SVU-IJAS SVU-International Journal of Agricultural Science
Volume 3 Issue (4) pp.: 10-19, 2021
Print ISSN 2636-3801 | Online ISSN 2636-381X
Doi: 10.21608/svuijas.2021.85811.1128
RESEARCH ARTICLE

Seasonal Abundance of the White Butterfly *Pieris rapae* L. in the old and reclaimed areas with reference to its relative susceptibility and damage to certain cabbage cultivars

Abdel-Galil, F.A.,[1], S.M.A. Amro[2], A.A. Abd El-Raheem[2], D.Y.A. Darwish[1] and M.A.B. Mahmoud[3*]

[1]*Plant Protection Department, Faculty of Agriculture, Assiut University, Assiut, Egypt.*
[2]*Plant Protection Research Institute, Agricultural Research Center, Dokki, Giza, Egypt*
[3]*Zoology Department, Faculty of Science, South Valley University, Qena, Egypt*

Abstract

The main goal of this study was to determine the seasonal abundance of the white butterfly *Pieris rapae* L. (Lepidoptera: Pieridae) on several local and imported cabbage cultivars in old and reclaimed lands. The impact of certain cabbage metabolites on *P. rapae* populations was examined, as well as the relative susceptibility of different cabbage cultivars. Damage caused by *P. rapae* Varies. During the first two months following transplantation, *P. rapae* can cause economic damage to cabbage plants in both areas. One month later, its population had multiplied several times in the old land. Three of the six tested cabbage cultivars were appeared as susceptible (S) cultivars and harbored high numbers of the pest with an average of 0.63, 0.60 and 0.53 Kenz, Crossina and Ganzory cultivars, respectively. However, the imported white cabbage hybrids, 728, 730 and 747 showed sort of resistance and appeared as low resistant (LR) hybrids and harbored 0.40, 0.41 and 0.45 individuals/plant, respectively. Chlorophyll only showed highly significant negative correlation with *P. rapae* populations. However, the remaining metabolites showed non-significant positive correlation. In a comparison between *P. rapae* populations in Assiut (the old area) and El-Fath province (the reclaimed area), it can be note that the pest populations, the damaged (infested and unmarketable) plants were multiplied several times in the later. It can be noted that the general mean of the pest numbers recorded in the reclaimed area (2.14 individuals/plant) was found to equal 4.28 folds more than that recorded in the old area (0.50 individuals/plant).

Keywords: Damage; *Pieris rapae* L.; relative susceptibility; seasonal abundance.

1. Introduction

Cabbage (*Brassica oleracae* var. *capitata* L.) is an herbaceous green leafy vegetable belonging to the *Brassica* genus, of the Brassicaceae family with several other crop species including broccoli, cauliflower, kale and kohlrabi (Katz and Weaver, 2003). Cabbages plantations have been subjected to attack by severe key insect pests especially the white butterflies, *Pieris brassicae*, L. and *Pieris rapae* L (Razmi *et al.*, 2011; El-Sheikh, 2020). However, management of plant pests should be based on observations of the pest density and stadia of pest species (Ellis and Singh, 1993). Lepidopteron insect pests, such as the white butterflies are able to completely eliminate cabbage yield (Shternshis, 2005). In north Egypt, a weekly survey of pests presented on cabbage crops was undertaken by Embaby and Lotfy (2015). They reported that cabbageworm; *P. rapae* was the most common brassica pests. Cartwright *et al.* (1987) mentioned that, in commercial cabbage fields, an action threshold of 0.3 *P. rapae* larvae per plant maintained damage below 1% of total harvested cabbage. Resistance status of cruciferous cultivars to the white butterfly *P. rapae* was cleared by several authors e.g. Hwang *et al*. (2008) in Taiwan; Hasan and Ansari (2011) in India; Sadozai and Khan (2014) in Pakistan; El-Sheikh (2020) in Egypt. The main goal of the current study is to

***Corresponding author:** Mervat A.B. Mahmoud
Email: mervat.mahmoud@sci.svu×.edu.eg
Received: July 13, 2021; Accepted: August 18, 2021;
Available online: August 19, 2021.
Published by South Valley University.

determine the seasonal abundance of the white butterfly *P. rapae* on certain local and imported cabbage cultivars in the old and reclaimed areas in Assiut Governorate. Relative susceptibility and the impact of certain cabbage metabolites on *P. rapae* populations were investigated. Variations between *P. rapae* damage in the old and reclaimed areas were clarified.

