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Effect of Potassium Fertilization on The Main Piercing-Sucking Insect Species Infesting Maize Plants

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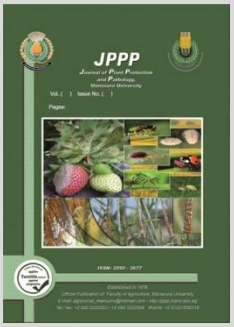

ABSTRACT

This study was carried out to survey the main piercing–sucking insect species that infesting maize plants in Zagazig district, Sharkia Governorate, Egypt during 2020 and 2021 seasons, in addition to estimate the effects of potassium fertilization on populations of aphid, leafhopper and planthopper insects. Plant samples, sweeping net, yellow sticky broad traps were used to collect these piercing–sucking insects from different potassium fertilized maize plants. Results showed that aphid species that infesting maize plants were *Rhopalosiphum maidis*, *R. padi*, *Aphis gossypii*, the leafhoppers were *Empoasca decipiens*, *E. decedens*, *Cicadellina chinai*, *C. bipunctella zea* and *Balclutha hortensis*, and the planthoppers were *Sogatella vibix* and *S. furcifera*. Potassium fertilization of maize plants influenced the population density of the aforementioned homopterous insect species. The highest mean number of the aforementioned homopterous insect species occurred with F1 (zero potassium fertilization) treatment, while the lowest population density was recorded with F4 (150 kg. Potassium sulphate/feddan). Chemical analysis showed a reverse relationship between protein and carbohydrate contents and aphid, leafhopper and planthopper populations on all tested potassium fertilized maize plants, while a positive relationship between pH values and the aforementioned insect populations was obtained.

Keywords: Aphid, Leafhopper, Planthopper, Potassium fertilization.

INTRODUCTION

The maize crop (*Zea mays* Linn. Family Poaceae) is one of the most important graminaceous crops used as human and animal feed all over the world. However, the production of this crop has been constrained by the limitations imposed by piercing-sucking insects (Hegab, 2001). Maize plants are attacked by several serious piercing–sucking insects belonging to order Homoptrera especially aphid, leafhopper and planthopper insect species which cause a considerable damage to maize plants. Further, these insect species are responsible in transmitting the pathogens that causing several plant diseases (Nielson, 1968, Maramorosch, 1969, Harris and Maramorosch, 1977, 1980, and Hegab, 1980). Several studies surveyed these insects in many fields of vegetable crops and fruit trees in Egypt (Ammar and Farrag, 1976; EL-Nahal *et al.*, 1977; Aboul Atta, 1983; Hegab *et al.*, 1989a, b; Helal *et al.*, 1996; Hegab, 2001; El-Khawas *et al.*, 2004; Awadalla *et al.*, 2011, 2013, 2014 and 2019; Shalaby *et al.*, 2012). However, this work aims to survey the major piercing-sucking insect species that inhibiting maize crop, to examine the influence of potassium fertilization on such insect species, and to estimate the effect of chemical constituents on the population density of aphid, leafhopper and planthopper insects.

MATERIALS AND METHODS

This study was carried out to survey the main piercing–sucking insect species that infesting maize plants in Zagazig district, Sharkia Governorate, Egypt during 2020 and 2021 seasons, in addition to estimate the effects of potassium fertilization on populations of aphid, leafhopper and planthopper insects .

Maize plant (*Zea mays* Linn.), variety of Single white 2030 was used in this experiment. Seeds of this variety were planted in the recommended sown date (Mid of May) in an area of about 600 m2 for two successive seasons 2020 and 2021. For each fertilization rate, an area of about 150 m2 was divided into three replicates (50 m2/ replicate). This experiment was arranged in a completely randomized design (CRD). The normal agricultural practices were applied without using any pesticides treatment. To examine the effect of potassium fertilization on the population density of the main piercing-sucking insects, four rates of potassium sulphate (24% K20) 00, 50, 100 and 150 kg./feddan were used and the recommended rates of phosphorus (Calcium superphosphate 15% P2O5) and nitrogen (Urea 46%) were also applied during preparing the soil for plantation. The amount of potassium fertilizer (Potassium sulphate 24% K20) was added to plants at three equal times. The first addition was during preparing the soil for plantationof seeds, the second was with the first irrigation and the third one was with the second irrigation. In order to examine the effect of potassium fertilization on the population density of the major piercing-sucking insects that inhibiting maize plants during 2020 and 2021 seasons, the following procedures of sampling were followed:

