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Research Article

Assessment of Trap Crops for The Wheat Bug, *Nysius huttoni* Management: A Cage Study

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Abstract

The wheat bug, *Nysius huttoni*, is an endemic New Zealand insect pest. Its feeding can seriously reduce crop establishment in forage A cage study was conducted in Lincoln University, New Zealand to evaluate the pest's host preferences on four plant species. Kale plants (*Brassica oleracea*) were used as a potentially susceptible control and other four trap plants were tested to evaluate as potential trap-plants. These were: *Lobularia maritima* (alyssum), *Triticum aestivum* (wheat), *Coriandrum sativum* (coriander) and *Trifolium repens* (white clover). The alyssum plant was more attractive to the wheat bug. The survival rate and preferences of the wheat bug was significantly better than other four plants. The deployment of such flowering trap crops can potentially trap the wheat bug and also provide multiple ecosystem services (ES) in an agro-ecosystem. The findings can be used to develop the wheat bug management protocol and also potentially provide ecosystem services in brassica fields.

Keywords: Alyssum; Brassica crops; wheat bug; integrated pest management

Introduction

The wheat bug, *Nysius huttoni* White 1878 (Hemiptera: Lygaeidae) is an endemic New Zealand insect pest and which is a major threat to forage brassicas and other cultivated crops (He and Wang, 1999). The first damage record of the wheat bug was recorded in 1936 in New Zealand (Morrison, 1938). The bug has a wide host range comprising almost all cultivated brassicas as well as weeds, and many other cultivated crops. There has been up to 90% plants damage recorded in brassica crops where the wheat bug primarily attacks seedlings (AgResearch 2016; Speciality Seeds, 2016). In wheat, *N. huttoni* damages the grains which reduced the gluten protein and reduced baking quality (Every *et al*., 1992). Now this pest has been distributed in The Netherlands (Aukema *et al*., 2005) and in Belgium (Bonte *et al*., 2010).

The management of *N. huttoni* has become a quite difficult task because of its high mobility, polyphagous nature, feeding annual weeds and crops, laying eggs in the soil, diapause behaviour, migration to overwintering sites and breeding in fallow land (Farrell and Stufkens, 1993).

However, insecticides are the primary means of managing the wheat bugs (AgResearch, 2016)). These practices have been linked to biodiversity loss and pollinator population declines (Brittain *et al*., 2010), which further increased cost of productions in farming sectors (Dhaliwal *et al*., 2010). Before the invention of synthetic chemical pesticides, trap cropping was a common method of pest management in several agro-ecosystems (Talekar and Shelton, 1993) which is the suitable method of pest management in agricultural fields (Hokkanen, 1991). An approach that can be integrated into the other integrated pest management (IPM) is the use of trap plants, which are composed of one or more plant species grown at within-crop, within-farm, or landscape level (Landis *et al*., 2000), which minimize the pest damage to the main crop (Shelton andNault, 2004). is focussed on selection of potential trap plant species of the wheat bugs in forage brassicas. The idea behind of this research was, once the wheat bug is trapped on any trap crop, it helps to protect the target crops from the attack of the bugs (Hokkanen, 1991). Then protection of the main crop can be achieved either by preventing the pest from reaching the crop or by concentrating them in a certain part of the field where the insect can be economically managed, either by removal of the trap plants or using insecticides (Shelton and Nault, 2004).

Materials and Methods

Colony Management for Field-Cage Experiment

Adult wheat bugs were collected from shepherd's purse (*Capsella bursa-pastoris* L.Medik: Brassicaceae) field by using a suction machine (Shred n Vac Plus^{TM}, Stihl BG 75, USA, 80.0cm length x 12.0 cm inlet diameter) from the Iversen Field Plant Science Research Unit (39° 48' 31.315" N, 75° 55' 37.53" W) of Lincoln University in Spring 2016. Laboratory colonies were maintained in a controlled temperature (CT) room in circular Petri dishes (13.5cm diameter) and provided twin cress, *Coronopus didymus* (L.) Smith (Brassicaceae) and hulled organic sunflower seed (*Helianthus annuus* L.) as their food materials. The room temperature photoperiod and humidity were 22^{o}C, 16L: 8Dh, and 60 ± 10% RH, respectively. The same ages adults (male and female) obtained from laboratory colonies were used in field-cage experiments.