2. Materials and Methods

2.1. Experiment procedure

Experiments were carried out at an old cultivated area (the experimental farm of the Faculty of Agriculture, Assiut University) and a reclaimed area (Private farm at El-Fath province) at the border of the eastern desert, during 2017-2018 and 2018-2019 cabbage growing seasons at (Ca.1050 m^2) /each. The first area was divided into plots (10.5 m^2 / plot). Six local and imported cabbage cultivars and hybrids (Ganzory, Sabeny, Kenz, Crossina, 728,730, 747) were obtained from El-Salam arboretum and RIJK ZWAAN Company, Assiut Governorate. In the first area cabbage cultivars were cultivated in the greenhouse on 3rd September, in both seasons. One month later, cabbage plants were transplanted to the sustainable farm. Another local cultivar (Sabeny) was cultivated on July, 17th in El-Fath province (the reclaimed area) during the 2018 and 2019 cabbage growing seasons. The same procedures were conducted. Insecticides were completely prevented.

2.2. Seasonal abundance of the white butterfly Pieris rapae

The direct count method was used to record numbers of the white butterfly *P. rapae* as described by El-Fakharany and Hendawy (2014). Four cabbage plants / each replicate (4 replicates) / each cultivar were randomly checked in the field. Mean numbers of *P. rapae* immature stages (larvae + pupae) were counted 47 days after transplantation until harvesting in the old area. The same procedure was illustrated at the reclaimed area (El-Fath province) 61 days after transplantation by using the local cultivar (Sabeny).

2.3. Relative susceptibility of the selected cabbage cultivars to the white butterfly Pieris rapae

To determine the susceptibility degrees of the tested cabbage cultivars against the white butterfly *P. rapae*, the following procedure was used:

Numbers of *P. rapae* (larvae + pupae) were visually counted in the field /each cultivar by the abovementioned direct count method at weekly intervals to determine the relative susceptibility degrees of the tested cabbage cultivars as described by Chiang and Talekar (1980) equation. Relative susceptibility degree was dependent on the general mean number of the pest $\bar{X}$ and the standard deviation (SD). Cultivars that had mean numbers more than $\bar{X}$+2SD were considered highly susceptible (HS); between $\bar{X}$ and $\bar{X}$+2SD, susceptible (S); between $\bar{X}$ and $\bar{X}$-SD, low resistant (LR); between $\bar{X}$-SD and $\bar{X}$- 2SD, moderately resistant (MR) and less than $\bar{X}$-2SD, were considered highly resistant (HR) cultivars.

To confirm the results obtained by using the abovementioned equation; plant soluble primary metabolites (soluble proteins, soluble sugars and total free amino acids) were determined calorimetrically according to procedures described by Lowry *et al.* (1951), Dubois *et al.* (1956) and Lee and Takahashi (1966), respectively. The content of each metabolite in the studied plant was expressed in mg.g-1 dry weight. Chlorophyll content index (CCI) was measured by a digital apparatus. The CCI was calculated using chlorophyll content meter (Opti-sciences CCM 200, USA) as Debra and Daniel (2012) described. . The reading of CCI was taken as an average of different 5 leaves (5 plants) from each genotype. Correlation coefficient between the seasonal abundance of *P. rapae* with the aforementioned plant soluble primary metabolites has been estimated and their effects on this pest abundance were determined.

2.4. Damage and yield loss caused by Pieris rapae L.

Damage percentage (infested and unmarketable) plants caused by *P. rapae* that attacking the tested cabbage cultivars was determined by the direct count at weekly intervals. Damage percentages

were estimated by the equations used by Rehman *et al.* (2017) as follows:

$$\text{Damage\%} = \frac{\text{Number of Damage cabbage plants}}{\text{Total number of cabbage plants}} X100$$

were statistically analyzed by using one and three-way ANOVA by the Advanced Statistical Analysis Package (ASAP)^{R} (Darwish *et al.*, 2012). F-test and means were compared according to Duncan's multiple range tests as described by Steel and Torrie (1982).

3. Results and Discussion

3.1. Seasonal abundance of the white cabbage butterfly Pieris rapae L.

3.1.1. Assiut province (Old cultivated area)

Data presented in Table (1) expressed about the average numbers of the white cabbage butterfly *Pieris rapae* inhabiting cabbage plantations in Assiut (Old area) during 2017-2018 and 2018-2019 growing seasons. Data revealed that *P. rapae* was found to be active in December (three months after transplantation) when plants are in the seventh-ninth cabbage developmental stages with an average of 0.46 (larvae + pupae) individuals / plant. The peak of *P. rapae* appeared in February (before harvesting) with an average of 0.94 individuals / plant. Highly significant variation was recorded between inspection months (F=234.45 **). The imported cultivar Kenz harbored the highest *P. rapae* immature stages with an average of 0.63 individuals/ plant. The remaining cultivars harbored less numbers with highly significant variations (F=9.64 **).

