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Field assessment of corn yield losses and compensatory yield for infested plants by Lepidopteran stem borers in different sowing dates at El-Behiera governorate, Egypt.

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ABSTRACT

Whenever the determination of yield loss and economic injury levels are essential tools for initiating integrated pest management (IPM) programs in the maize field, the assessment of compensatory yield is very important for determinate the accurate losses in the field and the recovery power for the maize verity. The present study aimed to estimate the yield losses of three maize varieties due to *Sesamia critica* and *Ostrinia nubilalis,* infestation; regression between maize yield losses and percent of infestation and determine the compensatory yield arising in intact plants as a result of absence or dead (caused by infestation) of adjacent plants under field conditions in El-Behiera governorate. The present results showed that yield losses resulting from *S. cretica* infestation in early sowed maize ranged from 5.29 – 32.17%. In case of maize that sowed in recommended date "June", yield losses due to *S. cretica* was slightly decreased, and it accompanied with *O. nubilalis* infestation in two fields, which increased the total yield losses. A simple linear regression turned out between the percentage of infestation of *S. cretica* or *O. nubilalis* and percentage of yield losses, with R^2 values 0.84 and 0.45, respectively. The yellow corn was more tolerant to stem borers infestation than white corn with percentages of increase rate in compensatory yield 27.07 %.

Keywords: yield losses, stem borers, *Sesamia critica. Ostrinia nubilalis,* sowing dates

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INTRODUCTION

Maize, *Zea mays* L. (Graminae: cereals) is an important grain food and industrial cereal **(FAO, 1998)**. The economic importance of maize was increased since it is used for human, livestock's and poultry consumption; also, it was used as a source of industrial raw material for the production of oil, alcohol and starch. It sawed under a wide range of environmental conditions, so it contributed greatly to the growth of many developing countries **(Andeet *al.*, 2008 and Mbahet *al.*, 2009)**.

In Egypt, maize is an important multipurpose crop; it occupies the third rank after rice and wheat, about 2 million Feddans were cultivated with maize in 2013, which produced about 7 million tons of grain yield, with an average of 23.7 Ardabs/Feddan **(Metwally, 2015)**.

The lepidopteran stem borers, *Sesamia cretica* Led. (Noctuidae), *Ostrinia nubilalis* (Hb.) (Pyraustidae) and *Chilo agamemnon* (Bles.) (Crambidae) were the most important varieties of insect pests in Egypt **(Metwally, 2015 and Massoudet *al.*, 2016)**. They attack the maize plants throughout the different growth stages, and caused percentages of yield losses,39.25 and 53.62% for 2014 and 2015 seasons, respectively **(Massoud *et al.*, 2016)**. *Sesamia cretica* Led and *Ostrinia nubilalis* Hub are regarded among the major factors causing great damage, yield loss and affecting the productivity of growing maize plants **(Abd El-Gawad *et al.*, 2002)**.

S. cretica infests maize at early vegetative growth stage (15 days after emergence) to (45 – 60 days). At early infestation, most infested young plants dead and leave gaps in the field. One of the reasons for absence of infested plants with *S. cretica* from the field is the farmer's behavior. Most of them decide to cut the infested plants early at vegetative stage (age of 45-60 days) to be used as fodder for farm animals.

Making quantitative assessments of losses caused by pest attack crops is very important for establishment of the economic status of specific pests (**Golebiowska & Romankov, 1968**); and to give a basis for directing future research and agriculture planning **(Walker, 1967)**. Yield losses caused by corn insect pests were investigated and estimated by several authors such as **Abdel Rahim *et al*., 1992; Ismail *et al*., 1993; Mansour *et al*., 1994 and Al-Eryan & El-Tabbakh, 2004.** Attention should be paid for assessing yield loss due to these stem borers, yield loss is a prerequisite step for the determination of economic injury levels (EILs) which is not representing a permanent constant value, that differs according locality, product price and insecticide cost, and it used as a tool for initiating integrated pest management (IPM) programs in maize field **(Massoud *et al*., 2016)**.

The aim of the present study is to estimate the yield losses of the maize due to infestation with stem borers; *Sesamia critica* and *Ostrinia nubilalis* under field conditions in two varieties of maize (white "SC10", and yellow "Pioneer 3062") in small holder maize fields in El-Behiera governorate and determine the compensatory yield arising in intact plants as a result of absence or dead due to infestation of neighboring plants.