Field-Cage Experiment

In 2016, field-cage experiments were conducted at Biological Husbandry Unit (BHU) of Lincoln University (43^{0} 38.946S′ 172^{0} 27.484E′) in February-April, 2017. On the basis of the laboratory results, two potential 'good' trap crops, alyssum (*L. maritime* cv 'Benthamii White' and wheat (*Triticum aestivum* L. cv 'Morph'), and two 'poor' trap crops (*Coriandrum sativum* L. cv 'Santo' and *Trifolium repens* L. 'Nomad') were selected, all these trap crops were compared with kale (*Brassica oleracea* L. cv 'Kestrel') in field-cages (Tiwari *et al*., 2018). The field-cages were made up of cylindrical iron frame (50 cm height and 30 cm diameter) and covered by fine high-density polyethylene (HDPE) mesh (0.6x0.6 mm). Seedlings of potential trap plants (see above) were grown in a glasshouse in cell trays (size 144 cell) using organic potting mix (composted bark, coco fibre, NuFert and pumice) and irrigated daily. Five seedlings for each trap plant species (18-days old, 3-5 true leaves and no-reproductive buds) were transplanted inside the field-cages on 20 February 2017. Each field-cage was fixed into the soil with the help of angular iron fixer. The experiment design was randomized complete block design (RCBD) with five replicates for each treatment. Treatments were randomly allocated in a block. On 5 March 2017, each field-cage (see above) received ten-pairs (male and female) of *N. Huttoni* which were compared to each control cage (no *N. huttoni*) in a block. The plants of each treatment-cage were compared to the plants of each control-cage to see the changes in vegetative characteristics in between them. The total numbers of the wheat bugs colonized on each plant species were observed over 29 days after the release of *N. huttoni*. The numbers of *N. Huttoni* settled on each plant species were counted at 1-d, 2-d, 3-d, 4-d, 5-d, 6-d, 7-d, 8-d, 9-d, 12-d, 15-d, 21-d, 22-d, 26-d and 29 days after introduction and mean numbers of *N. huttoni* settled over time were calculated by the area under the curve (AUC) method. The overall survival of *N. huttoni* in each field-cage was recorded on 18 April 2017.

Data Analysis

The mean number of *N. huttoni* recorded in each trap plant species were first averaged by the area under the curve (AUC) method against the time and analyzed by two-way analysis of variance (two-way ANOVA). Number data were square-root transferred to meet the normality assumptions before analysis. The percent survival data at 55-days of bug's introduction were analyzed using two-way analysis of variance. Mean numbers and survival data were separated by unprotected least significance difference (LSD) at $P<0.05$ (Saville, 2015).

Results

The overall numbers of the wheat bugs settling in different plant species over 29 days were significantly different ($P= <0.001$). Significantly more wheat bugs adults were observed on alyssum than any other plant species. The number of *N. huttoni* observed on wheat was significantly higher than on clover but not significantly different with coriander and Kale (Fig. 1). However, the number of the wheat bugs colonizing in each plant species did not differ significantly at 2d, 3d, 4d, 5d, 7d, 8d, 9d and 12 days of the wheat bugs introduction (Table 1).

Table 1. For the field-cage tests, mean numbers (√ transformed) of *N. huttoni* adults recorded on each of five plant species after 24h to 29 days plus overall AUC mean.