Similar results were obtained by Sharma *et al.* (2017) who reported that *P. brassicae* was first observed in the 43rd standard week (1.33 larvae plant^{-1}) and lowest population of 0.12 larvae per plant^{-1} during the 15th standard week. The *P. brassicae* population was maximum (5.74 larvae plant^{-1}) in 7th standard week. So, it can be noted that, *P. rapae* does not perform any risk to cabbage plantations throughout the first 60 days after transplantations in the old cultivated areas. On the other hand, its first incidence (two months after transplantations) causes economically harmless damage to cabbage plantations.

3.1.2. El-Fath province (Reclaimed area)

The pest immature stages were recorded in El-Fath province in quietly high numbers and coincided with the seventh-eight cabbage developmental stages (two months post transplantation) with an average of (1.53 individuals/plant) (Table 2). It is clear that numbers of *P. rapae* immature stages in the third month post transplantation (October) was found to be equal 1.99 folds of those recorded before cupping formation (September). Highly significant variations were recorded between inspection months during the entire period of study (F=45.28**). The peak of the pest immature stages (3.04 individuals/plant) was found to be equal to 10.13 fold of those constitute its economic injury level as reported by Cartwright et al. (1987).

In general, it can be concluded that the white cabbage butterfly *P. rapae* appeared in the old cultivated areas in moderately numbers (round up its economic injury level) during winter months (November – February). Although, this insect pest appeared in the reclaimed areas two months after transplantation, its population multiplied several times one month later. It can destroy all cabbage plants 4-5 months after transplantation if neglected. Note that the general mean of the pest numbers recorded in the reclaimed area (2.14 individuals/plant) was found to equal 4.28 folds of that recorded in the old area (0.50 individuals/plant).

3.2. Relative susceptibility of the selected cabbage cultivars to the white butterfly Pieris rapae

Three of the six tested cabbage cultivars were appeared as susceptible (S) cultivars and harbored moderately high numbers of the pest with an average of 0.63, 0.60 and 0.53 individuals / plant for Kenz, Crossina and Ganzory cultivars, respectively.

Table 1. Average numbers of the white cabbage butterfly *Pieris rapae* inhabiting cabbage plantations in Assiut (Old area) during 2017-2018 and 2018-2019 growing seasons.

Inspection Month	Plant		Mean No.(larvae + pupae) / plant / plot / cabbage cultivar						Mean
	Age (Days)	Stage	Kenz	Crossina	Ganzory	WCH 728	WCH 730	WCH 747	
Nov.2017&18 (2)	47-61	5-6	0.00^{h}	0.00^{h}	0.00^{h}	0.00^{h}	0.00^{h}	0.00^{h}	0.00^{D}
Dec.2017&18 (4)	61-89	7-9	0.48^{fg}	0.52^{fg}	0.50^{fg}	0.40^{g}	0.43^{g}	0.44^{g}	0.46^{C}
Jan.2018 &19(5)	89-124	9	0.72^{de}	0.74^{de}	0.67^{def}	0.48^{fg}	0.47^{fg}	0.55^{efg}	0.60^{B}
Feb.2018 &19(4)	124-152	9	1.31^{a}	1.13^{b}	0.95^{bc}	0.73^{de}	0.73^{de}	0.80^{cd}	0.94^{A}
Mean			0.63^{A}	0.60^{AB}	0.53^{BC}	0.40^{D}	0.41^{D}	0.45^{CD}	0.50

WCH=White Cabbage Hybrid (Numbers in parenthesis) No of monthly samples F value: Between months= 234.45**; between cultivars= 9.64**; Months × Cultivars= 2.95**
Averages having the same letter are not significant at 5% level according to Duncan's multiple range tests.

Table 2. Average numbers of white cabbage butterfly *Pieris rapae* inhabiting cabbage plantations in El-Fath province (Reclaimed area) during 2018 and 2019 growing seasons.

Inspection Month		Plant		Mean No. (larvae + pupae) / plant / plot		
		Age (Days)	Stage	2018	2019	2018 &2019 (Mean)
Sept.	(2)	61-75	7-8	1.47^{b}	1.59^{c}	1.53^{c}
Oct.	(5)	75-110	9	2.76^{a}	3.31^{a}	3.04^{a}
Nov.	(4)	110-138	9	2.19^{b}	2.97^{ab}	2.58^{b}
Dec.	(1)	138-145	9	0.25^{c}	2.63^{b}	1.44^{c}
Mean				1.65	2.63	2.14
$F_{0.05}$				57.85**	13.45**	45.28**

Averages having the same letter are not significant at 5% level according to Duncan's multiple range test.