MATERIALS AND METHODS

Estimation of yield losses due to stem borers in maize fields sawed in three different dates:

Twelve maize small holder fields were chosen at El-Bostan and Abo Elmatamer (30° 54′ 29.16″ N, 30° 10′ 27.48″ E) districts, El-Behiera governorate. Three corn varieties, white corn ("SC10"= single crosses) and yellow corn ("Pioneer 3062"= yellow two single crosses) were sowed in three different dates (early in May, recommended in June and late in July) in the season of 2016.After 15 days from sowing date, an area of 21 m^2 (1/20 from feddan)at the center of each field was chosen for easy checking plants and number of naturally absent plants was recorded. At 30 days from sowing, the plants infested with *Sesamia cretica* were labeled by rings of yellow ribbons to be under observation till yield estimation. This procedure was applied every two weeks until 45 days from sowing date. In addition, at 45 days age, infested plants with *Ostrinia nubilalis* were recorded using red ribbons.

Crop yield parameters and percentages of grain yield losses of the maize fields due to plant absence and infestation with the two stem borers were calculated in three different sowing dates using the analytical method. At harvesting time, the following yield parameters were estimated: -

ACT = mean of stand plants actual grain yield/ plot.

The yield loss (LOSS) and percentage of economic loss (% LOSS) were calculated according to **Judenko (1973)** as follows: -

EXP (Expected yield) = No. of sowed plants (N) per plot x Mean of actual grain yield per intact plant (Y*)

LOSS (The yield loss) = EXP – ACT

% LOSS (The percentage of economic loss) = LOSS / EXP x 100

Percentage of infested plants with either *S. cretica* or *O. nubilalis* was used as variable predictor to build regression models for predicting the dependents variable (percentage of yield loss). Regression analysis by **Hyams, (2014)** V.2.0.4. was used for this purpose. Linear regression of maize yield losses due to infestation with corn borers, *S. cretica* and *O. nubilalis*was illustrated.

Assessment of compensatory yield:

Two maize varieties, white and yellow maize, were chosen to estimate compensatory yield (C) resulted from absent plants (C_{abs}) or for death plants due to *S. cretica* infestation (C_{inf}). The method of detection is to compare the yields of intact plants next to absent or infested plants with the yields of intact plants surrounded by other intact plants.

At 30 days from sowing date, the plants infested with *S. cretica* were labeled by rings of colored strands. The five intact plants adjacent to each of: other intact plants, absent plants or dead infested plants, were chosen and labeled.

At harvesting time, labeled absent and dead plants caused from infestation were examined.

The next yield parameters were estimated:

Y_{int} = mean yield of intact plant adjacent to intact plant.

E = mean yield of intact plant adjacent to absent or dead plant from infestation.

Percentage of increase rate in compensatory yield in intact plant adjacent to absent (C_{abs}%) or dead (C_{inf}%) plant in white and yellow corn was calculated.

Mean compensatory yield of plants adjacent to absent or dead plant (C) = (E $-Y_{int}$)

RESULTS AND DISCUSSION

Estimation of yield losses due to stem borers in maize fields sawed in three different dates:

The yield losses due to plant absence and infestation with two stem borers, *S. creticae* and *O. nubilalis* was assessed in twelve small holder maize fields in El-Behiera governorate at three sowing dates (early in "May", recommended in "June" and late in "July") using the analytical method.

The obtained results in Table 1 and Fig. 1 showed that yield losses in early sowed maize due to infestation with *S. cretica* ranged from 5.29 – 32.17%. While, yield losses due to absent plants ranged between 4.2 – 17.23%. In case of maize that sowed in recommended date "June" the yield losses due to *S. cretica* was slightly decreased and it accompanied with *O. nubilalis* infestation in two fields, which increased the total yield losses.

Table 1: percentages of grain yield losses of the maize fields in El-Behiera governorate at three sowing dates.

Sowing date	Corn Fields	Field 1		Field2		Field3		Field4	
	Plant status	% Plant	% Grain yield Loss	% Plant	% Grain yield Loss	% Plant	% Grain yield Loss	%Plant	% Grain yield Loss
early date (May)	Intact	73.04	0	88.33	0	65.38	0	60.95	0
	Absent	19.35	17.38	5.84	5.89	6.92	4.2	6.67	6.09
	Infested with *S. cretica*	7.61	9.82	5.83	5.29	27.69	27.53	32.38	32.17
recommended date (June)	Intact	69.01	0	43.53	0	59.58	0	64.52	0
	Absent	2.82	4.41	24.8	24.8	4.17	4.17	4.53	4.52
	Infested with *S. cretica*	28.17	27.94	31.67	31.2	6.25	2.33	18.87	2.09
	Infested with *O. nubilalis*	-	-	-	-	30	7.29	12.08	2.57
late date (July)	Intact	57.62	0	69.52	0	46.53	0	21.67	0
	Absent	5.71	5.72	2.86	2.86	21.24	21.24	5.0	5
	Infested with *S. cretica*	10.48	4.05	8.57	4.12	12.4	12.39	13.33	13.33

