Agronomy Research **7**(Special issue I), 406–411, 2009

Oviposition preference of *Pieris brassicae* (L) on different *Brassica oleracea* var. *capitata* L. cultivars

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Abstract Cabbage White Butterfly**,** *Pieris brassicae* L. is widely distributed pest world wide and causes severe damage to white cabbage (*Brassica oleracea* var. *capitata* f. *alba* L.). We studied oviposition preference of *P. brassicae* on six different cabbage cultivars in the field experiment. As in Estonia farmers grow rather numerous cabbage cultivars, the determination of more resistant cabbage cultivars is of great importance for farmers. Significantly more eggs were laid on the late cultivars 'Krautkaizer' (52% of all of the counted eggs) and 'Turquoise' (40%). The mid season cultivars 'Krautman', and 'Lennox' were chosen more or less to the same extent (2.5–5%). *P. brassicae* adults avoid the early cultivars 'Parel' and 'Golden Acre'.

Key words: white cabbage cultivars, *Pieris brassicae*, oviposition preference

INTRODUCTION

The Large White Butterfly (LWB), *Pieris brassicae* L., is a cosmopolitan insect, and is found wherever cruciferous plants are grown (Hill, 1987). Sometimes massive outbreaks of LWB may occur and injury on cabbage cultures may be extensive. The first generation larvae of LWB in Estonia usually feed on various cruciferous weeds; the second generation prefers cabbage vegetable plants. Insecticide application against the larval stage of the LWB is the primary method of control. However, the use of broad spectrum insecticides has led to well-known problems, such as development of insect resistance, the resurgence of secondary insect pests, and persistence of residues that are toxic to humans, animals and nontarget organisms (Hardin et al., 1995).

The insects' sensitive olfactory sense can be exploited by humans in several ways to reduce damage to economically important plants. Host plant selection is a behavioural process, which is mainly regulated by chemoreception (Jeremy & Szentesi, 2003). Choosing a good site for oviposition is a challenging task for female and her decision has far-reaching and profound consequences for the life history of her offspring (Janz, 2002). The thickness of wax layer, physiological age, as well as the peculiarities and biochemical composition of the plant leaf are among the most significant factors when choosing the suitable oviposition place (Bernays & Chapman, 1994). Schoonhoven (1972) supposed that *P. brassicae* adults select substrates for oviposition based on presence of a specific group of allelochemical – glucosinolates, which are common for all Brassicaceae, and now more than 120 different structures of those are known (Hopkins et al., 2009). Distribution of individual glucosinolates as

well as their relative amounts in plants varies considerably. Cabbage cultivars have different glucosinolate profiles that only partly overlap, but the predominant glucosinolates are sinigrin (2-propenyl-glucosinolate) and glucobrassicin (Poelman et al., 2008).

This research addresses the need for finding effective options for managing the cruciferous insect pest LWB in Estonia in the face of the declining availability and popularity of conventional chemical insecticides. Damage caused by LWB could be reduced by growing resistant plants and could be recommended to be incorporated in the breeding programmes so as to reduce the losses to this crop by *P. brassicae*. We studied *P. brassicae* oviposition preference and the dynamics of their egg numbers on six cultivars of white cabbage in the field.

MATERIALS AND METHODS

Studies on the preference of *P. brassicae* on different white cabbage (*Brassica oleracea* var. *capitata* f. *alba* L.) cultivars were carried out in the experimental garden of the Estonian University of Life Sciences in summer, 2008. The experiment was conducted in a randomized complex block design with three replications. The host plants used in this study included six cultivars of white cabbage: early cultivars 'Parel' and 'Golden Acre', mid season cultivars 'Krautman' and 'Lennox', late cultivars 'Krautkaizer' and 'Turquoise' were grown in separate 2 x 2 m plots. In mid-May the seedling were transplanted in the plots with a plant to plant distance of 70 cm, 9 plants per plot in total. All the agronomic practices were kept normal and uniform in all plots. The inter-plot buffer zones were planted with beet (*Beta vulgaris* L). The experiment started in mid July. *P. brassicae* egg-laying was monitored weekly; eggs in all experimental plots were counted and removed from plants to avoid repeated counting.

The data were not suitable for analysis with parametric statistics and were instead compared using the Kruskal-Wallis test. Significant differences among cultivars were determined using the Duncan's multiple test ($P < 0.05$).

RESULTS

The oviposition choice of LWB was significantly affected by the cabbage cultivars (Kruskal-Wallis test: $H_{5;18}$=13,73; P = 0.0174; Fig. 1). Significantly more eggs ($P < 0.05$, Duncan test) than on any other cultivars were laid on late cultivars 'Krautkaizer' (52%) and 'Turquoise' (40%). Comparison of those two varieties did not reveal any significant difference between 'Krautkaizer' and 'Turquoise' (P = 0.307) (Fig. 1). No eggs were laid by LWB on early cultivar 'Parel', while only few eggs were found on the other early cultivar 'Golden Acre' during the whole observation period. Likewise, the mid-season cultivars 'Krautman' and 'Lennox' were chosen for oviposition poorly, with 2.5% and 5% respectively. Statistically significant difference could not be observed (P = 0.8) in comparison of the four cultivars, but neither in comparison of early and mid-season varieties (P = 0.8).