Weekly samples of 10 leaves and 5 tassels were taken randomly from five plants during the period from mid of June to end of September during 2020 and 2021 seasons. The plant samples were kept in paper bags and transferred in the same day to the laboratory for examination. For this purpose, a simple apparatus composited of a wooden desk with a white

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card board paper that divided into 4 cm2. A part column put in the bottom on which a glass plate was fixed and the top surface of the plate was allowed to be wetted with few droplets of water to impede the movement of collected insect pests (Hegab *et al.*, 1987). Then, the plants were carefully wiped on the plate using a small brush in each column. The samples were examined in the laboratory using stereo-microscope and a hand lens (5 X). Then, the total number of insects were preserved in 70% Ethyl-alcohol. Specimens of collected insects were identified according to Habib (1961); Szelegiewiez (1977) and Blackman and Eastop (2000).

Weekly samples of 50 double strokes were taken by sweeping net (35 cm in diam. and 60 cm in dep.) from both diagonal directions of the experimental area to survey the major piercing-sucking insect species in different treatments of potassium fertilized maize plants. In each sample, the collected insects were kept in paper bags and then transferred to the laboratory for further inspection and counting.

Yellow paper boards of 10 × 20 cm. coated with sticky material and hung on wood rods varied in height according to the height of plants through the period of sampling. The traps levels were always kept over plant surface with 20 - 30 cm. Six yellow sticky board traps were used in this investigation. Counts of the main piercing-sucking insect pests that captured in the traps were recorded according to Herakly (1980) and Hegab *et al.* (1987 and 1988).

Chemical analyses to determine the total protein, carbohydrate contents and pH values of fertilized maize plants with different levels of potassium were performed in the central Lab., Faculty of Agriculture, Zagazig University. The effect of various potassium rates on population density of the dominant insect species (aphid, leafhoppers and planthoppers) that inhibiting maize plants along with the obtained yield quantities were statistically analyzed according to Little and Hills (1975).

Statistical analysis:

Statistical analysis of the data was performed using version 6.303 of a computer program Costat (2005). Data were analyzed using one-way ANOVA and means were compared using Duncan Multiple Range Test (Duncan, 1955) at a probability level of 0.05.

RESULTS AND DISCUSSIONS

Survey of the major homopterous insect species on various potassium fertilized maize plants

Data in Tables (1 and 2) present the aphid, leafhopper and planthopper insects that infesting different potassium fertilized maize plants during 2020 and 2021 seasons at Zagazig district, Sharkia Governorate. Three aphid species belonging to Family: Aphididae, five leafhoppers belonging to Family: Cicadellidae and two planthoppers belonging to Family Delphacidae were recorded. The aphid species were *Rhopalosiphum maidis* (Fitch, 1856), *R. padi* (Linnaeus, 1758), *Aphis gossypii* (Glover, 1877); the leafhopper species were *Empoasca decipiens* (Paoli, 1930) *E. decedens* (Paoli, 1932), *Cicadulina chinai* Ghaur, *Balclutha hortensis* Lindberg, 1948 and *C. bipunctella zea* China; and the planthopper species were *Sogatelle vibix* (Haupt) and *S. frucifera* (Horv.).

Aphid species (Aphididae: Homoptera)

Data given in Tables (1 and 2) show that the lowest population density of *R. maidis* insects was recorded with 150 Kg of potassium sulfate/feddan, (191 and 161 individuals) in the two seasons, respectively. The four treatments were arranged in a descending order according to their influence on maize infestation with *R. maidis* as follows; control or Zero, 50, 100 and 150 kg of potassium sulfate /feddan which represented by 414, 324, 264 and 191 individuals, respectiviely in 2020 season and 297, 262, 222 and161 individuals, respectively in 2021 season.

Results recorded in Tables (1 and 2) show that the highest mean number of *R. padi* (300 and 226 individuals) occurred with F1, (zero potassium sulfate fertilization /feddan) during 2020 and 2021 seasons, respectively. The four treatments were arranged in a descending order according to their influence on maize infestation with aphid, *R. padi* as follows; control or Zero, 50, 100 and 150 kg of potassium sulfate /feddan, which represented by 300, 212, 149 and 108 respectiviely in 2020 season and 226, 194, 164 and 118 individuals, respectively in 2021 season.