	Infested with *O. nubilalis*	26.19	8.29	19.05	3.98	19.83	8.32	60	21.62

% Plant= Percent of plants from total plants

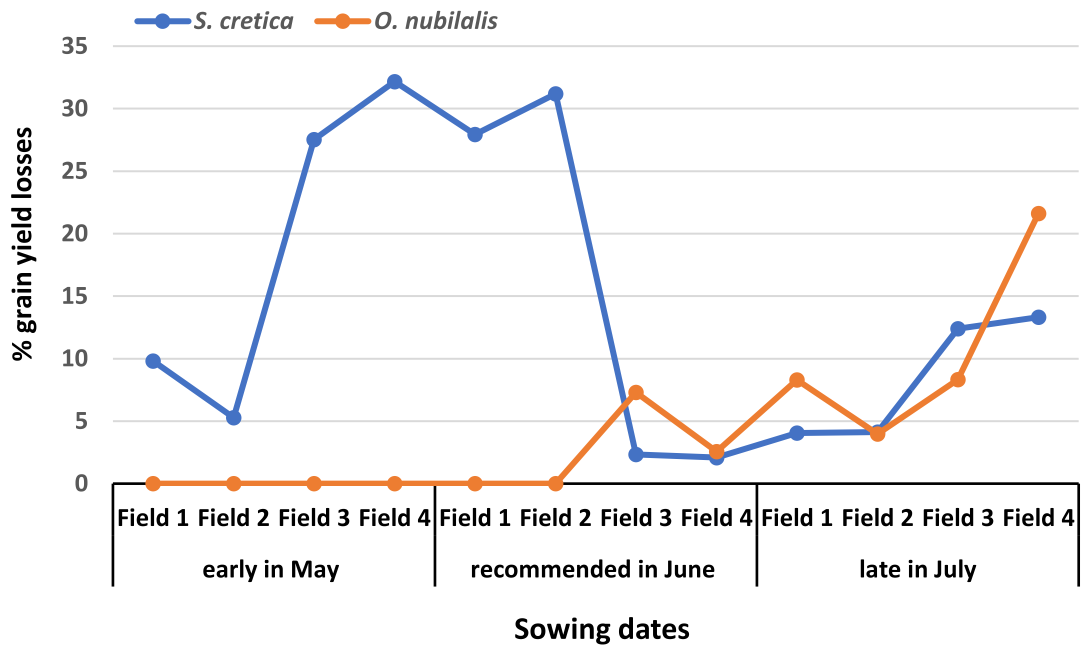

Figure 1: The percentages of grain yield losses caused by two pests in four maize fields in different sowing dates.

The present results indicated that yield losses due to *S. cretica* was higher in field early sowed in May (ranged from 5.29 to 32.17%) than that recommended sowed in June (ranged from 2.09 to 31.2%) and late sowed in July (ranged from 4.05 to 13.33%).These results were confirmed by **Abd El-Rahman, (2002)** who indicated that infestation by *S. cretica* was slightly higher, on all tested genotypes, in early plantation of May than in late plantation of July. On the contrary, the yield losses due to *O. nublalis* increased in late sowed four fields (3.98 – 21.62 %) than that in recommended sowed two fields (ranged from 2.57 to 7.29%). **Obopile *et al.*, (2012)** suggested that when planting is delayed. the European corn borer population is known to cause economic damage in an area, selection of short-season can be beneficial in controlling damage and improving yield.

Figure 1 concluded the effect of sowing date on the pest infestation and subsequently the percentages of yield losses caused by two stem borers in twelve small fields. It is clear that when the corn sowed early in May the plants were infested by *S. creticae* only, but the infestation was very heavy specially in fields 3 and 4. On the contrary, when the corn sowed late in July, the infestation level of *S. creticae* decreased, but generally the percentages of yield losses caused by two pests together increased. Planting within early time in May frame provide maize plants with full-season maximum growing degree days and reduced pest pressure associated with late planting. Planting date is critical in maize production because it influences the availability of growing degree days required to mature the maize crop, and the number of pests on the crop throughout the season. **(Motshwari, 2009). Culy, 2000** reported that sowing long-season genotypes early was the best strategy to avoid more damages. Because yield reduction in shorter-season genotypes as compared with longer-season genotypes are more significant, especially when they are sown late. Delayed planting often subjects maize plants to heavier infestation of pests and diseases which can result in yield loss **(Wiatrak*et al.*, 2004).**

The present results were confirmed by **Mesbah, *et al.* (2002)** who concluded that the lately sown biofertilized plant, showed somewhat higher levels of stem borers infestation than the early planted ones. Also, this agreed with **Abed-Elgayed (1996)** who found that *O. nubilalis* infestation started 4 to 7 weeks after planting according to sowing date.

