Relationship between the Available Biotic and Abiotic Factors with Major Cruciferous Insect Pests Inhabiting Cabbage Plantations

BY

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SUMMARY

The present study was conducted on 7 cabbage cultivars belonging to *Brassica oleraceae* L. and includes 2 local (Sabeny and Ganzory) and 5 imported (Kenz, Crossina, 728,730,747) cabbage cultivars during the cabbage growing sesons 2017/2018 and 2018/2019 in the experimental farm of Assiut University and El-Fath reclaimed area. Tow destructive insect pests (Cabbage aphid *Brevicoryne brassicae* L. and the white cabbage butterfly *Pieris rapae* L.) were recorded. Relationships between the available biotic factors (Parasitoids, relative susceptibility and plant primary soluble metabolites) and populations of both insect pests were evaluated. Also, relationships between certain abiotic factors (Temperature, relative humidity and soil temperature) and populations of both insect pests were taken in consideration. The parasitoid *Diaeretiella rapae* (McIntosh) was recorded on the cabbage aphid, *B. brassicae*. Four parasitoid species was found to be attacking *P. rapae* inhabiting the local cultivar (Sabeny) in the reclaimed area of Upper Egypt for the first time. These parasitoid species were *Hyposoter ebeninus* (Gravenhorst) on larvae; *Brachymeria femorata* (Panzer), *Pteromalus puparum* (L.) and *Tetrastichus* sp. (Haliday) on pupae. One hyperparasitoid species *Baryscapus galactopus* (Ratzeburg) was recorded on *H. ebeninus.* Efficiency of certain bio-insecticides against both cabbage insect pests was evaluated. So, results of the present investigation can be summarized as follows:

I-Studies on cabbage aphid *Brevicoryne brassicae* (L.)

1- Seasonal abundance of the cabbage aphid *Brevicoryne brassicae* (L.)

Data revealed that *B. brassicae* was found to be active on cabbage plantations 30-45 days after transplantation (fifth-sixth cabbage developmental stages). Its peak was recorded throughout the 4th month after transplantation (ninth stage) with an average of 229.60 individuals / 5 inch^2 / leaf. The imported cabbage hybrid (Kenz) harbored the highest pest numbers

and constituted 1.44 folds more than those infesting the local cultivar (Ganzory). The local cultivar (Ganzory) harbored less numbers than all of the tested cultivars which varied significantly in harboring *B. brassicae*.

2- Relations between the available biotic factors with the cabbage aphid *Brevicoryne brassicae* (L.)

2-1- Natural parasitism rates on cabbage aphid *Brevicoryne brassicae*

Mean percentages of mummified aphid *B. brassicae* parasitized by *Diaeretiella rapae* revealed that the aphid parasitoid *D. rapae* was found to be attack *B. brassicae* as soon as it appears at the beginnings of the season (November) (7-8 weeks after transplantation). It is clear that natural parasitism rate before harvesting (late season) was found to be equal to 6.14 folds more than that recorded 7 weeks after transplantation (early season). In general, the obtained data revealed that *D. rapae* reduced *B. brassicae* populations by 33.26 % during the entire period of the study. The multiple increases of mummified aphids before harvesting reflect the role of *D. rapae* as an effective naturally occurring biological control agent against *B. brassicae* in cabbage fields.

2-2- Successful parasitism rate on cabbage aphid *Brevicoryne brassicae*

It is clear that the highest successful parasitism rate was recorded during November (82.75%), while the lowest one was recorded during January (66.00%). In general, 76.67% of immature *D. rapae* succeeded to emerge into adult parasitoids. Impact of the tested cabbage cultivars on the successful parasitism rates revealed that the local cultivar (Ganzory) lonely had quietly conversable effect on *D. rapae* development.

2-3- Relative susceptibility and damage of the tested cabbage cultivars

2-3-1- Relative susceptibility of cabbage cultivars to *Brevicoryne brassicae*

Three amongst the tested cultivars were appeared as susceptible (S) cultivars and harbored the highest numbers of the pest. However, white

cabbage hybrids, 728 and 730 showed some sort of resistance. Also, the local cultivar (Ganzory) showed an obvious resistance degree and appeared as moderately resistant (MR).