LBW infestation started at the last week of July and increase gradually (Fig. 2). It remained at the peak during first week of August and declined gradually till the last decade of August. First eggs were found on the July 28 only on late cultivars 'Krautkaizer' and 'Turquoise'.

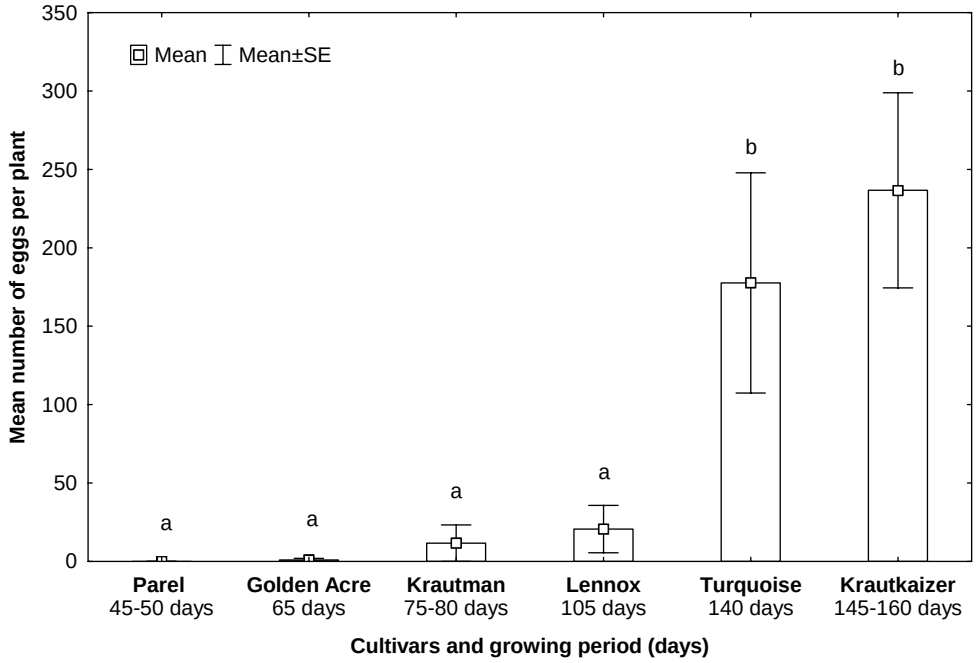

Fig. 1. Oviposition of *Pieris brassicae* on different white cabbage (*Brassica oleracea* var. *capitata* f. *alba* L.) cultivars. Bars denoted with different letters are significantly different ($P < 0.05$, Duncan multiple range test).

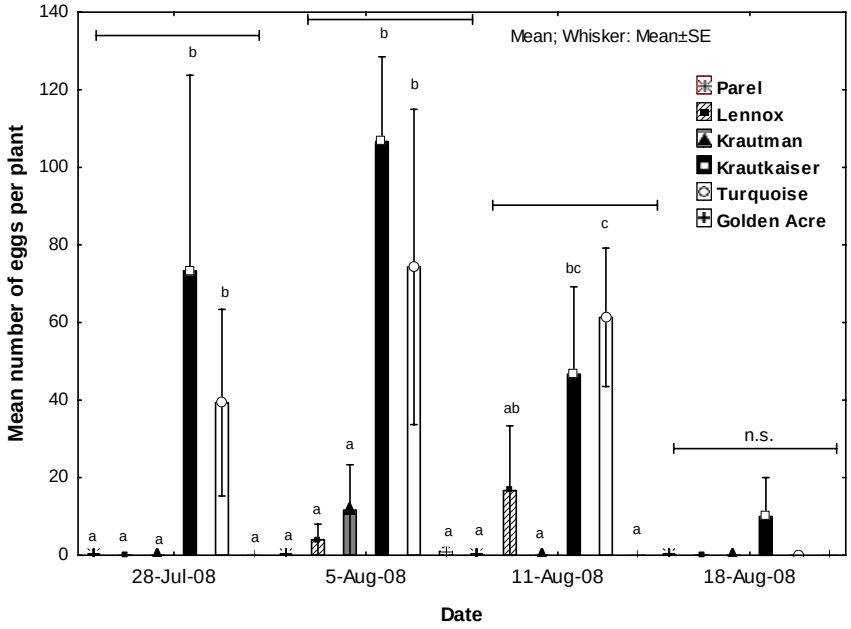

Fig. 2. Dynamics of oviposition of *Pieris brassicae* on different white cabbage cultivars. Means within columns followed by the same letter are not significantly different based on Duncan's test ($P < 0.05$).