Adjusting planting dates has been recommended as a cultural method to control European corn borer. **Jarvis, *et al.* (1986)** demonstrated that the yield of full season hybrids in both European corn borer infested and non-infested plots were much greater than those of short season hybrids. The losses due to European corn borer were greater in short season hybrids when planted late. Also, recommended that growers should plant full season hybrids early. They recommended that if short season hybrids are planted late, European corn borer must be closely monitored. **Benson (1995)** reported that the potential yield of maize decline by 10-20% if planting is delayed until 20 May and 1 June, respectively.

1- Regression between percent of corn borers infestation and yield losses:

Appreciation of regression is adequate for predication of yield losses caused by pests. However, new observations and new data for many successive seasons are requested to validate the models in prediction. Linear regression of maize yield losses due to infestation with corn borers, *S. cretica* and *O. nubilalis* was evaluated using **Hyams, (2014)** V.2.0.4.

Regression analysis showed a simple linear regression between percentage of infestation of *S. cretica* or *O. nubilalis* with percentage of yield losses, with R^2 values 0.84 and 0.45, respectively Fig. 2. As corn ear yield (EY) negatively correlated with infestation with *S. cretica* or with *O. nubilalis* infestation percentage was used as predictor variable to build regression models for predicting the dependent variable (EY).

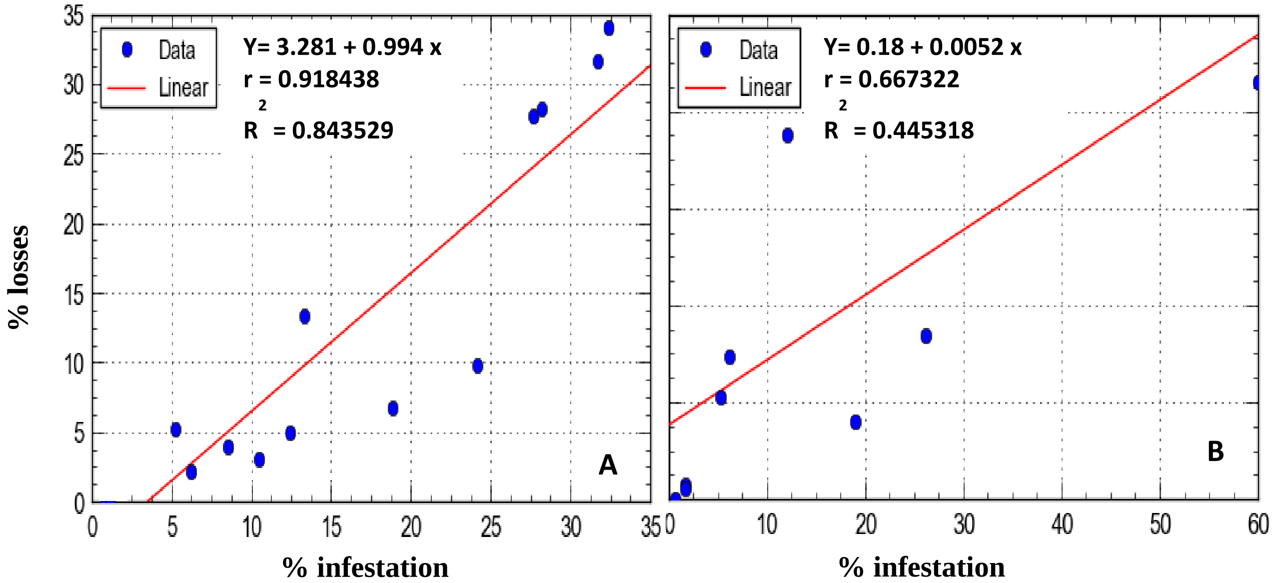

Figure 2: Regression between percentages of yield losses and percent of infestation by *S. cretica* (A) and *O. nubilalis* (B).

Regression analysis between % infestation of *S. cretica* and percentage of yield losses revealed that simple linear provided a good fit to the data (R^2 = 0.84). With model: Y= 3.281 + 0.994x

Regression analysis between percentage of infestation of *O. nubilalis* and % yield losses revealed that simple linear provided a weak fit to the data (R^2= 0.45). With model: Y= 0.18 + 0.0052 x.

