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Environmental and anthropogenic factors influencing key cabbage Lepidopteran pests in the southwestern Siberia

The lepidopteran pest community composition on cabbage (Brassica oleracea L.*) as the main vegetable crop in the conditions of southwestern Siberia was presented. In 2015-2019, the dominant cabbage pests were diamondback moth (Plutella xylostella* L.*) and cabbage moth (Mamestra brassicae* L.*). The continuous application of insecticides against the cabbage pests along with climatic factors led to a change in insect species community composition. This was manifested as an increase in the number of the diamondback moth and a decrease in the abundance of other Lepidoptera species. The mean number of diamondback moths varied from 0.06 (in a year of low numbers) to 1.4 specimens per plant (in years of outbreaks), and for cabbage moth - 0.12 (2015) and 0.43 (2016), respectively. In commercial cabbage field, both egg-laying and caterpillars of Pieris brassicae* L. *and P. rapae* L. *were found as a single individual. During the years of research, we noted earlier diamondback moth and cabbage moth appearance dates in the field. More frequent diamondback moth outbreaks were observed. The period of cabbage damage by the diamondback moth lasted longer than usual during the growing seasons due to an increase in the number of insect generations in the conditions of the southwestern Siberia.*

The paper contains 2 Figures and 15 References.

Key words: *diamondback moth; cabbage moth; insect distribution; plant damage; environmental conditions; outbreak.*

The Authors declare no conflict of interest.

Introduction

White cabbage (*Brassica oleracea* L.) is the main vegetable crop in the southwestern Siberia. The crop productivity is negatively affected by phytophagous insects, including Lepidoptera pests, among which the most important are the diamondback moth *Plutella xylostella* L. and the cabbage moth *Mamestra brassicae* L. It is known that the structure of the Lepidoptera complex and the number of

individual species can vary significantly depending on diverse environmental factors. With the growing trend of global warming, an increasing research is aimed at studying the impact of climate change on the damage by insect pests [1-3]. Seasonal and long-term climate changes have a direct impact on insect pests of cultivated plants, manifested in changes in survival rates and development, fertility, distribution and the number of generations, which fully applies to cabbage pests [4-9].

Another factor that affects the change in the field situation is the formation of resistant populations to chemical insecticides in different types of pests. Acquired resistance to insecticides is one of the reasons for the increase in the insect number, as well as the habitat expansion of some species of phytophagous insects, including the diamondback moth *P. xylostella*, which was noted in different regions of the world [4, 10-12]. In general, the structure of the insect species community composition in the cabbage field is gradually undergoing significant changes due to the above reasons, as well as changes in the composition and number of the areas occupied by cabbage crops, and breeding new cabbage varieties and hybrids.

The aim of the research was to analyze changes in the structure and the species composition of Lepidoptera insect pests on white cabbage depending on environmental factors in the conditions of southwestern Siberia.

Materials and methods

White cabbage hybrids of different groups of maturity: early Champ F1 (2015), Green Flash F1 (2016), Lemma F1 (2017), and Pushma F1 (2018-2019); middle - Tobia F1; late - Arriviste F1 were studied in this research. Cabbage pests, such as diamondback moth *Plutella xylostella* L. (Lepidopera: Plutellidae), cabbage moth *Mamestra brassicae* L. (Lepidopera: Noctuidae), cabbage white butterfly *Pieris brassicae* L. and imported cabbageworm *Pieris rapae* L. (Lepidopera: Pieridae) were counted on plants.

Observations and records of the number of phytophagous insects were carried out on commercial cabbage crop in the forest-steppe zone of the Ob region (southwestern Siberia, 54°51'12.2"N, 82°48'29.3"E), in 2015-2019. The cultivation technology of cabbage was typical of this region and included the following main operations: growing seedlings by cassette method, planting seedlings in the open ground according to the planting scheme of 60×40 cm for early varieties, 60×70 cm for mid- and late hybrids. Regular watering, a single application of a complex of mineral fertilizers and pesticides were applied. Plant protection included one spraying by Aktara (thiamethoxam) against *Phyllotreta cruciferae*, and from one to three sprayings by one of the following chemicals: Accord (alfa-cypermethrin), and Gladiator (lambda-cyhalothrin) against Lepidopteran insects depending on their number.