Soluble metabolites such as proteins and amino acid contents showed highly significant positive correlation (r = 0.920** and 0.921**, respectively) with *B. brassicae* populations. However, chlorophyll showed highly significant negative correlation (r = - 0.962**).

Correlation coefficient (r) between aphid population and cortex thickness of leafe margin revealed negative values (-0.379 and -0.848*) in the case of healthy and infested leaves, respectively. These relations showed positive values when aphid concentrated around the leaf mid-rib.

2-3-2- Damage and yield loss

2-3-2-1-Infested plants

The lowest percentage of infested plants was recorded (before cupping formation) with an average of 2.88% infested plants/plot. Multiple increases were recorded when cabbage undergo toward ripening at the 9th stage till harvesting. Infested plant percentages at the harvesting period (throughout cupping formation period) were found to be equal to 11.58 folds more than that recorded before the ripening period. The lowest percentage of infested plants was recorded on Ganzory cultivar with an average of 9.14%. This finding could be attributed to the antixenosis and / or antibiosis phenomena that presented by this local cultivar.

2-3-2-2- Unmarketable plants

The obtained results revealed no or less presence of unmarketable plants before cup formation and/or plant ripening period. Before harvesting (complete ripening) percentages of unmarketable cabbage plants reached 22.80% and constituted 10.13 folds more than that recorded two months after transplantation. The general mean of unmarketable plant percentages recorded

7.70%. So, harvesting cabbage plants at the beginnings of the ripening period could be increase the yield income by more than 17%.

Regarding the tested cabbage cultivars, the highest percentage of the unmarketable cabbage plants was recorded on Kenz hybrid (10.23 % unmarketable plants / plot), while the lowest percentage of the unmarketable cabbage plants was recorded on Ganzory cultivar with an average of 3.35 % unmarketable plants / plot.

2-4- Resistance status of the tested cabbage cultivars to the cabbage aphid *Brevicoryne brassicae*

Population trend of *B. brassicae* offspring produced by one individual of the 2nd instar nymph throughout 6 weeks has been initiated. Aphid populations multiplied until the appearance of the peak at the third and fourth week after inoculation. Positive correlation was recorded between the average number of aphids per cup and protein content in cabbage leaves. Strong positive linear relationship was recorded between number of aphids and both amino acids and soluble sugar. Conversely, a very strong negative linear relationship between number of aphid's offspring and chlorophyll content per leaf was recorded.

Cabbage cultivars kenz and Crossina had significantly lower chlorophyll content and higher protein, amino acid and sugar contents per leaf and consequently had significantly greater abundance of aphids. Conversely, the local cultivar Ganzory had higher chlorophyll content and lower protein, amino acid and sugar contents in cabbage leaves and consequently had the lowest abundance of aphids.

3- Relations between the available abiotic factors with the cabbage aphid *Brevicoryne brassicae*

Although, *B. brassicae* had several overlapping generations, it presented one peak only at 1st January. This peak was coincided with the optimum high and low air temperatures (21.86 and 7.14 °C, respectively). Also, coincided

with the optimum high and low soil temperatures (22.00 and 12.43 °C, respectively) at 5 cm under soil surface. On the other hand, this peak was coincided with quietly high relative humidity (74.00 and 15.71 %).

Maximum and minimum air and soil temperatures showed high significant negative correlations with *B. brassicae* populations. Relative humidity showed non-significant positive (r) with *B. brassicae* populations.

4- Efficacy of newly used bio-insecticides and safe alternative compounds to suppress the cabbage aphid *Brevicoryne brassicae*

The newly imported compound Lambda cyhalothrin Sc 9.4% (Karate® Zeon) was the most effective compound on the population density of *B. brassicae* during the entire period of study with 98.98% reduction in the pest numbers. It followed by Tau-fluvalinate (Evure®) with average reduction 94.20%, then by the growth regulator compound Methoxyfenozide (Melody 24% SC) with average reduction 93.40%. However, the synthetic compound Bermectin (Abamectin 1.8% EC) reduced the pest populations by 78.99%. The biocid compound Spinosad (Biosad 22% SC) reduced the pest populations by 59.08% and appeared as the least effective compound.

