N fed^{-1} in 2018/19 and 2019/20 seasons. Further, nitrogen at the higher rate (100 kg N fed^{-1}) exhibited the highest population density of beet moth recording 73.84 and 65.34 larvae / 20 plants in both seasons, respectively. These results are a reflection of the positive effect of excess nitrogen on vegetative growth, mentioned before. The obtained results are in harmony with those of **Shalaby *et al.* (2012), Singh and Sood (2017) and Bala *et al.* (2018).**

Average data Tables (3 and 4) showed that the lowest dose of potassium fertilizers 24 kg K_2O fed^{-1} gave highest number of beet moth larvae / 20 plants recording 68.00 and 60.45 larvae in both seasons, respectively. Meantime, a gradual and apparent reduction in the population density of beet moth, *S. ocellatella* when K fertilizer increase to 36 and 48 kg K_2O fed^{-1}. Adequate K increases phenol concentrations, which play a critical role in plant resistance **(Prasad *et al.*, 2010)**. Furthermore, **Sarwar (2012)** explained that less pest damage in higher K plants can be attributed to a lack of pest preference under sufficient nutrient concentrations, as well as the synthesis of defensive compounds leading to higher pest mortality.

Data given in Tables (3 and 4) revealed that foliar application of some trace elements in a mixture (Zn, Mn and Fe) was not significantly affected beet moth infestation in the first and the second seasons. These results are the same as discussed before with *C. vittata*.

Interactions Effect:

The first and second interaction degrees among the three study factors showed insignificant effect on population density of beet moth, *S. ocellatella* in both seasons (Tables 3 and 4). These findings give evidence that each factors perform independently under this work with regard to beet moth insect. In general, the lowest population density of beet moth, *S. ocellatella* recording 52.33 and 44.67 larvae was corresponding to nitrogen at 60 Kg N+ 48 Kg K_2O fed^{-1} +mixture of trace elements.

Table (3): Effect of nitrogen, potassium fertilization and mixture foliar spray on *C. vittata* and *S. ocellatella* infestations of sugar beet plants in 2018/2019 season

Nitrogen fertilization level (kg/fed)	potassium fertilization level (kg/fed)	*Cassida vittata* (Larvae+Adult No./20 plant)			*Scrobipalpa ocellatella* (Larvae No./20 plant)		
		Trace elements mixture					
		without (control)	With	Mean	without (control)	With	Mean
60	24	279.00	278.33	278.67	59.67	59.00	59.34
	36	275.00	274.67	274.83	57.00	56.33	56.67
	48	270.67	270.67	270.67	53.00	52.33	52.67
Mean		274.89	274.56	274.72	56.56	55.89	56.23
80	24	292.00	291.67	291.83	68.67	67.33	68.00
	36	288.67	288.00	288.33	67.00	66.67	66.84
	48	284.33	283.33	283.83	65.67	64.00	64.84
Mean		288.33	287.67	288.00	67.11	66.00	66.56
100	24	304.67	304.00	304.33	77.00	76.33	76.67
	36	300.00	299.33	299.67	75.00	74.67	74.84
	48	295.33	294.00	295.17	70.33	69.67	70.00
Mean		300.00	299.44	299.72	74.11	73.56	73.84
Aver. of K	24	291.89	291.33	291.61	68.45	67.55	68.00
	36	287.89	287.33	287.61	66.33	65.89	66.11
	48	283.44	283.00	283.22	63.00	62.00	62.50
Total Mean		287.74	287.22	287.48	65.93	65.15	65.54

L.S.D 5%:

	C. vittata	*S. ocellatella*
N	1.02**	0.91**
K	0.93**	1.25**
T	N.S.	N.S.
NK	N.S.	N.S.
NT	N.S.	N.S.
KT	N.S.	N.S.
NKT	N.S.	N.S.