On the other hand, the imported white cabbage hybrids, 728, 730 and 747 showed some sort of resistance and appeared as low resistant (LR) hybrids and harbored 0.40, 0.41 and 0.45 individuals / plant, respectively (Table 3). Correlation coefficient between cabbage metabolites and *P. rapae* populations were clarified in Table (4). Chlorophyll only showed significant negative correlation (r = -0.495**) with *P. rapae* populations. However, the remaining metabolites showed non-significant positive correlation with *P. rapae* populations.

Effects of plant nutrient availability and host plant species on the performance of two *Pieris* butterflies was studied by Hwang *et al*. (2008). They reported that *Pieris* larvae that fed on highly-nutritious foliage increased their growth rates and showed a shorter development period. This research revealed that the availability of plant nutrient of host plant can strongly influence the physiology and foliar chemistry of host plants. Moreover, the changes of phytochemical in the host plants may play an important role in affecting the performance (growth and food utilization efficiency) of *Pieris* butterflies.

Table 3. Susceptibility degrees of cabbage cultivars against the cabbage butterfly *Pieris rapae* inhabiting cabbage plantations in Assiut during 2017-2018 and 2018-2019 growing seasons.

Inspection Year	Mean No.(larvae + pupae) / plant / plot / Cabbage cultivar						Mean
	Kenz	Crossina	Ganzory	WCH 728	WCH 730	WCH 747	
2017-2018	0.66	0.58	0.59	0.40	0.45	0.53	0.53
2018-2019	0.60	0.61	0.47	0.40	0.36	0.37	0.47
Mean (2017-2019)	0.63	0.60	0.53	0.40	0.41	0.45	0.50
Susceptibility degree	S	S	S	LR	LR	LR	

S=Susceptible LR= Low Resistant

Table 4. Correlation coefficient between the seasonal abundance of the white cabbage butterfly *Pieris rapae* and some plant metabolites in Assiut during 2017-2018 and 2018-2019 growing seasons.

Cabbage cultivars	*P. rapae* mean no/ plant / plot	Proteins Mg/g Dry wt.	Amino Acids	Nitrogen	Sugars Mg/g Dry wt.	Chlorophyll
Kenz	0.63	32.11	13.95	2.23	124.24	16.23
Crossina	0.60	28.81	12.38	1.98	139.02	17.03
Ganzory	0.53	16.77	4.27	0.68	54.17	32.53
WCH 728	0.40	25.08	10.25	1.64	107.23	25.93
WCH 730	0.41	26.55	8.96	1.43	108.26	24.63
WCH 747	0.45	27.00	11.47	1.83	141.33	20.57
r values		0.305	0.339	0.339	0.122	-0.495**

3.3. Damage and yield loss caused by Pieris rapae

3.3.1. Damage and yield loss in Assiut province (Old area)

3.3.1.1. Infested plants

Data in Table (5) revealed that no infested plants were recorded (2 months after transplantations) before cupping formation. Gradual increases were recorded when cabbage undergo toward ripening throughout the 9th stage till harvesting with average percentages of 3.42, 4.04 and 5.76% infested plants / plot during December, January and February, respectively. Data revealed that infested plants at the harvesting period were equal 1.68 folds of that recorded before the ripening period. The general mean of infested plant percentages recorded 3.30%. Significant variation between the inspection months (F=448.32**) and non-significant variation between the tested cultivars (F=3.51^{ns}) were recorded.

3.3.1.2. Unmarketable plants

Mean percentages of unmarketable cabbage plants infested by the white butterfly *P. rapae* in cabbage fields during 2017-2018 and 2018-2019 growing seasons was calculated and presented in Table (6). Before harvesting (complete ripening) percentages of unmarketable cabbage plants reached to 2.92% and constituted 3.74 folds of that recorded three months after transplantation. So, harvesting cabbage plants at the beginning of the ripening period could be increase the yield income by more than 2.14%. Regarding the tested cabbage cultivars, the highest unmarketable cabbage plants percentage was recorded on both Kenz and Crossina cultivars (1.59 % unmarketable plants), while the lowest

unmarketable percentage was recorded on the white cabbage hybrid 728 with an average of 1.11% unmarketable plants. The general mean of unmarketable plant percentages recorded 1.35%. Highly significant variation between the inspection months and between the tested cultivars was recorded (F= 171.13** and 3.44**, respectively).

Dependent on the fact that, insect pests cause enormous yield and economic losses in *Brassica* crop production every year, and are a threat to global agriculture, Ahuja et al. (2010) discussed *Brassica* multiple defense mechanisms, which can be constitutive, inducible, induced, direct or indirect depending upon the insect or the degree of insect attack.