The highest mean number of *A. gossypii* (114 and 92 individuals) occurred with F1, (zero potassium sulfate fertilization /feddan) during 2020 and 2021 seasons, respectively. The four treatments were arranged in a descending order according to their influence on maize infestation with aphid, *A. gossypii* as follows; control or Zero, 50, 100 and 150 kg of potassium sulfate /feddan, which represented by 114, 66, 42, and 23 individuals, respectively in 2020 season and 92, 70, 51 and 33 individuals, respectively in 2021 season.

Leafhoppers species (Cicadellidae: Homoptera)

During 2020 and 2021seasons, the four treatments were arranged in a descending order according to mean numbers of *E. decipiens* recorded per sample as follows; control or Zero, 50, 100 and 150 kg of potassium sulfate/feddan and represented by 132, 76, 51 and 29 individuals, respectively in 2020 season and 89, 68, 50, and 27 individuals, respectively in 2021 season, Tables (1 and 2).

During 2020 and 2021 seasons, the four treatments could be arranged in a descending order according to the mean numbers of *E. decedens* recorded per sample as follows; control or Zero, 50, 100 and 150 kg of potassium sulfate/feddan which represented by 96, 49, 29 and 15 individuals, respectively in 2020 season and 84, 61, 42, and 24 individuals, respectively in 2021 season.

According to the Tables (1 and 2) the lowest mean numbers of *C. chinai* (13 and 20 individuals) occurred in the treatment of 150 kg. potassium sulfate/feddan during 2020 and 2021 seasons, respectively. While the highest mean number of *C. chinai* was recorded with the treatment of zero level of potassium sulfate/feddan, 82 and 75 individual during the two seasons, respectively.

According to the same Tables (1 and 2), the lowest mean number of *C. bipunctella*, (11 and 18 individuals) occurred in the treatment of 150 kg. potassium sulfate/feddan during 2020 and 2021 seasons, respectively. While the highest mean number of *C. bipunctella* was recorded with the treatment of zero level of potassium sulfate/feddan, 68 and 73 individual during the two seasons, respectively.

According to the Tables, (1 and 2), the highest mean numbers of *B. hortensis* (84 and 81 individuals) occurred in the treatment of zero level of potassium sulfate /feddan during 2020 and 2021seasons, respectively. While the lowest mean numbers of *B. hortensis* were recorded with the treatment of

150 kg. potassium sulfate/feddan (18 and 23 individual/ sample during the two seasons, respectively.

Planthopper species (Delphacidae: Homoptera)

During 2020 and 2021seasons, the four treatments were arranged in a descending order according to mean numbers of *S. vibix* recorded per sample as follows; zero level of potassium sulfate fertilization (61 and 73 individuals), 50 kg. potassium sulfate /feddan (37 and 54 individuals) , 100 kg. potassium sulfate /feddan (21 and 35 individuals) and 150 Kg. potassium sulfate /feddan (11 and 18 individuals) during the two seasons, respectively.

Data presented in Tables (1 and 2) show also that the highest mean number of *S. frucifera* was recorded in the zero level of potassium sulfate fertilization (63 and 70 individuals), while the lowest mean numbers of *S. frucifera* occurred with 150 kg. potassium sulfate fertilization/feddan (9 and 15 individuals) for the two seasons, respectively.

As clearly shown from the results in Tables (1 and 2) the yield of maize crop treated with the different tested potassium fertilization treatments were highly significant influenced by changing the fertilization program in the two seasons. The highest yield 48.5 and 52.5 kg/plot was recorded with F4, (150 kg potassium sulfate /feddan) in 2020 and 2021 seasons, respectively, Whereas, the lowest yield (42.5 and 44.5 kg/plot) was obtained in case of F1, (control without potassium fertilization) treatment during 2020 and 2021 seasons, respectively. The other tested treatments gave a moderate yield.

In general, the obtained results indicated that F4 (150 kg potassium sulfate /feddan) treatment harboured the lowest mean number of the main piercing-sucking insect species (aphids, leafhoppers and planthoppers), while, the infestation increased on F3 (100 kg potassium sulfate /feddan) treatment, on F2 (50 kg potassium sulfate /feddan) and it was the highest infestation on F1 (control without potassium fertilization) treatment.

Statistical analysis revealed that there was significant differences between the different potassium fertilization levels and population of aphid, leafhopper and planthopper insect species in each season.