Table (4): Effect of nitrogen, potassium fertilization and mixture foliar spray on *C. vittata* and *S. ocellatella* infestations of sugar beet plants in 2019/2020 season

Nitrogen fertilization level (kg/fed)	potassium fertilization level (kg/fed)	*Cassida vittata* (Larvae+Adult No./20 plant)			*Scrobipalpa ocellatella* (Larvae No./20 plant)		
		Trace elements mixture					
		Without (control)	With	Mean	without (control)	with	Mean
60	24	272.67	272.00	272.33	53.67	52.33	53.00
	36	267.67	267.33	267.50	50.00	49.67	49.84
	48	263.33	263.00	263.17	45.33	44.67	45.00
Mean		267.89	267.44	267.67	49.67	48.89	49.28
80	24	287.67	287.00	287.33	60.33	59.67	60.00
	36	283.00	282.33	283.17	57.33	57.00	57.17
	48	277.33	276.67	277.00	56.00	55.33	55.67
Mean		282.67	282.33	282.50	57.89	57.33	57.61
100	24	299.00	298.33	298.67	68.67	68.00	68.34
	36	296.67	296.00	296.33	66.33	65.67	66.00
	48	292.33	291.67	292.00	62.00	61.33	61.67
Mean		296.00	295.33	295.67	65.67	65.00	65.34
Aver. of K	24	286.44	285.78	286.11	60.89	60.00	60.45
	36	282.44	282.22	282.33	57.89	57.45	57.67
	48	277.67	277.11	277.39	54.44	53.78	54.11
Total Mean		282.19	281.70	281.95	57.74	57.08	57.41

L.S.D 5%:

	C. vittata	*S. ocellatella*
N	0.79**	0.75**
K	0.78**	1.06**
T	N.S.	N.S.
NK	1.34**	N.S.
NT	N.S.	N.S.
KT	N.S.	N.S.
NKT	N.S.	N.S.

Effect of nitrogen, potassium and mixture of microelements on yield and quality:

1. Yield and Yield attributes:

Nitrogen addition at the rate of 80 kg N fed^{-1} was improved root yield (ton/fed.) in both seasons compared with the rate of 60 kg N fed^{-1} (Table 5). Such effect may be due to an enhancement in the specifications of the individual root in terms of average root weight and its dimensions (Table 5), and also may be due to less insect infestation as mentioned before. Otherwise, an increase in nitrogen application rate to 100 kg N fed^{-1} slightly dimensioned root yield statistically insignificant in both seasons. These findings may be due to the positive effect of excess nitrogen on vegetative growth and the higher insect infestation. These results are in line with those reported by **Neameat Alla *et al.*, (2014); Snyder (2017) and Paul *et al.* (2018).**

Data Table (6) also indicated a gradual and significant increase in top yield (ton/fed.) in both seasons as nitrogen rate increased up to 100 kg N fed^{-1}. The increase in top yield accompanied by the high nitrogen dressing may be due to that large nitrogen stimulates the initiation of new leaves, leaf area and dry matter accumulation **(Stevens *et al.*, 2011 and Neameat Alla *et al.*, 2014).**

Potassium is taken up rapidly by sugar beet and responded greatly to increasing rate of potassium. This element was needed for maximum yield. Whereas, a gradual increase in root yield and top yield (ton/fed.) have been detected with the increase in potassium fertilizer level from 24, 36 to 48 kg K_2O fed^{-1} in both seasons (Table 6), at the same time, the increase in root yield may be corresponded to the same effect of K fertilizer on individual root weight and root dimension and less insect infestation accompanied K fertilizer (Table 5). Similar results were obtained by several workers among them **Awad *et al.* (2013) and Hamad *et al.* (2015).**

Potassium plays an important role in activating the photosynthesis process through its activating the enzymes involved in this process, moreover, potassium plays a vital role in synthesis of sugars **(Lakudzala, 2013).**

Regarding the effect of a mixture of trace elements *i.e.* Zinc, Manganese and Iron together as foliar application on beet foliage indicated a significant increase on root width, root length and individual root weight as compared to not spraying one (control) with mentioned elements (Table 5). This positive impact was reflected obviously on root yield (ton/fed.), where a significant increase in root yield has been detected in both seasons (Table 6). Moreover, the foliar application of the three trace elements in mixture improved significantly top yield in both seasons (Table 6). Similar trends were observed by **Masri and Hamza (2015) and Zewail *et al.* (2020).**

Table (5): Effect of nitrogen, potassium fertilization and mixture foliar spray on root width, root length and root weight of sugar beet plants in two seasons