According to forecasting system suggested by **Abraham and Ledolter (1983)**, the constructed models are used to obtain the forecasts. As these forecasts depend on the specific model, one has to make sure that the model and its parameters stay constant during the forecast period. Checking the forecasts against the new observations can assess the stability of the models. Forecast errors can be calculated, and possible changes in the model can be detected.

Easwaramoorthy (1995), indicated that in India, a yield loss of 3.5% for every 5% increase in the level of borer incidence. **Szokeet *al* (2002)** also, found that losses caused by the European corn borer (*O. nubilalis* ranged from 250-1000 kg/ha depending on the degree of infestation. **Sabra, *et al.* (2005)** found that simulated *O. nubilalis* damage reduced grains yield with about 4.11- 35.14% according to the sort of damage.

In conclusion, although the investigated models are situated for predicting the corn yield at different levels of corn borers infestation, but their long run stability in prediction should be investigated through many successive seasons and areas with more diversity of corn varieties and weather conditions.

2- Determination of compensatory yield arising in intact plants as a result of absence of some plants:

Compensatory yield is defined as the increase in yield of non-infested plants resulting from better growth caused by the death or injury of neighboring plants that have been attacked by a specific pest. Also, this is defined as "power of recovery" **(Judenko, 1973)**. The method of detection of compensatory yield is to compare the yields of intact plants next to those infested plants with the yields of intact plants surrounded by non-infested plants.

Estimation of compensatory yield in intact plant adjacent to absent plant of two varieties of maize (white corn and yellow corn) presented in Table 2 and Fig. 3. In white corn, weight of grain yield was 151.14 and 185.6 gm/plant for intact plant adjacent to intact plant and intact plant adjacent to absent plant, respectively, with compensatory yield 34.46 g/plant. While in yellow corn weight of grain yield were 108.6 and 132.4 gm/plant for intact plant adjacent to intact plant and intact plant adjacent to absent plant, respectively with compensatory yield 23.8 gm/plant. Percentage of increase rate in compensatory yield in intact plant adjacent to absent plant was 22.8% and 21.92 % in white and yellow corn, respectively.

Table 2: Estimation of compensatory yield in intact plant adjacent to absent plant or dead infested plant with *S. creitca*in two maize varieties.

Character	**Grain Yield/plant (gm)**	
	White corn	**Yellow corn**
intact plant adjacent to intact plant (Y)	151.14 ± 6.07	108.6 ± 10.04
intact plant adjacent to absent plant (Eabs)	185.60 ± 47.15	132.4 ± 23.8
Compensatory yield of absent plant (Cabs)	34.46	23.8
% increase of compensatory yield (C %)	22.8 %	21.92 %
intact plant adjacent to dead plant (Einf)	173.0 ± 38.18	138.0 ± 23.76
Compensatory yield of dead plant (Cinf)	21.86	29.4
% increase of compensatory yield (C %)	14.46 %	27.07 %

Mean compensatory yield of adjacent plant to absent or dead plant (C) = $(E - Y_{int})$