Table 5. Mean percentages of cabbage plants infested by the white cabbage butterfly *Pieris rapae* inhabiting cabbage plantations in Assiut during 2017-2018 and 2018-2019 growing seasons.

Inspection Month	Plant		% infested plants / plot /cabbage cultivar						Mean
	Age (Days)	Stage	Kenz	Crossina	Ganzory	WCH 728	WCH 730	WCH 747	
Nov.2017&18 (2)	47-61	5-6	0.00^{h}	0.00^{h}	0.00^{h}	0.00^{h}	0.00^{h}	0.00^{h}	0.00^{D}
Dec. 2017&18 (4)	61-89	7-9	3.54^{de}_{fg}	3.88^{cde}	4.10^{cd}	2.85^{g}	2.98^{fg}	3.15^{efg}	3.42^{C}
Jan. 2018 &19 (5)	89-124	9	4.20_{cd}	4.33^{cd}	4.62^{bc}	3.62^{defg}	3.80^{cdef}	3.68^{defg}	4.04^{B}
Feb. 2018 &19 (4)	124-152	9	5.56^{a}	5.66^{a}	6.14^{a}	5.39^{ab}	5.94^{a}	5.88^{a}	5.76^{A}
Mean			3.33^{A}_{BC}	3.47^{AB}	3.72^{A}	2.96^{C}	3.18^{BC}	3.18^{BC}	3.30

WCH=White Cabbage Hybrid (Numbers in parenthesis) No of monthly samples
F value: Between months = 448.32**; between cultivars = 3.51^{ns} ; Months × Cultivars = 0.93^{ns}
Averages having the same letter are not significant at 5% level according to Duncan's multiple range tests.

Table 6. Mean percentages of unmarketable cabbage plants infested by the white cabbage butterfly *Pieris rapae* inhabiting cabbage plantations in Assiut during 2017-2018 and 2018-2019 growing seasons.

Inspection Month	Plant		% unmarketable plants / plot /cabbage cultivar						Mean
	Age (Days)	Stage	Kenz	Crossina	Ganzory	WCH 728	WCH 730	WCH 747	
Nov.2017&18 (2)	47-61	5-6	0.00^{i}	0.00^{i}	0.00^{i}	0.00^{i}	0.00^{i}	0.00^{i}	0.00^{D}
Dec.2017&18 (4)	61-89	7-9	0.88^{gh}	0.82^{h}	1.10^{fgh}	0.66^{hi}	0.68^{hi}	0.53^{hi}	0.78^{C}
Jan.2018 &19(5)	89-124	9	1.75^{ef}	1.95^{e}	1.82^{ef}	1.62^{ef}	1.58^{efg}	1.55^{efg}	1.71^{B}
Feb.2018 &19(4)	124-152	9	3.73^{a}	3.58^{ab}	2.85^{cd}	2.17^{de}	2.23^{de}	2.98^{bc}	2.92^{A}
Mean			1.59^{A}	1.59^{A}	1.44^{AB}	1.11^{B}	1.12^{B}	1.26^{AB}	1.35

WCH=White Cabbage Hybrid (Numbers in parenthesis) No of monthly samples
F value: Between months = 171.13**; between cultivars= 3.44**; Months × Cultivars= 1.80^{ns}
Averages having the same letter are not significant at 5% level according to Duncan's multiple range tests.

3.3.2. Damage and yield loss - El-Fath province (Reclaimed area)

3.3.2.1. Infested plants

Mean percentages of cabbage plants infested by the white cabbage butterfly *P. rapae* in (El-Fath province) during 2018 and 2019 growing seasons was illustrated in Figure (1). During the first year of study (2018) percentages of the infested plants were recorded in low levels in December, (7-8) cabbage developmental stages. Throughout October when cabbage plants undergo towered ripening, obvious multiplication of infested plants was recorded as follows: October by 15.69 < November by 22.93 < December by 27.35%. It is clear that, percentages of the infested plants at December were found to be equal 1.19, 1.74 and 2.60 folds of that recorded 3 months before harvesting, respectively. Variations between inspection months showed high significant values (F=51.05**). During the entire season 19.12% of cabbage plants were found to be infested by *P. rapae*. Similar results were obtained during the second season with 14.25% infested plants. As an average of both seasons data revealed that, percentages of the infested plants before harvesting was found to be equal 3.50 folds of that recoded two months after transplantation. General average of infested plants percentages recorded 16.69%. So, it must be draws attention of cabbage growers to harvest cabbage plants up to date day by day during the ripening period.