In general, potency of the tested compounds to reduce the pest populations was highly synchronized with their potency to reduce levels of the infested plants. Also, use of these compounds increased the marketable cabbage plants (yield income) by more than 50%.

II-Studies on the white cabbage butterfly *Pieris rapae* (L.)

1- Seasonal abundance of the white cabbage butterfly *Pieris rapae* (L.)

1-1- Assiut province (Old cultivated area)

The white cabbage butterfly (WCB) *P. rapae* has not appeared on cabbage plantations during two months after transplantation in both years of study. However, it was found to be active three months after transplantation when plants are in the seventh-ninth stages. Gradual increase in the pest immature stage numbers was recorded until harvesting. The peak of (WCB) appeared in February (0.94 individuals/plant) and was found to be equal to

2.04 and 1.57 folds more than those recorded during 9-13 (December) and 13-17 (January) weeks after transplantation, respectively. The imported cultivar Kenz harbored the highest *P. rapae* immature stage's numbers. So, it can be concluded that the white cabbage butterfly, *P.rapae* don't perform any risk to cabbage plantations throughout the first 60 days after transplantations in the old cultivated areas. Consequently, it can be recommended cabbage growers to maintain *P. rapae* immature stage's numbers throughout the seventh cabbage stage (before plants undergo toward cupping and mature stages) under observation.

1-2- El-Fath province (Reclaimed area)

The first appearance of *P.rapae* immature stages was recorded in quietly high numbers (1.53 individuals/ plant) and coincided with the seventh-eights cabbage stages. It is clear that *P. rapae* immature stage numbers during the third month after transplantation (October) were increased by 1.99 folds more than those recorded before cupping formation (September). The peak of the pest immature stage's numbers (3.04 individuals/plant) was found to be equal to 10.13 folds more than those constitute its documented economic injury level (0.3 larvae/plant). Therefore, cabbage growers must be took attention for controlling the white cabbage butterfly *P. rapae* (Forty five days after transplantation) especially in the reclaimed areas.

2- Relations between the available biotic factors white cabbage butterfly *Pieris rapae*

2-1- Natural parasitism rates on cabbage butterfly *Pieris rapae*

2-1-1- Larvae parasitoids

The first attack of the larval parasitoid, *Hyposoter ebeninus* on *P. rapae* larvae was recorded on November, 6 (110 days after transplantation) with an average of 42.81% parasitism. Although, *H. ebeninus* showed its highest attacking on mid-November (46.02%), its parasitism percentages declined gradually. This finding could be attributed to the appearance of its eolophid hyperparasioid *Baryscapus galactopus* (Ratzeburg).

2-1-2-Pupae parasitoids

2-1-2-1- Solitary pupae parasitoids

The solitary parasitoid, *Brachymeria femorata* was found to be active in cabbage plantations from October, 2 (75 days after transplantation) until November, 10. This parasitoid exhibited one peak on October, 16 with an average of 56.25 % parasitism. A gradual decrease on the parasitoid numbers and consequently in parasitism percentages was recorded after the parasitoid peak appearance (110 days after transplantation). The general parasitism percentage of *B. femorata* on *P. rapae* pupae during the entire period of the study recorded 22.92%.

2-1-2-2- Gregarious pupae parasitoids

Two gregarious parasitoid species were recorded as primary parasitoids of *P. rapae* pupae in cabbage fields, vs. *Pteromlus puparum* and *Tetrastichus* sp. The parasitoid *P. puparum* ranked the first and presented the highest parasitism percentages with an average of 23.73% as compared with *Tetrastichus* sp which exhibited 6.96% parasitism percentage during the entire period of the study. Gregarious parasitoids together reduced *P. rapae* pupae populations by 30.69%.

Concerning the abundance of parasitoids complex, data revealed that the larval parasitoid *H. ebeninus* revealed moderate abundance percentage (42.00%), and presented high parasitism percentage on *P. rapae* larvae ranged between (46.25-29.80%). The solitary parasitoid *B. femorata* showed the absolutely highest parasitism percentage on *P. rapae* pupae and 75.00% abundance. In respect to the gregarious parasitoids, *P. puparum* ranked the first and parasitized *P. rapae* pupae by the highest parasitism percentage with abundance percentage (75.00%). Although, *Tetrastichus* sp appeared throughout 5 weeks only in the field, its parasitism percentage (ranged between 26.00 and 12.50%). This finding reflects to the importance of these parasitoids as important bio control agents against *P. rapae*.