The years of research differed significantly in meteorological parameters. Out of five years, one year (2016) was characterized as dry; two years (2017 and 2018)

- with excessive moisture, meanwhile in 2017, a large amount of precipitation was combined with high air temperatures, and 2018 was characterized by a cold prolonged spring. In 2015, the temperature generally exceeded the average annual value, and in 2019, they slightly differed from the norm, however, in both years there was uneven precipitation during the growing season.

Counting the number of pests on white cabbage was based on regular monitoring throughout the growing season (5 counts per season for the main phases of crop development). Insects were counted on 100 plants of each cabbage hybrid, and counted plants were selected on a staggered basis or along a diagonal line in the plot (20 samples of 5 plants). The stage of development and number of each insect species were taken in account.

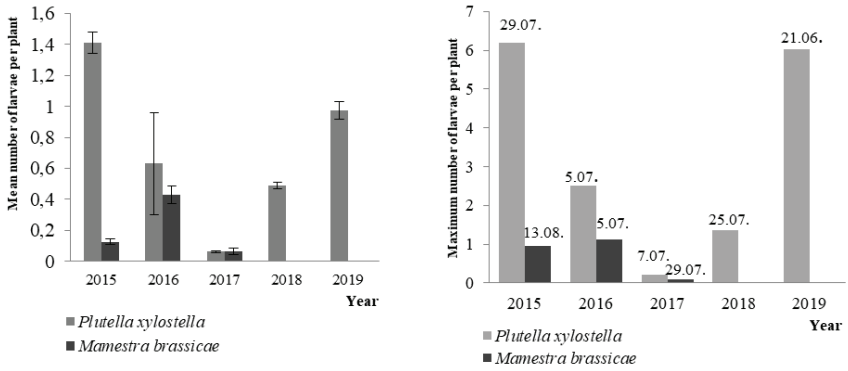
The mean number of insects (A) was determined by the formula:

$$A = (\overline{x}_1 + \overline{x}_2 + \overline{x}_3 + \cdots x_n) \div n,$$

x - mean of insects on each counting date, individuals /one plant, *n* - the number of counts during the season.

Results and Discussion

During the years of research, the diamondback moth and the cabbage moth were discovered as the dominant insect pests on cabbage plantations, whose abundance varied significantly depending on the conditions of the growing seasons (Fig. 1).



A *B*

Fig. 1. Number of insect larvae per plant: *A* - Mean (columns) and *B* - Maximum

Outbreak of the diamondback moth was observed in four of the five growing periods, with an abnormal increase in 2015 and 2019, during which the mean number of the pest in all hybrids was 1.4±0.07 ($p < 0.001$) and 0.97±0.056 ($p < 0.001$)