Nitrogen fertilization level (kg/fed)	Potassium fertilization level (kg/fed)	2018/2019									2019/2020								
		Root diameter (cm)			Root Length (cm)			Aver. Root Weight (kg)			Root diameter (cm)			Root Length (cm)			Aver. Root Weight (kg)		
		Trace elements mixture									Trace elements mixture								
		Without (control)	With	Mean	Without (control)	With	Mean	Without (control)	With	Mean	Without (control)	with	Mean	Without (control)	With	Mean	Without (control)	With	Mean
60	24	9.2	9.9	9.55	16.7	17.1	16.90	0.800	0.906	0.853	11.3	11.5	11.40	17.1	17.9	17.50	1.005	1.123	1.064
	36	10.2	11.5	10.85	18.1	17.9	18.00	0.930	1.192	1.061	11.7	13.1	12.40	18.3	19.6	18.95	1.161	1.305	1.233
	48	11.7	12.6	12.15	17.8	18.3	18.05	1.203	1.280	1.242	13.4	13.6	13.50	20.1	19.9	20.00	1.367	1.419	1.393
Mean		10.37	11.33	10.85	17.53	17.77	17.65	0.978	1.126	1.052	12.13	12.73	12.43	18.50	19.13	18.82	1.178	1.282	1.230
80	24	12.2	12.6	12.40	19.8	20.5	20.15	1.299	1.404	1.352	13.4	13.8	13.60	20.5	20.7	20.60	1.328	1.351	1.340
	36	12.8	13.1	12.95	20.8	21.6	21.20	1.447	1.526	1.487	14.1	14.6	14.35	21.6	22.8	22.2	1.497	1.593	1.545
	48	13.4	14.2	13.80	21.8	22.3	22.05	1.554	1.616	1.585	14.5	14.9	14.70	22.9	23.3	23.10	1.578	1.625	1.602
Mean		12.80	13.30	13.05	20.80	21.47	21.13	1.433	1.515	1.474	14.00	14.43	14.22	21.67	22.27	21.97	1.468	1.523	1.496
100	24	11.7	12.3	12.00	19.9	20.3	20.10	1.072	1.169	1.121	12.8	13.4	13.10	20.9	21.6	21.25	1.281	1.305	1.293
	36	12.6	12.8	12.70	20.8	20.5	20.65	1.265	1.328	1.297	13.3	13.8	13.55	21.9	22.3	22.10	1.316	1.458	1.387
	48	13.3	13.6	13.45	21.6	22.9	22.25	1.398	1.415	1.407	14.1	14.3	14.20	22.7	22.8	22.75	1.449	1.529	1.489
Mean		12.53	12.90	12.72	20.77	21.23	21.00	1.245	1.304	1.275	13.40	13.83	13.62	21.83	22.23	22.03	1.349	1.431	1.390
Mean of K	24	11.03	11.60	11.32	18.80	19.30	19.05	1.057	1.160	1.109	12.50	12.90	12.70	19.50	20.07	19.79	1.205	1.260	1.233
	36	11.87	12.47	12.17	19.90	20.00	19.95	1.214	1.349	1.282	13.03	13.80	13.42	20.60	21.60	21.05	1.325	1.452	1.389
	48	12.80	13.47	13.13	20.40	21.17	20.79	1.385	1.437	1.411	14.00	14.27	14.14	21.70	22.00	21.85	1.465	1.524	1.495
Total Mean		11.90	12.51	12.22	19.70	20.16	19.93	1.219	1.315	1.267	13.18	13.66	13.42	20.60	21.22	20.90	1.332	1.412	1.372

L.S.D 5%:

N	0.08**	0.05**	0.008**	0.20**	0.18**	0.013**
K	0.08**	0.07**	0.007**	0.19**	0.11**	0.018**
T	0.13**	0.12**	0.012**	0.31**	0.19**	0.031**
NK	0.11**	0.12**	0.015**	0.20**	0.14**	0.014**
NT	0.18**	0.20**	0.024**	N.S.	N.S.	0.024**
KT	N.S.	0.20**	0.024**	N.S.	0.24**	0.024**
NKT	0.30**	0.34**	0.042**	N.S.	0.41**	N.S.