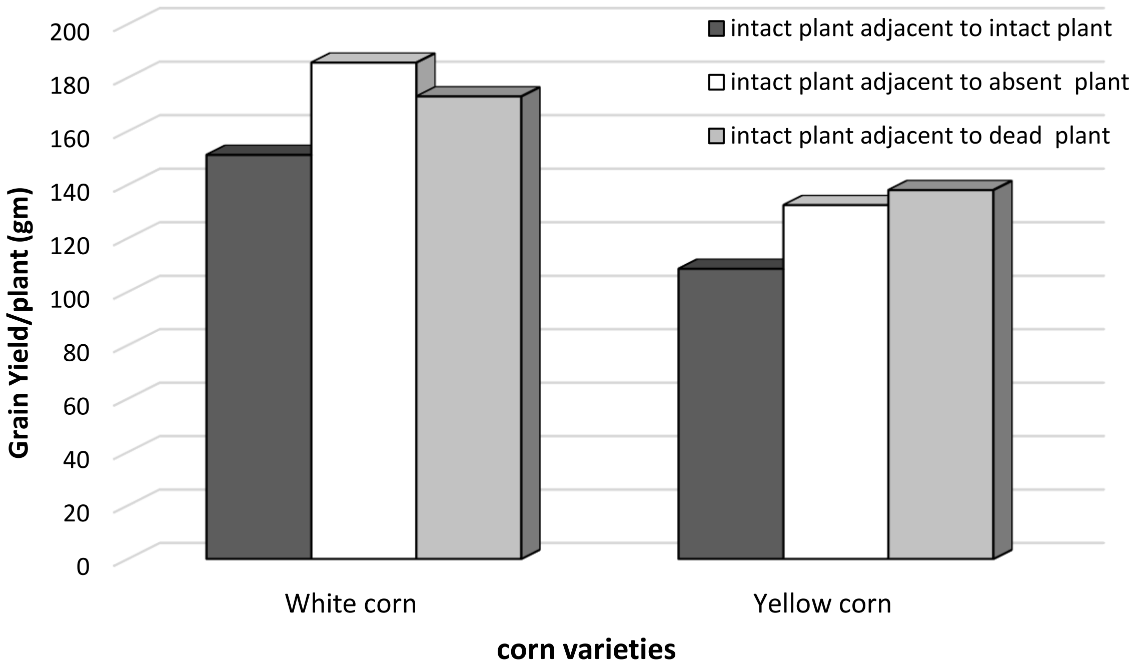

Figure 3: The compensatory yield in intact plant adjacent to absent plant or dead infested plant with *S. creitca* in two varieties of maize.

3- Determination of compensatory yield arising in intact plants as a result of dead plants with *S. creitca* infestation:

Data in Table 2 and Fig. 3, also showed the compensatory yield in intact plant adjacent to dead plant due to infestation by *S. creitca* of two varieties of maize (white corn and yellow corn). In white corn, weight of grain yield was 151.14 and 173 gm/plant for intact plant adjacent to intact plant and intact plant adjacent to dead plant, respectively, with compensatory yield 21.86 gm/plant. While in yellow corn, the weight of grain yield was 108.6 and 138.0 gm/plant, for intact plant adjacent to intact plant and intact plant adjacent to dead plant, respectively with compensatory yield 29.4 gm/plant. Percentage of increase rate in compensatory yield in intact plant adjacent to dead plant was 14.46 % and 27.07 % for white and yellow corn, respectively. The present results indicated that yellow corn was more tolerant of stem borers infestation than white corn because of its compensation ability and replacement the stems dead due to insect infestation.

In this context, **Judenko (1973)** reported that determination of losses without correction for compensatory yield would be misleading. In his yield losses experiment in sweet corn, *Z. mays* L. The author concluded that although 28% of the plants were destroyed by rats, *Rattus norvegicus*, the loss in value was only 8% owing to the compensatory yield of the unattacked plants adjacent to those destroyed. **Harris (1962)** found that well-grown guinea corn was very tolerant of high infestation by stem borers and because of its ability to tiller rapidly; it replaced the stems killed by the pest. **Kawada (1950),** according to **Ishikura (1967)** he found that rice yields from unattacked shoots of plants infested by stem borer were higher than those from unattacked shoots of unattacked plants.

Even when the damage to a crop appears heavy to the naked eye, the real losses of yield may be small and not necessitate control measures. **Kumar (1984)** reported that field experiments relating yield to stem-borer attack in Nigeria **(Harris, 1962)** indicate that loss of stand in maize (*Zea mays*) plots does not always result in loss of yield, and actually under certain conditions, loss of stands is compensated by the production of heavier cobs. **Brander (1968)** observed similar phenomenon in his work on the effect of wheat bulb fly on the growth and yield of wheat. Experiments on guinea corn **(Harris, 1962)** showed that the yield per bored stem was higher than that per intact stem. Actually, it is now known that excellent yields of guinea corn can be obtained in the presence of high population of stem borers **(Ingram, 1958)**. Beneficial effects of pests on crop yield are discusses by **Bardner and Fletcher (1974)**. **Harris (1974)** suggested that increase of plant yield following insect damage may result from the early removal of apical dominance of plants growing with little competition for nutrients and to hormone-like effects produced by some sucking insects. The author believes that the attainment of maximum crop yield may indeed sometimes require a certain density of “pest” insects.

Conclusions:

The maize verity and sowing date among the most important factors affecting the infestation level with stem borers, and subsequently affecting the percent of yield loses as well as the power of recovery for the maize verity that determined as the compensatory yield. In case of the early sowed maize in May, the yield losses due to *S. cretica* was higher than that recommended sowed in June and late sowed in July. Where, planting within early time in May provide maize plants with full-season maximum growing degree days and reduced pest pressure associated with late planting. The present results indicated that yellow corn was more tolerant to stem borers infestation than white corn, and it recorded the higher Percentage of increase rate in compensatory yield in intact plant adjacent to dead plant (27.07 %) than the return for the white corn (14.46 %).