3.3.2.2. Unmarketable plants

Mean percentages of unmarketable cabbage plants infested by the cabbage white cabbage butterfly *P. rapae* in cabbage fields in (El-Fath province) during 2018 and 2019 growing seasons was illustrated in Figure (2). Although unmarketable plants were recorded in low percentages (8-11 weeks after transplantation) by 2.89% as an average of the entire period of study, traditional multiplications of unmarketable plants were recorded month by month until harvesting. Variations between inspection months showed high significant values (F=271.71**). The general loss of cabbage plants without any control, recorded 11.23%.

Scarce information was obtained about unmarketable cabbage plants that were affected by *P. rapae* infestation. In a similar study of the present investigation, Sharma *et al.* (2015) evaluated weakly correlation existed between yield of marketable cabbage heads and *Pieris brassicae* populations/plant infestations. The data recording on population and infestation commenced with the onset of pest activity in the first fortnight of June. Therefore, the present findings suggested that it was very important to manage the late *P. rapae* infestation to get higher monetary returns.

In a comparison between *P. rapae* populations in Assiut (the old area) and El-Fath province (the reclaimed area), it can be note that, the pest populations, the infested plants and the unmarketable plants were multiplied several times in the later. Factors responsible for this finding could be due to the suitability of the summer cultivar (Sabeny) evaluated in El-Fath province for the pest reproduction than the other experimented winter cultivars evaluated in Assiut. However, the unwise use of insecticides in the old areas could be reducing the pest reproduction on its favorable and alternative host plants. In addition, environmental factors in the reclaimed area which located beside the eastern desert could be more responsible for this insect pest reproduction.

Knowledge of the often complex relationship between insect populations and their effects on the yield-forming processes of crops is useful for assessing pest status and for devising methods of minimizing the effects of infestation on yield. Investigations into the yield-forming processes of un-attacked crops can often provide useful insights into the likely effect of insect injuries on yield (Bardner and Fletcher, 1974).

There is no doubt, there are changes in insect pest problems facing the farmers in the newly reclaimed land as well as in the old valley in Egypt due to different reasons, e.g., pesticide misuse, pest resistance, secondary pest outbreaks, absence or inefficient presence of natural enemies, and climate changes (El-Husseini *et al*, 2018).

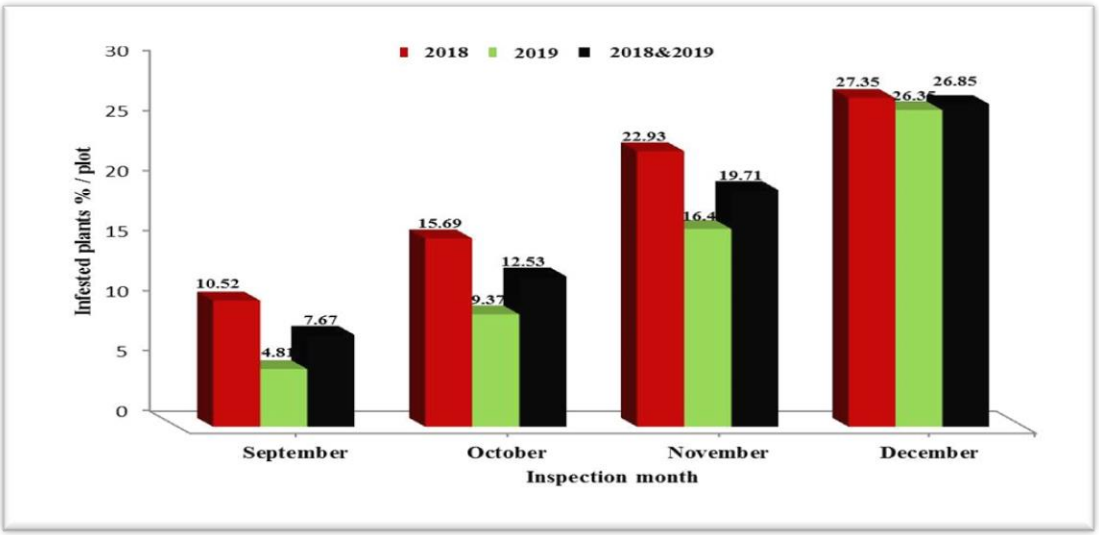

Figure 1. Mean percentages of cabbage plants infested by the white cabbage butterfly *Pieris rapae* inhabiting cabbage plantations in El-Fath province (Reclaimed area) during 2018 and 2019 growing seasons