These results are in agreement with the findings of Hegab and Hegab (2020) and Youssef (2006) which mentioned that there were significant differences between potassium fertilization levels on maize plants and mentioned that the highest mean number of aphids, leafhoppers and planthoppers recorded in the zero level of potassium fertilization The present results are in agreement with those obtained by Hashem (1997); El-Dafrawi *et al.* (2000); El-Gindy (2002); Abdel-Samad and Al-Habashy (2013); El-Mashaly (2013); Awadalla *et al.* (2017); Mansour (2017) and Elshyeb (2020) who mentioned that different aphid,leafhopper and planthopper insect species were collected from some vegetable and field crops with a great effect of host plant on infestation incidence by piercing-sucking insects.

Table 1. Effect of potassium fertilization levels on the mean numbers of aphid, leafhopper and planthopper insect species that inhibiting maize plant during the first planting season of 2020.

Potassium Fert. / Insect species		Mean number of the main piercing- sucking insect pests				"F" value	L.S.D. 0.05
		00 Kg. (Check)	50 Kg.	100 Kg.	150 Kg.		
Fam: Aphididae	*Rhopalosiphum maidis*	414 a	324 b	264 c	191 d	532.07**	4.72
	Rhopalosiphum padi	300 a	212 b	149 c	108 d	203.58**	6.76
	Aphis gossypii	114 a	66 b	42 c	23 d	294.25**	2.64
Fam: Cicadellidae	*Empoasca decipiens*	132 a	76 b	51 c	29 d	576.20**	2.13
	Empoasca decedens	96 a	49 b	29 c	15 d	180.85**	3.03
	Cicadulina chinai	82 a	44 b	25 c	13 d	520.00**	1.53
	Cicadulina bipunctella	68 a	36 b	21 c	11 d	154.96**	2.10
	Balclutha hortensis	84 a	49 b	30 c	18 d	213.33**	0.1
Fam: Delphacidae	*Sogatella furcifera*	63 a	33 b	18 c	9 d	547.00**	0.1
	Sogatella vibix	61 a	37 b	21 c	11 d	216.34**	1.88
Yield		42.50 d	43.50 c	45.33 b	48.50 a	68.35*	0.865

Mean followed by the same letter are not significantly different (P= 0.05; Duncan multiple range test)..

Table 2. Effect of potassium fertilization levels on the mean numbers of aphid, leafhopper and planthopper insect species that inhibiting maize plant during the second planting season of 2021.

Potassium Fret. / Insect species		Mean number of the main piercing- sucking insect pests				"F" value	L.S.D. 0.05
		00 Kg. (Check)	50 Kg.	100 Kg.	150 Kg.		
Fam: Aphididae	*Rhopalosiphum maidis*	297 a	262 b	222 c	161 d	575.61**	2.80
	Rhopalosiphum padi	226 a	194 b	164 c	118 d	112.96**	1.66
	Aphis gossypii	92 a	70 b	51 c	33 d	92.77**	3.03
Fam: Cicadellidae	*Empoasca decipiens*	89 a	68 b	50 c	27 d	120.87**	2.76
	Empoasca decedens	84 a	61 b	42 c	24 d	132.45**	2.57
	Cicadulina chinai	75 a	56 b	36 c	20 d	55.31**	3.70
	Cicadulina bipunctella	73 a	50 b	33 c	18 d	126.26**	2.42
	Balclutha hortensis	81 a	59 b	40 c	23 d	182.32**	2.13
Fam: Delphacidae	*Sogatella furcifera*	70 a	48 b	30 c	15 d	204.45**	1.91
	Sogatella vibix	73 a	54 b	35 c	18 d	92.44**	2.80
Yield		44.50 d	48.50 c	51.50 b	52.50 a	24.67*	0.745

Mean followed by the same letter are not significantly different (P= 0.05; Duncan multiple range test).

Relationship between certain chemical constituents of different potassium fertilized maize plants and the population density of the main piercing-sucking insect species.

From the obtained results in Table (3) the highest mean numbers of aphid, leafhopper and planthopper insect species occurred in the treatment of zero level of potassium sulfate treatment, where the lowest total protein and carbohydrate contents and the highest pH value, the lowest susceptible to aphid, leafhoppers and planthopper infestations and the highest yield during the season 2021,while the lowest mean numbers of of aphid ,leafhopper and planthopper insect

species were recorded with the treatment of 150 kg. potassium sulfate/feddan , where the highest total protein and carbohydrate contents and the lowest pH value , the lowest susceptible to aphid, leafhoppers and planthopper infestations and the highest yield during 2021 season Table (3).

Data represented in Table (3) show the average number of the main piercing –sucking insect pests (aphid, leafhopper and planthopper insects) that affected by the chemical constituents of the different potassium fertilized maize plants and the yield of crop wad also affected.