REFERENCES

Abd El- Gawad, H. A. S., El- Khawas, M. A. M., & El-Bishry, M. H. (2002). Combined effects of entomopathogenic nematodes and biofungicide on two corn borers, *Sesamia cretgica* Led. (Lepidoptera: Noctuidae) and *Ostrinia nubilalis* (Hubn.) (Lepidoptera: Pyralidae). *2nd International Conf., Plant Protection Research Institute, Cairo, Egypt,* 21-24 December 2002.

Abdel Rahim, M. M., Abdel Fattah, M. I., Farag, A. I., & El-Naggar, M. A. Z. (1992) Contribution to the study of the corn leaf aphids *Rhopalosiphum maidis* Fitch, on maize plants. *Bull. Entomol. Soc. Egypt*, 70, 91–98.

Abd El-Rahman, M. S. (2002). Evaluation of certain corn varieties to yield, yield components and its susceptibility to infestation by some insects. *M. Sc. Thesis, Fac. of Agric., Moshtohor, Zagazig Univ., Egypt*.

Abed-Elgayed, A. A. (1996). Studies on some maize insect pests and their natural enemies. *M.Sc. Thesis, Fac. of Agric., Fayoum branch, Cairo Univ., Egypt.*

Abraham, B. and Ledolter, J. (1983). Statistical Methods for Forecasting. Wiley, New York. https://doi.org/10.1002/9780470316610

Al-Eryan, M. A. S., & El-Tabbakh, S. Sh. (2004). Forecasting yield of corn, Zea mays infested with corn leaf aphid, *Rhopalosiphum maidis*. *Blackwell Verlag, Berlin, JEN 128(4):* 312–315. https://doi.org/10.1111/j.1439-0418.2004.00852.x

Ande, O. T., Adediran, J. N., Ayola, O. T., & Akinlosotu, T. A. (2008). Effects of land quality management and cropping on cassava production in South Western Nigeria. *African Journal of Biotechnology*, 7(14), 2368-2374. (cf. Nwite)

Bardner, R. and Fletcher, K. E. (1974). Insect infestation and their effects on growth and yield of field crops: a review. Bull. Ent. Res., 64, 141 – 60. (cf. Kumar (1984)). https://doi.org/10.1017/S0007485300027061

Brander, R. (1968). Wheat bulb fly, *Leptohylemiacoarctata* Fall., and its effect on the growth and yield of wheat. Ann. Appl. Biol., 61, 1-11. (cf. Kumar (1984)). https://doi.org/10.1111/j.1744-7348.1968.tb04504.x

Benson, G. O. (1995). Late-May corn planting strategies. Integrated crop management newsletter, IC-478(11). University Extension, Iowa State University, Ames.

Culy MD. (2000). Yield loss of field corn from insects, in: Peterson RKD, Higley LG. (Eds.), Biotic stress and yield loss. CRC.;53-82. https://doi.org/10.1201/9781420040753.ch4

Easwaramoorthy, S. (1995). Insect pests of sugarcane and Constraints in their Management in tropical India. *In: Proceedings of the national seminar on sugarcane production contracts. (Eds.) G.B. Singh and U.S. Shukla, IISR, Luknow, India*, pp. 133-137.

Food and Agricultural Organization (FAO) (1998). FAO Production Bulletin FAO, Rome pp. 34-40. (cf. Nwite)

Golebiowska, Z. and Romankov, W. (1968). Trials to assess losses caused by cecidomyid larvae to foxtail-grass (Alopecurus pratensis L.). (In polish with English and Russian summaries.) Roczn, Naukroln. (A), 93: 685-699.

Harris, K. M. (1962). Lepidopterous stem borers of cereals in Nigeria. Bull. Ent. Res., 53 (1), 139 – 171. (cf. Kumar (1984)). https://doi.org/10.1017/S0007485300048021

Harris, P. 1974. A possible explanation of plant yield increases following insect damage. Agro--Ecosystems 1:219-25. https://doi.org/10.1016/0304-3746(74)90028-6

Hyams, D. G. (2014). Curve expert professional, software program, v.2.0.4 documentation.

Ingram, W.R., (1958). The lepidopterous stalk borers associated with Gramineae in Uganda. Bull ent. Res. 49, 367-383. https://doi.org/10.1017/S0007485300053682

Ishikura, H. (1967). Assessment of rice loss caused by the rice stem borer. In the major insect pests of the rice plant. Proceedings of a symposium at the International Rice Research Institute, 1964. Baltimore Md, Johns Hopkins Press. Pp. 251-264.

Ismail, I. I., Semeada, A. M., & El-Salam, A. (1993). Seasonal occurrence and host rang of the corn leaf aphid *Rhopalosiphum maidis* Fitch at Giza and Qualubia Governorates. *Bull. Entomol. Soc. Egypt*, 71, 33–40.