Table (6): Effect of nitrogen, potassium fertilization and mixture foliar spray on root yield, top yield and sugar yield of sugar beet plants in two seasons

Nitrogen fertilization level (kg/fed)	Potassium fertilization level kg/fed)	2018/2019									2019/2020								
		Root Yield (t/fed)			Top Yield (t/fed)			Sugar Yield (t/fed)			Root Yield (t/fed)			Top Yield (t/fed)			Sugar Yield (t/fed)		
		Trace elements mixture									Trace elements mixture								
		without	With	Mean	Without	With	Mean	without	With	Mean	without	with	Mean	without	With	Mean	Without	with	Mean
60	24	20.99	21.11	21.05	6.06	6.17	6.12	2.47	2.87	2.67	23.32	23.67	23.50	7.49	7.60	7.55	2.90	3.12	3.01
	36	23.58	24.83	24.21	6.39	6.60	6.50	2.99	3.56	3.27	25.03	25.36	25.20	7.75	7.91	7.83	3.42	3.38	3.40
	48	24.06	26.59	25.33	6.81	6.86	6.84	3.43	3.77	3.60	26.23	26.19	26.21	8.08	8.24	8.16	3.64	3.61	3.63
Mean		22.88	24.18	23.53	6.42	6.54	6.49	2.96	3.40	3.18	24.86	25.07	24.97	7.77	7.92	7.85	3.32	3.37	3.35
80	24	28.57	30.88	29.73	7.19	7.65	7.42	4.25	4.59	4.42	30.76	31.22	30.99	8.06	8.25	8.16	4.62	4.50	4.56
	36	31.83	33.58	32.71	7.76	7.90	7.83	5.37	5.67	5.51	32.00	32.71	32.36	8.75	8.95	8.85	5.32	5.59	5.46
	48	34.18	35.55	34.87	8.03	8.25	8.14	5.21	5.45	5.33	34.52	35.42	34.97	9.17	9.34	9.26	5.34	5.53	5.44
Mean		31.53	33.34	32.44	7.66	7.93	7.80	4.94	5.24	5.09	32.43	33.12	32.78	8.66	8.85	8.76	5.09	5.21	5.15
100	24	27.31	29.22	28.27	8.81	9.02	8.92	3.49	3.83	3.66	29.85	30.94	30.40	9.62	9.82	9.72	4.62	4.83	4.73
	36	31.37	32.68	32.03	9.25	9.68	9.47	4.44	5.05	4.75	31.60	31.82	31.71	10.20	10.42	10.31	3.99	4.56	4.28
	48	34.15	36.17	35.16	10.03	10.31	10.17	4.38	4.85	4.62	32.46	33.44	32.95	10.61	10.86	10.74	4.15	4.46	4.32
Mean		30.94	32.69	31.82	9.36	9.67	9.52	4.10	4.58	4.34	31.30	32.07	31.69	10.14	10.37	10.26	4.26	4.62	4.44
Mean of K	24	25.62	27.07	26.35	7.35	7.61	7.48	3.40	3.76	3.58	27.98	28.61	28.30	8.39	8.56	8.48	4.05	4.15	4.10
	36	28.93	30.36	29.65	7.80	8.06	7.93	4.27	4.76	4.51	29.54	29.96	29.75	8.90	9.09	9.00	4.24	4.51	4.38
	48	30.80	32.77	31.79	8.29	8.47	8.38	4.34	4.69	4.52	31.04	31.68	31.35	9.29	9.48	9.39	4.39	4.53	4.46
Total Mean		28.45	30.07	29.26	7.81	8.05	7.93	4.00	4.40	4.20	29.42	29.97	29.80	8.86	9.04	8.95	4.23	4.37	4.31

L.S.D. 5%:

N	0.21**	0.09**	0.11**	0.11**	0.11**	0.04**
K	0.20**	0.10**	0.07**	0.09**	0.09**	0.03**
T	0.33**	0.17**	0.12**	0.15**	0.15**	0.03**
NK	0.24**	0.11**	0.10**	0.19**	0.17**	0.10**
NT	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
KT	N.S.	N.S.	N.S.	0.32**	N.S.	N.S.
NKT	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

The main function of those trace elements in the plant may be due to its action as a metal component in series of enzymes, activate certain enzymes, synthesis of protein and carbohydrates and photosynthesis and building up chlorophyll. The available literature showed that foliar application of micronutrients increased plant resistance to pests and diseases **(Ghasemian *et al.*, 2010)**. These findings are in harmony with those reviewed by **Shafeek *et al*. (2014)** and **Chávez-Dulanto *et al.* (2018)** showed that plants sprayed by the mixture of Fe, Mn and Zn gained the lowest insect and mite population besides the best plant growth and quality.