2-2 - Relative susceptibility and damage of the tested cabbage cultivars

2-2-1- Relative susceptibility of cabbage cultivars to *Pieris rapae*

Three amongst the tested cultivars were appeared as susceptible (S) cultivars (hybrids) and harbored moderately high numbers of the pest. The imported white cabbage hybrids, 728 and 730 and 747 showed some sort of resistance and appeared as low resistant (LR). Correlation coefficient between cabbage metabolites and *P. rapae* populations clarified that Chlorophyll only showed significant negative correlation with *P. rapae* populations. However, the remaining metabolites showed non-significant positive correlation with *P. rapae* populations.

2-2-2- Damage and yield loss -Assiut province (Old area)

2-2-2- 1- Infested plants

Data revealed that no infested plants were recorded (2 months after transplantations) and/or (5-6) cabbage growing stages (before cupping formation). Gradual increases were recorded when cabbage undergo toward ripening throughout the 9^{th} stage till harvesting. Infested plants percentage at the harvesting period (throughout the cupping formation period) was equal 1.68 folds more than that recorded before the ripening period.

2-2-2-2- Unmarketable plants

No or less presence of unmarketable plants before cupping formation and/or plant ripening period was recorded. 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. The general mean of unmarketable plant percentages recorded 1.35%.

2-3- Damage and yield loss - El-Fath province (Reclaimed area)

2-3-1- Infested plants

As an average of both seasons, data revealed that percentage of the infested plants before harvesting was increased by 3.50 folds more than that

recoded two months after transplantation. General average of infested plants percentages recorded 16.69%.

2-3-2- Unmarketable plants

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. The general loss of cabbage plants without any control recorded 11.23%.

3- Relations between the available abiotic factors with the white cabbage butterfly *Pieris rapae* populations

3-1- Assiut province (Old cultivated area)

The highest mean numbers of *P. rapae* coincided with the maximum and minimum temperatures (23.71 and 6.86 ^{o}C), respectively. Both maximum and minimum relative humidity (RH) and soil temperature at 5 cm under the soil surface showed negative values with the pest populations. The obtained data revealed conversable relations between most of the tested abiotic factors and *P. rapae* population trend.

3-2- El-Fath province (Reclaimed area)

In the reclaimed area the relation showed negative (r) with both maximum and minimum air temperature. However, relative humidity showed positive (r) with *P. rapae* seasonal abundance. Both maximum and minimum soil temperatures showed negative (r) with *P. rapae* seasonal abundance. Similar correlation coefficient between the available abiotic factors and *P. rapae* seasonal abundance were recorded during the second year of the study**.**

4- Efficacy of synthetic biocides, safe alternative compounds and naturally prepared bio-insecticides to suppress the whit butterfly *Pieris rapae* populations and infestation

4-1- Efficacy of synthetic biocides and safe alternative compounds

Potency of the tested compounds indicated that Broact 5% SG showed the highest reduction percentages in all of the tested measurements (93.29% for larvae populations; 52.13% for infested plants and 36.04% for unmarketable plants). It followed by the recent introduced European compounds, Karate® Zeon and Evure®. However, Melody 24% SC and Biosad 22% SC appeared as the least effective compounds on *P. rapae* population trends.

In general, potency of the tested compounds to reduce *P. rapae* populations was highly synchronized with their potency to reduce infested plant's levels, which led to increase of the marketable cabbage plants (yield income) by more than 36%.

4-2- Efficacy of the naturally prepared bio-insecticides

Data revealed that the fungus compound (Biosiana 2.5% WP) reduced the pest larvae populations by 71.85%. However, the bacterial compound Bt (Xentari 54% DF) was found to be capable to reduce *P. rapae* larvae populations by 68.24% and ranked the second.

Using the fungus compound (Biosiana 2.5% WP) reduced cabbage plants infested by the pest by 18.00 %. However, the Bt compound (Xentari 54% DF) efficiency reached 15.74%.