individuals per plant, respectively (Fig. 1A). In these years, the maximum number of caterpillars on individual cabbage hybrids reached 6.2 and 6.0 insect per plant, respectively (Fig. 1B). Therefore, 3 treatments per season were applied that timed to the appearance of younger instar larvae. Larval appearance time depended on the year of research. In the year of the depression (2017), the mean number of the diamondback moth was 0.06±0.007 ($p < 0.001$) individuals / plant, that provided one insecticide treatment only. The results showed that the appearance of phytophagous insects on cabbage plantings had been observed in recent years at an earlier and earlier time. Thus, if in 2015-2018, the first larvae of *P. xylostella* appeared in the middle of June (10.06-18.06.), in 2019, the emerging adults of first generation were recorded at the end of May, and the larvae were found in early June (starting from 5.06.), almost immediately after planting cabbage seedlings in the open ground. According to our previous research, the second generation of the pest in Western Siberia is the most numerous and harmful, the peak of which usually occurred in the end of July [13]. However, in 2019, during the outbreak the largest number of pests was recorded almost one month earlier (in the middle of June). In addition, there was an extension of the period of the diamondback moth damage, which reached 107-109 days in 2015-2016, due to an increase in the number of pest generations. Particularly, in 2015, the insect produced four complete and partially fifth generations [4], which was due to climate change in the region. It is known that temperature conditions are the main regulating factor of the population dynamics of this pest. Therefore, for example, the number of diamondback moth generations varies from 2-3 in the northern regions to 20 in the tropical zone [5, 14]. In 2017 and 2019, the development of *P. xylostella* populations completed in August due to various reasons. Thus, 2017, in general, was characterized by a low insect abundance, and in 2019, there was a mass death of caterpillars in August due to the development of epizootics caused by entomophthoralean fungi in the pest population.

Significant plant damage by *M. brassicae* was noted in 2015 and 2016, in these years the number of larvae per plant was 0.13±0.02 and 0.43±0.056 ($p < 0.001$), respectively; however, in the next three years, this pest had no economic significance. The *c*abbage moth egg-laying period was characterized by a significant length of time and lasted 1-1.5 months depending on the meteorological conditions of the year. The first caterpillars usually appeared in the late June-early July, with the exception of the 2018-2019 growing seasons. In this period, despite the laying of eggs by females, cabbage moth caterpillars were not found, the reason being the use of chemical insecticides to control the number of diamondback moth. The period of damage by phytophagous insects in 2015-2017 was limited from one and a half to two months (46-62 days). Thus, in comparison with the data of previous studies, when the cabbage moth was considered the most dangerous pest of cabbage in the Siberian region [15], in recent years there was a decrease in the damage by *M. brassicae;* however, there was an earlier appearance of caterpillars on cabbage plants. For example, in 2008, during the outbreak of

this insect, cabbage moth larvae reached peak abundance at 7 weeks after cabbage seedlings had been planted in the ground (early cabbage head formation), which corresponded to the end of July [15]. After 8 years (in 2016) the first egg-laying was detected in mid-June, and the maximum number of caterpillars was observed in the beginning of July (9-12 true cabbage leaves) (Fig. 1B).

It should be noted that in the years of this research on cabbage plants, *M. brassicae* laid unusually small egg clutches consisting of 7-15 eggs, while, for example, in 2008, the pest egg-laying consisted mainly of 50-100 eggs (Fig. 2). Such changes are obviously due to the regular use of chemical insecticides in commercial fields to control the diamondback moth in recent years.

Fig. 2. Egg-laying of *Mamestra brassicae* collected on cabbage plants: *A* - in 2008, *B* - in 2019. Photos by Elena Shatalova

During five years of research, the percentage of *P. brassicae* and *P. rapae* in the pest community structure on commercial cabbage crop has significantly decreased. Thus, only single egg-laying and single plants inhabited by cabbage white butterfly and imported cabbageworm were observed in 2015 and 2017. In 2016, single egg-laying of *P. brassicae* with no caterpillars were found, and in 2018, single egg-laying of *P. rapae* were observed. In 2019, these two pests were not found at all.

Conclusion

The results of this research showed the significant changes in the lepidopteran pest community composition in the commercial cabbage field in the southwestern Siberia. These changes depended on environmental and anthropogenic factors. With the annual use of chemicals on cabbage plants, there was an increase in the abundance of the diamondback moth *Plutella xylostella* L., and a decrease in the number of other Lepidopteran insects that were less resistant to pesticides. Under the changing climatic conditions, the timing of the appearance of the diamondback moth and the cabbage moth *Mamestra brassicae* L. on cabbage plants has also changed, as well as the periods of their plant damage during the growing

seasons. The obtained results show that the trends for this region are similar to those observed in other areas, and this fact should be taken into account for further improvement of pest management on cabbage.

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