Interactions effect:

Concerning the interaction effect, data Tables (5 and 6) demonstrated that most first and second interaction degrees among the used factor had a significant effect on root yield and individual root specifications in both seasons.

Meantime, the interaction between nitrogen and potassium only significantly influences top yield, while, the other interaction degrees had insignificant effect (Table 6).

2. Root Quality:

Total Soluble Solids (TSS), sucrose and purity are considered as the main quality attributes which affected greatly together with root yield the produced sugar yield per unit area.

Average data Table (7) showed that TSS linearly and significantly increased as nitrogen fertilizers increased from 60, 80 and 100 Kg K_2O fed^{-1} during 2018/19 and 2019/20 seasons. On the other hand, sucrose and purity were maximized in exchangefor 80 kg N fed^{-1} nitrogen fertilizer, thereafter; excess nitrogen 100 kg N fed^{-1} reduced those traits significantly in both seasons. Such effect may be due to that the excess nitrogen encourage vegetative growth than sucrose accumulated in roots as already mentioned before, where, an increase in top weight was detected corresponding to 100 kg N fed^{-1} **(Masri and Hamza, 2015).**

Potassium application on the rate of 24, 36 and 48 Kg K_2O fed^{-1} increased gradually and significantly TSS values in both seasons to reach their maximum value with48 Kg K_2O fed^{-1}(Table 7). Nevertheless, sucrose and purity were maximized as potassium fertilized added on the rate of 36 Kg K_2O fed^{-1}. Suppling 48 Kg K_2O fed^{-1} decreased purity significantly, while, sucrose in the first season insignificantly decreased **(Awad *et al.* 2013 and Hamad *et al.* 2015).** It's well known that potassium had an important rate in carbohydrates synthesis through its activation of photosynthesis in addition to its primary role in transporting and accumulating sugar in roots.

Regarding trace elements effect, data Table (7) illustrated that all quality attributes *i.e*. total soluble solid, sucrose and purity were increased significantly as a foliar application with a mixture of Zn, Mn and Fe after two months from sowing in comparison with control (Table 7). **Masri and Hamza (2015) and Zewail *et al.* (2020)** reviewed similar findings.

Interactions effect:

Data Table (7) showed that all interaction among the three factors significantly affected sucrose and purity in both seasons. Where, the use of 80 Kg nitrogen + 36 Kg potassium and a mixture of Zn + Mn + Fe achieved sufficient root sucrose and purity percentages, meantime, TSS trait insignificantly affected by various interaction degrees.

Sugar Yield (ton/ fed.):

Data Table (6) stated the use of 80 kg N fed^{-1} maximized sugar yield (T/fed) in both seasons, thereafter, excess nitrogen rate (100 kg N fed^{-1}) led to a significant decreased sugar yield in both seasons (Table 6). Such effect may be due to that excess nitrogen fertilizer encourage vegetative growth (top yield) and reduce sucrose synthesis than accumulating process of sugar to storage roots **(Neameat Alla *et al.*, 2014).**

Looking to the effect of potassium application, data Table (6) showed that sugar yield increased significantly and gradually with the increase of K rate from 24, 36 and 48 Kg K_2O fed^{-1}. Such effect may be due to the positive impact of K fertilizer on root yield and sucrose synthesis which previously recorded. Similar observation was found by **Awad *et al.* (2013).**

Data Table (6) also cleared that foliar application of a mixture of some trace elements *i.e.* Zn, Mn and Fe on beet foliage increased substantially sugar yield (Ton/Fed.) as compared with check treatments in both seasons. Such effect may be due to the positive effect on the enzyme system and may be reflected greatly on root yield and quality traits discussed before (Tables 6 and 7). The obtained results are in harmony with those reviewed by **Barłóg *et al.* (2016) and Zewail *et al.* (2020).**

Interactions Effect:

With respect to the interaction among the three studied factors, data Table (6) demonstrated that the interaction between nitrogen + potassium only had a significant effect on this trait, where, the highest sugar yield (5.51 and 5.46 ton/fed.) as obtained from nitrogen on the rate of 80 Kg N fed^{-1} and potassium at the rate of 36 Kg K_2O fed^{-1}.