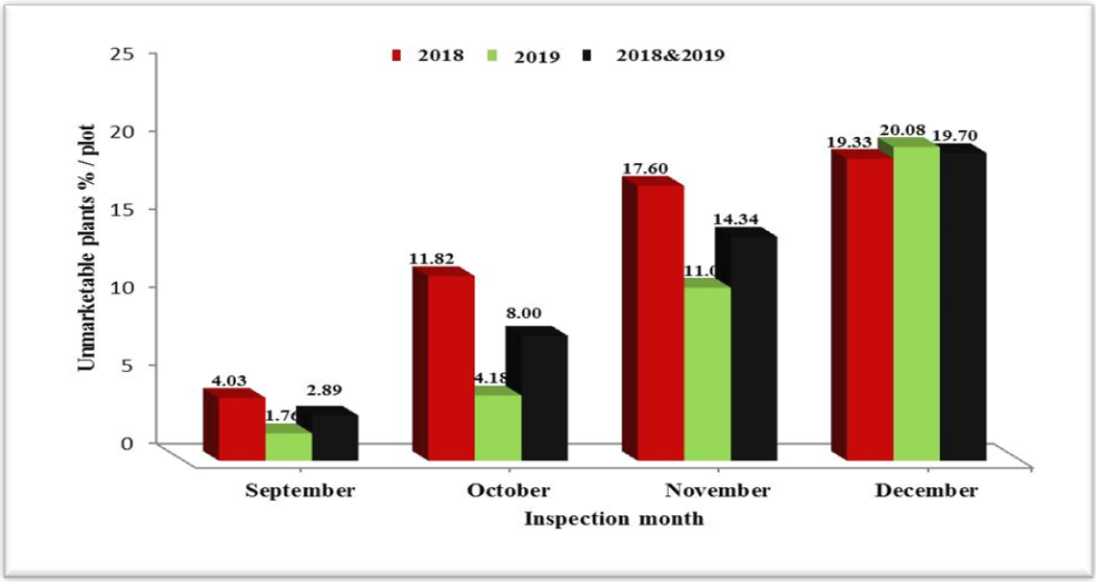

Figure 2. Mean percentages of unmarketable cabbage plants infested by the white cabbage butterfly *Pieris rapae* inhabiting cabbage plantations in Assiut (El-Fath province) during 2018 and 2019 growing seasons

4. Conclusion

Pieris rapae appeared in the old cultivated areas in moderately numbers during winter months while appeared in the reclaimed areas two months after transplantation. It can destroy all cabbage plants 4-5 months after transplantation if neglected. Kenz, Crossina and Ganzory cultivars were appeared as susceptible (S) cultivars. Hybrids, 728, 730 and 747 showed resistance. Gradual increases were recorded when cabbage undergo toward ripening throughout the 9th stage till harvesting. Mean percentages of unmarketable cabbage plants infested by *P. rapae* in cabbage fields in (El-Fath province) were recorded in low percentages (8-11 weeks after transplantation). *Pieris rapae* cuses loss of cabbage plants without any control and continuous inspection.

Acknowledgements

Deep thanks to Prof. Dr. Mohamed A. M. Amro [Plant Protection Research Institute, Agricultural Research Center, Dokki, Giza, Egypt] who provided insight and expertise that greatly assisted the research. Especial thank to the staff members of Plant Protection Department, Faculty of Agriculture, Assiut University and staff members of Insect Research Laboratory in Assiut, Plant Protection Institute for supporting and encouragement during the study.

5. References

Ahuja, I., Rohloff, J., Bones, A.M. (2010) 'Defense mechanisms of Brassicaceae: implications for plant-insect interactions and potential for integrated pest management: A review' *Agronomy for Sustainable Development*, 30, pp. 311-348.

Bardner, R. and Fletcher, K.E. (1974) 'Insect infestations and their effects on the growth and yield of field crops: A review' *Bulletin of Entomological Research*, 64(1), pp. 141-160. doi: https://doi.org/10.1017/S0007485300027061.

Cartwright, B.J., Edelson, V. and Chambers, C. (1987) 'Composite action thresholds for the control of lepidopterous pests on fresh-market cabbage in the Lower Rio Grande Valley of Texas' *Journal of Economic Entomology*, 80(1), pp 175-181. doi: https://doi.org/10.1093/jee/80.1.175.

Chiang, H.S. and Talekar, N.S. (1980) 'Identification of sources of resistance to the bean fly and two other Agromyzid flies on soybean and mungbean' *Journal of Economic Entomology*, 73(2), pp. 197–199. doi: https://doi.org/10.1093/jee/73.2.197.

Debra, M. and Daniel, M. (2012) *'Chlorophyll content. In: Physiological Breeding'* II: Alistair Pask, Julian Pietragalla, Debra M. and Matt H. R. (Eds.). International Maize and wheat improvement center, pp. 41-43.

Dubois, M., Gilles, K.A., Hamilton, K., Rabers, P.A. and Smith, F. (1956) *'Colorimetric method for the determination of sugars and related substances'* Analytical Chemistry, 28 (3), pp. 350-356. doi: https: //doi.org/10.1021/ac60111a017.