Generaly, it is evident that chemical analysis of the tested potassium fertilized maize variety pointed out that the total number of main piercing-sucking insects infesting fertilized maize plants (aphid, leafhopper and planthopper insects) were negatively related with the total of protien and carbhydrate contents of the different fertilized maize plants, while it was positively related with the pH values of the different tested potassium fertilized maize plants and also with quantity of yield Table (3).

These results are in agreement with those of Hegab (2001); Hashem (2005); Youssef (2006); Awadalla et al. (2013); Hegab (2015); Awadalla et al. (2017); Mansour, (2017); El-Shyeb (2020). Hegab and Hegab (2020). They found that the chemical constituents of host plants have a great impact on infestation incidence by piercing-sucking insects and there were significant differences were obtained between the chemical constituents of the different fertilized field and vegetable crops and certain piercing-sucking insect infestations.

Table 3. Effect of potassium fertilization levels on the chemical constituents in fertilized maize Signal white 2030 variety and their relation with aphid, leafhopper and planthopper insects infestation at Zagazig district, Sharkia Governorate during 2021 season.

Potassium Fertilization levels	00kg (check)	50 kg	100kg	150 kg	F.	L.S.D. 0.05
Protein	14.98[d]	16.82[c]	18.88[b]	19.91[a]	640.22 **	0.64
Carbohydras	41.16[d]	43.50[c]	46.36[b]	48.96[a]	686.28**	0.526
Ph	4.98[a]	4.68[b]	4.46[c]	4.22[d]	8.01*	0.177
K	2.96	3.44	3.7	3.9	4.68	0. 98
Ca	2.98	2.68	2.3	2.1	2.85	0.947
P	0.94	0.72	0.52	0.34	2.69	0.68
Mean number of aphid insects	615[a]	526[b]	437[c]	312[d]	719.493**	5.47
Mean number of leafhopper insects	402[a]	294[b]	201[c]	112[d]	471.354**	11.87
Mean number of planthopper insects	143[a]	102[b]	65[c]	33[d]	250.67**	3.31

CONCLUSION

These results indicated the potassium fertilization of maize plants influenced the population density of certain homopterous insect pest species. Chemical analysis showed a reverse relationship between protein and carbohydrate contents and aphid, leafhopper and planthopper populations on all tested potassium fertilized maize plants, while a positive relationship between pH values and the aforementioned insect populations was obtained.

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تأثير التسميد البوتاسي على أهم الحشرات الثاقبة الماصة التي تصيب نباتات الذرة

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الملخص

أجريت تلك الدراسة بغرض حصر أهم الحشرات الثاقبة الماصة التى تصيب نباتات الذره فى منطقة الزقازيق بمحافظة الشرقية خلال موسمي 2020 و2021م بالإضافة إلى تقييم تأثير التسميد البوتاسي على مجاميع حشرات المن ونطاطات الأوراق وكذلك نطاطات النباتات. تم جمع الحشرات الثاقبة الماصة من نباتات الذرة المسمدة بمعدلات مختلفة من التسميد البوتاسى عن طريق، العينات النباتية، شبكة جمع الحشرات بالإضافة الى المصائد الصفراء اللاصقة. ولقد أظهرت النتائج إصابة نباتات الذرة بأنواع مختلفة من حشرات المن وهي: *R. maidis, R. padi, A. gossypii* , وأنواع نطاطات الأوراق وهى: *E. decipiens ، E. decedens ، C. chinai ، C. bipunctella* و *B. hortensis* وكذلك نطاطات النباتات *S. furcifer*، *S. vibix* . ولقد أوضحت النتائج أيضا أن التسميد البوتاسى لنباتات الذرة أثرت على كثافة المجموع لكل من الحشرات الثاقبة الماصة سالفة الذكر، وأن أعلى تعداد للحشرات الثاقبة الماصة لوحظ على النباتات التى لم تسمد بالسماد البوتاسى، وأن اقل تعداد لتلك الحشرات كان عندما تم تسميد النباتات بمعدل عالى من التسميد البوتاسى (150كجم/فدان). كما أوضحت نتائج التحليل الكيماوى وجود علاقة عكسية بين محتوى النبات من البروتين والكربوهيدرات وتعداد حشرات المن، ونطاطات الأوراق وكذلك نطاطات النباتات على جميع معدلات التسميد البوتاسى، بينما كانت هناك علاقة موجبة بين درجة حموضة عصارة النبات وتعداد الحشرات سالفة الذكر.