A comparison of those varieties in first assessment proved certain prevalence of 'Krautkaizer', however, no statistically significant difference was present ($P = 0.059$). In the next assessment on August 05 'Krautkaizer' and 'Turquoise' were again determined to be the preferred oviposition sites. As the first time, majority of eggs were counted on 'Krautkaizer', although difference between 'Turquoise' was not statistically significant ($P = 0.26$).

The same day, eggs were found on 'Lennox' and 'Krautman', but former counted significantly less than 'Krautkaizer' ($P = 0.0004$) or 'Turquoise' ($P = 0.03$) and the latter, significantly less than 'Krautkaizer' ($P = 0.006$) or 'Turquoise' ($P = 0.04$). It was the only time during the whole observation period when few eggs were found on 'Golden Acrelt'. Similarly, more eggs were found on 'Krautkaizer' and 'Turquoise' in the next assessment, on August 11. This time, 'Turquoise' was the preferred cultivar, but when compared with 'Krautkaizer' significant difference was absent ($P>0.05$). Eggs could be found also on 'Lennox', but significantly less than on 'Turquoise' ($P = 0.04$), whereas statistically significant difference was not observed when compared to 'Krautkaizer' ($P = 0.45$). Last assessment on August 18 revealed eggs only on 'Krautkaizer'; no other cultivars were used for oviposition.

DISCUSSION

The results confirm that selection of cultivars can significantly influence the oviposition of LWB females. Significantly more eggs were laid on late cultivars 'Turqouise' and 'Krautkaizer'. Several plant-specific factors affect the oviposition choice, most important of which are physiological age of plants and secondary metabolites present. Decline in egg production with leaf age has been reported in many insect species. On the basis of our experiment we may conclude that physiological age of cultivars is the most significant factor in finding a suitable oviposition site. By the time of flight of LWB, early cultivars 'Parel' and 'Golden Acre' (growth periods up to 50 and 65 days respectively) had already stopped growing with outer leaves senescing and vegetable ripened. Such plants were neglected for oviposition by LWB. We observed the same trend in mid-season varieties: the shorter the growth period, the fewer eggs were laid. Late cultivars were clearly preferred for oviposition. These results concur with the data by Dickson & Eckenrode (1980) and Hoy & Shelton (1987), who have noted that plant physiological age affects the oviposition of LWB in *Brassica* crops. LWB usually selects a substrate for oviposition based on the presence of glucosinolates and their breakdown products isothiocyanates (Schoonhoven, 1972; Renwick & Lopes, 1999; Jankowska, 2006). Rahman et al. (1986) detected that total and individual glucosinolate contents vary among cultivars, physiological age, etc. Glucosinolates are more concentrated in young plants than in mature plants and decline with plant age (Rosa et al., 1997; Velasco et al., 2007; Cartea et al., 2008).

Another factor possibly affecting behaviour of LWB is plant colour. Though, glycosinolates are short distance cues, colour and plant size are long distance cues. Early cultivars 'Parel' and 'Golden Acre' were yellowish green, notably lighter coloured than any other cultivars in the experiment. This could have been a major consideration for avoiding by LWB. Late cultivars were dark green coloured, which may have caused the oviposition preference. Radcliffe and Chapman (1966) detected that a colour factor appeared to be important in determination of host preference for *P.*

brassicae and *Pieris rapae* L. Terafol (1965) showed that perception of colour from a distance was an important landing stimulus for LWB. Myers (1985) found, that females of *Artogeia rapae* L. (=*P. rapae*) are more likely to approach greener plants. Plant size may influence butterfly oviposition choice, and large plants may receive more eggs than small plants because they are visually conspicuous (Talsma et al., 2008). The biggest leaves in our experiment were displayed by late 'Krautkaizer', which was overwhelmingly preferred. Leaf area of earlier cultivars was remarkably smaller.

The cabbage plants contain a coating of wax on the surface on the cuticles. Our experiments also indicated that the thickness of the wax layer on the leaves can play an important part in choosing the late cabbage cultivars. By visual and tactile examinations we assumed that comparing to the second late cultivar 'Krautkaizer' 'Turquoise' had the thickest wax layer and LWB chose 'Turquoise' less. Wax coating makes it difficult for females of LWB to obtain information on the chemical composition of leaves since it prevents the discharge of specific odours from the leaf. Obviously both the chemistry of leaf waxes and their physical attributes act together with some plant-specific features. Eigenbrode et al. (1991) studied oviposition preferences of *Plutella xylostella* L. on different cabbage cultivars and found that the wax of more resistant cultivars contained much greater proportion of primary alcohols than the susceptible cultivars. The resistant cabbage cultivars had a thicker wax layer, and their chemical composition differed from that of non-resistant cultivars. Resistance of the cultivars that we examined is likely to be a function of several factors. A comprehensive study of cultivar differences would complement the more specific studies described here.

ACKNOWLEDGEMENTS. This study was supported by grants no 6722 and 7130 of the Estonian Science Foundation, and Estonian Ministry of Education and Research targeted financing project no SF 0170057s09.

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