El-Fakharany, S.K.M. and Hendawy, A.S. (2014) 'Field studies on cabbage white butterfly, *Pieris rapae* (Linnaeus) and its associated parasitoid and predatory species in Egypt' *Egyptian Journal of Biological Pest Control*, 24(2), pp. 437-444.

El-Husseini, M.M., El-Heneidy, A.H., Awadallah, K.T. (2018) 'Natural enemies associated with some economic pests in Egyptian agro-ecosystems' *Egyptian Journal of Biological Pest Control*, 28(1), pp. 1-17. doi: 10.1186/s41938-018-0081-9.

El-Sheikh, W.E. A. (2020) 'The Seasonal Abundance of Immature Stages of the Cabbage Worm, *Pieris rapae* L. on Cabbage Crop in Beni Suef Governorate' *Egypt. Journal of Plant*

Protection and Pathology, Mansoura Univ. 11(7), pp. 365-368. doi: 10.21608/jppp.2020.109727.

Ellis, P.R. and Singh, R. (1993*) 'A review of the host plants of the cabbage aphid, Brevicoryne brassicae (Homoptera: Aphididae)'* Bulletin OILB SROP (France), 16(5), pp. 192-201.

Embaby, M.E. and Lotfy, D.E. (2015) 'Ecological studies on cabbage pests' *International Journal of Agricultural Technology*, 11(5), pp. 1145-1160.

Hasan, F. and Ansari, M.S. (2011) 'Effects of different brassicaceous host plants on the fitness of *Pieris brassicae* (L.)' *Crop Protection*, 30, pp. 854-862.

Hwang, S.Y., Liu, C.H. and Shen, T.C. (2008) 'Effects of plant nutrient availability and host plant species on the performance of two *Pieris* butterflies (Lepidoptera: Pieridae)' *Biochemical Systematics and Ecology*, 36(7), pp. 505–513. doi: https://doi.org/10.1016/j.bse.2008.03.001.

Katz, S.H. and Weaver, W.W. (2003*) 'Encyclopedia of Food and Culture'* 2, pp. 279-285.

Lee, Y.P. and Takahashi, T. (1966) 'An important colorimetric determination of amino acids with the use of ninhydrine'. Analytical Biochemistry, 14(1), pp. 71-77. doi: https://doi.org/10.1016/0003-2697(66)90057-1.

Lowry, C.H., Rosebrough, N.J., Far, A.L. and Randall, R.J. (1951) 'Protein measurement with the folin phenol reagent' *Journal of Biological Chemistry*, 193, pp. 256-272.

Razmi, M., Karimpour, Y., Safaralizadeh, M.H., Safavi, S.A. (2011) 'Parasitoid Complex of Cabbage Large White Butterfly *Pieris brassicae* (L.) (lepidoptera, pieridae) in Urmia with New Records from Iran' *Journal of Plant Protection Research*, 51(3). doi: 10.2478/v10045-011-0041-9.

Rehman, S., Hassan, M. W., Jamil, M. and Akram, M. (2017) 'Screening of some chickpea (*Cicer arietinum* L.) varieties against *Helicoverpa armigera* under semi-arid climatic conditions' *Legume Research*, 40 (2), pp. 379-383. doi: 10.18805/lr.v0i0.7589.

Sadozai, A. and Khan, I. A. (2014) 'Developmental response of *Pieris brassicae* (L.) (Lepidoptera: Pieridae) on different cauliflower cultivars under laboratory conditions' *American Journal of Plant Sciences*, 5(18), pp. 2611-2616. doi: 10.4236/ajps.2014.518275.

Sharma, D., Abrol, D.P. and Bhagat, R.M. (2015) 'Seasonal incidence of *Brevicoryne brassicae* L. and *Pieris brassicae* L. on cauliflower seed crop in Jammu sub tropics' *SKUAST Journal of Research*, 4, pp. 214-218.

Sharma, S., Ahmad, H., Ganai, S. A., Sharma, D., Norboo, T., Khaliq, N. and Kumar, M. (2017) 'Seasonal incidence and management of cabbage white butterfly, *Pieris brassicae* (Linnaeus) (Lepidoptera: Pieridae) on Cabbage Crop' *International Journal of Current Microbiology and Applied Sciences*, 6(11), pp. 1913-1921. doi: 10.20546/ijcmas.2017.611.227.

Shternshis, M. (2005) 'Biopreparations for plant protection in Siberia: application and enhancement of activity' *Journal of Agricultural Technology*, 1 (1), pp. 1-18.

Steel, R.G.D. and Torrie, J.H. (1982) *'Principals and Procedures of Statistics'* A Biometrical Approach, McGraw-Hill Book Co.