Jarvis, J.L.; Guthrie, W.D. and Robbins, J. C. (1986). Yield losses from second generation European corn borers (Lepidoptera: Pyralidae) in long season corn hybrids planted early compared with short season hybrids planted late. Journal of Economic Entomology. 79: 243-246. https://doi.org/10.1093/jee/79.1.243

Judenko, E. (1973) Analytical Methods for Assessing Yield Losses Caused by Pests on Cereal Crops with and without Pesticide. Tropical Bulletin No. 2. Center for Overseas Pest Research, UK, 31 p.

Kawada, A. (1950). Study on the injury of the rice plant caused by the rice stem borer *Chilo simplex* Butler. I. Analysis of the injury caused by the second generation. Bull. nat. agric. Exp. Stn (Japan), no. 66: 1-8.

Kumar, R. (1984). Insect Pest Control, with special reference to African agriculture. Edward Arnold (Publishers) Ltd, 298 pp.

Mansour, M. H., Salem, N. Y., Amr, E. M., & Salem, H. A. (1994). Injury levels and yield loss model for the corn aphid, Rhopalosiphum maidis (Fitch) on corn, Zea mays (L.). *Bull. Entomol. Soc. Egypt*, 72, 217–227.

Massoud, M.A.; Zaghloul, O.A.; Barakat, A.S. Ebieda, A.M., Amr, A.A. (2016). Assessment of Maize Yield Loss to Determine Economic Injury Levels (Eils) Due To the Infestation by Stem Borers with Insecticidal Control under the Egyptian Conditions. Alexandria Science Exchange Journal, 37, (4): 729-737. https://doi.org/10.21608/asejaiqjsae.2016.2597

Mbah, C.N.; Nwite, J.N. and Nweke, I.A. (2009). Amelioration of spent Oil Contaminated Ultisol with Organic Wastes and its effects on soil properties and maize (*Zea mays* L.) yield. World J. Agric. Sci. 5(2):163-168. (cf. Nwite)

Mesbah, H. A., Mourad, A. K., El-Nimr, H. M., Massoud, M. A., & Abd El-Aziz, A. A. (2002). The role of some agricultural practices and fertilizer type on both the incidence of stem borers infestation and corn yield in Egypt. Mededelingen (Rijksuniversiteit te Gent. Fakulteit van de Landbouw kundige en Toegepaste Biologische Wetenschappen) 67(3), 575-589. (cf. Massoud*et. al*, 2016)

Metwally, Sameha A. (2015). The Relative Susceptibility of Certain Maize (*Zea mays* L.) Cultivars To Infestation With The Pink Stem Borer *Sesamia cretica* Led. (Lepidoptera: Noctuidae). *M.Sc. Thesis, Faculty of Agriculture, Cairo University*, 132.pp.

Motshwari, O., BSc (Hons), M.S. (2009). Interactions among maize phenoligies, transgenic *Bacillus thuriensis* maizeand seed treatment for management of pests and diseases of maize. Ph.D. The Ohio State University.219 pp.

Obopile, M. RB Hammond and PR Thomison. 2012. Maize–planting date interaction and effect of Bt maize on European corn borer (*Ostrinia nubilalis* (Hubner) (Coleoptera: Crambidae) damage.South African Journal of Plant and Soil 2012, 29(2): 109–115. https://doi.org/10.1080/02571862.2012.719040

Sabra, I. M., Khewa, M. M. I., &Shalaby, M. S. I. (2005). Assessment of yield losses in maize field caused by *Ostrinia nubilalis*(Hbn). (Lepidoptera: Pyralidae) at fayoum Governorate. *Egypt. J. Agric. Res*., 83 (3), 831- 837.

Szoke, C., Zsubori, Z., Pok, I., Racz, F., Illes, O., &Szegedi, I. (2002). Significance of the European corn borer (*Ostrinia nubilalis*Hubn.) in maize production. Acta, Agronomica, Hungarica, 50 (4), 447-461. https://doi.org/10.1556/AAgr.50.2002.4.8

Walker, P.T. (1967). A survey of losses of cereals to pests in Kenya and Tanzania. In Background Papers prepared for the FAO Symp. On crop losses, Rome, 2-6 October 1967. Rome, FAO. Pp. 79-84.

Wiatrak PJD, Wright L, Marois JJ, Sprenkel R. 2004. Corn hybrids for late planting in the southeast. Agronomy Journal 96: 1118–1124. https://doi.org/10.2134/agronj2004.1118