Otherwise, all the other interaction degrees have insignificantly effect on sugar yield, but in general, the highest sugar yield in both seasons 5.67 and 5.59 ton/fed. achieved using N (80 Kg N fed^{-1}), K (36 Kg K_2O fed^{-1}) and foliar spraying of Zn + Mn + Fe.

To conclude, this study mentioned to the importance of using nitrogen, potassium and some trace element at the optimum rate to maximize the productivity and quality of sugar beet, in addition to reducing insect pests infestation.

Table (7): Effect of nitrogen, potassium fertilization and mixture foliar spray on TSS%, Sucrose% and Purity% of sugar beet plants in two seasons

Nitrogen fertilization level (kg/fed)	Potassium fertilization level (kg/fed)	2018/2019									2019/2020								
		TSS%			Sucrose %			Purity%			TSS%			Sucrose %			Purity%		
		Trace elements									Trace elements								
		Without (control)	With	Mean	Without (control)	With	Mean	Without (control)	With	Mean	Without (control)	with	Mean	Without (control)	With	Mean	Without (control)	with	Mean
60	24	17.83	18.00	17.92	14.48	15.64	15.06	81.21	86.89	84.05	18.33	18.50	18.42	15.10	15.56	15.33	82.38	84.11	83.25
	36	18.50	19.17	18.84	15.32	16.58	15.95	82.81	86.49	84.65	18.67	19.67	19.17	15.88	16.19	16.04	85.06	82.19	83.63
	48	20.00	20.17	20.09	16.82	16.94	16.88	84.10	83.99	84.05	20.00	20.67	20.34	16.65	16.89	16.77	83.25	81.71	82.48
Mean		18.78	19.11	18.95	15.54	16.39	15.96	82.71	85.79	84.25	19.00	19.61	19.31	15.88	16.21	16.05	83.56	82.67	83.12
80	24	18.33	19.00	18.67	16.52	16.80	16.66	90.13	88.42	89.28	18.00	19.17	18.59	16.44	16.62	16.53	91.33	86.70	89.02
	36	19.07	19.50	19.29	18.23	18.11	18.17	92.53	92.87	92.70	19.33	20.00	19.67	17.93	18.48	18.21	92.76	92.40	92.58
	48	19.67	21.00	20.34	17.31	17.94	17.63	88.00	85.43	86.72	21.00	21.33	21.17	17.62	18.11	17.87	83.91	84.90	84.41
Mean		19.02	19.83	19.43	17.35	17.62	17.49	90.22	88.91	89.57	19.44	20.17	19.81	17.33	17.74	17.54	89.33	88.00	88.67
100	24	19.00	19.83	19.42	15.58	16.13	15.86	82.00	81.34	81.67	19.17	19.67	19.42	14.12	15.52	14.82	73.66	78.90	76.28
	36	20.17	20.17	20.17	16.89	17.67	17.28	83.74	87.61	85.68	20.67	21.00	20.84	16.16	17.34	16.75	78.18	82.57	80.38
	48	20.50	21.00	20.75	16.22	16.78	16.50	79.12	79.91	79.52	21.00	21.20	21.10	16.45	16.82	16.64	78.33	79.34	78.84
Mean		19.89	20.33	20.11	16.23	16.86	16.55	81.62	82.95	82.29	20.28	20.62	20.45	15.58	16.56	16.07	76.72	80.27	78.50
Mean of K	24	18.39	18.94	18.67	15.53	16.19	15.86	84.45	85.55	85.00	18.50	19.11	18.81	15.22	15.90	15.56	82.46	83.24	85.85
	36	19.25	19.61	19.43	16.77	17.45	17.11	86.36	88.99	87.68	19.56	20.22	19.89	16.66	17.34	17.00	85.33	85.72	85.53
	48	20.06	20.72	20.39	16.78	17.22	17.00	83.74	83.11	83.43	20.67	20.96	20.82	16.91	17.27	17.09	81.83	81.98	81.91
Total Mean		19.23	19.76	19.50	16.36	16.95	16.66	84.85	85.88	85.36	19.58	20.10	19.84	16.26	16.84	16.55	83.21	83.65	83.43

L.S.D. 5%:

N	0.05**	0.09**	0.35**	0.25**	0.04**	1.23**
K	0.06**	0.12**	0.21**	0.20**	0.09**	0.96**
T	0.11**	0.20**	0.36**	0.33**	0.15**	1.60**
NK	0.11**	0.10**	0.19**	0.16**	0.10**	0.78**
NT	N.S.	0.17**	0.32**	N.S.	0.16**	1.30**
KT	N.S.	N.S.	0.32**	N.S.	0.16**	1.30**
NKT	N.S.	0.30**	0.56**	N.S.	0.28**	2.26**

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تأثير التسميد النيتروجينى والبوتاسى وبعض العناصر الصغرى على الإصابة بالآفات الحشرية وإنتاجية وجودة بنجر السكر

رامي سمير بشيت و عصام حنفى سيد اللبودى

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أجريت تجربتان حقليتان بمحافظة كفر الشيخ خلال موسمي ٢٠١٩/٢٠١٨ و ٢٠٢٠/٢٠١٩ لدراسة تأثيرالإضافة الارضيه للتسميد النيتروجينى بثلاث معدلات ٦٠ و ٨٠ و ١٠٠ كجم نتروجين/ فدان والتسميد البوتاسى بمعدل ٢٤ و ٣٦ و ٤٨ كجم من بو٢ أ / فدان والرش على المجموع الخضرى بمخلوط من ثلاثة عناصر صغرى الزنك (١ جم / لتر) والمنجنيز (١ جم / لتر) والحديد (٢ جم / لتر) على الإصابات الحشرية وجودة ومحصول بنجر السكر .حيث إستخدام تصميم القطع المنشقة مرتين فى ثلاثة مكرارات.

وتوضح النتائج التي تم الحصول عليها:

تلاحظ زيادة معنويه فى الاصابات بحشرات ذبابة البنجر وخنفساء البنجرالسلحفائية وفراشة البنجرمع الزيادة فى معدل التسميد النيتروجيني. وقد سجلت أعلى إصابة بالآفات

الحشرية الثلاثه المشار اليها مع التسميد النيتروجينى بمعدل ١٠٠ كجم نتروجين / فدان ، بينما سجلت أقل إصابة حشرية عند إضافة التسميد النيتروجينى بمعدل ٦٠ كجم نتروجين / فدان. كما صاحب زيادة التسميد بالبوتاسيوم انخفاض معنوي في معدل الإصابة بحشرات بنجر السكرالثلاثه تحت الدراسه كما ادى الرش بالعناصر الصغرى الى انخفاضًا معنويًا في الإصابة بذبابة البنجر بينما لم يصل الانخفاض على الآفتين الأخريين الى درجة المعنويه.

جميع خصائص وجودة بنجر السكر مثل محصول العرش والمواد الصلبة الذائبة الكلية (TSS) زادت بشكل ملحوظ بزيادة مستوى النيتروجين من ٦٠ إلى ١٠٠ كجم نتروجين / فدان بينما أعطى أعلى قطر وطول ووزن الجذركما اعطى أعلى محصول جذور ومحصول سكر وكذلك السكروز والنقاء عند إضافة ٨٠ كجم نتروجين / فدان. ومن ناحية أخرى ، فإن زيادة التسميد بالبوتاسيوم من ٢٤ حتى ٤٨ كجم بو٢ أ / فدان الى زيادة قطر الجذر المحسن بشكل إيجابي وطول الجذر ووزن الجذر ومحصول العرش ومحصول السكر / فدان و TSS . ومع ذلك ، تمت زيادة صفة النقاوة والسكروز إلى أقصى حد عند إضافة التسميد البوتاسي بمعدل ٣٦ كجم بو٢ أ / فدان. فيما يتعلق بتأثير العناصر الصغرى، فقد تم زيادة جميع الصفات الأنتاجيه و الجودة لبنجر السكر معنوياً عند إضافة خليط (الزنك ، المنجنيز والحديد) على الأوراق مقارنة بالكنترول.

وبناء علي ئلك توصى الدراسة باضافة التسميد النيتروجينى بمعدل ٨٠ كجم نيتروجين/فدان والتسميد البوتاسى بمعدل ٣٦ كجم بو٢ أ / فدان مع رش خليط من الزنك والمنجنيز والحديد على اوراق بنجر السكر للحصول على أعلى محصول لبنجر السكر كماً ونوعا. كما توضح الدراسه أن المعدل المشار أدي الي التغطيه او تقليل الأثر الضار للإصابات الحشريه.