Plant Species	Mean numbers (√ transformed) of adult *N. huttoni*														
	1d	2d	3d	4d	5d	6d	7d	8d	9d	12d	15d	21d	22d	26d	29d	AUC Mean
Alyssum	0.20ab	0.20a	0.20a	0.20a	0.68a	0.60bc	0.60a	0.00a	0.88a	0.40a	0.68b	1.18b	1.21b	1.33b	1.29b	1.04c
Wheat	0.60b	0.20a	0.40a	0.40a	0.40a	0.80c	0.40a	0.00a	0.97a	0.40a	0.00a	0.00a	0.40a	0.20a	0.20a	0.55b
Clover	0.00a	0.00a	0.20a	0.40a	0.00a	0.00a	0.20a	0.00a	0.40a	0.20a	0.00a	0.00a	0.00a	0.00a	0.00a	0.25a
Coriander	0.00a	0.40a	0.20a	0.00a	0.20a	0.20ab	0.20a	0.20a	0.68a	0.20a	0.20ab	0.40a	0.20a	0.00a	0.20a	0.45ab
aaKale	0.60b	0.40a	0.00a	0.00a	0.68a	0.20ab	0.60a	0.20a	0.80a	0.20a	0.00a	0.20a	0.00a	0.20a	0.20a	0.45ab
LSD (5%)	0.536	0.656	0.636	0.561	0.767	0.545	0.764	0.328	0.622	0.650	0.502	0.569	0.538	0.715	0.678	0.251

Means within a same column with no letters in common are significantly different (Unprotected LSD; P<0.05). For each plant species and arena, the 696h-hour weighted mean was obtained by calculating the area under the curve (AUC) for a graph of √count against time (h) using the trapezoid rule, then dividing by the time period (696h) (n=5).

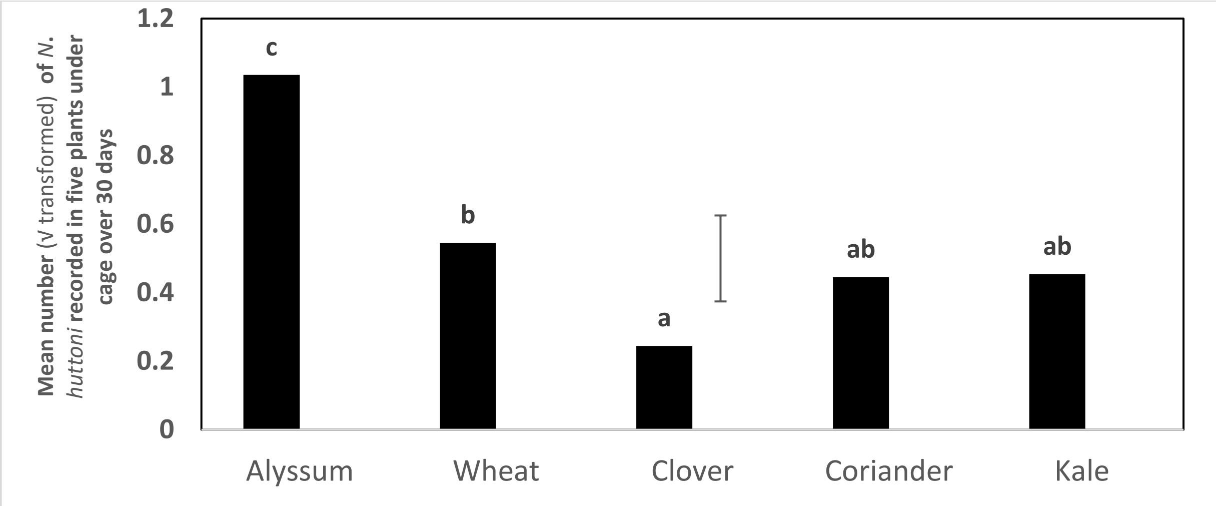

Fig. 1. Mean numbers (√ transformed) over 30 days of *N. huttoni* adults recorded in each of five plant species. The vertical bar is the least significant difference, LSD (5%). Means with no letters in common are significantly different (Unprotected LSD; P<0.05) (n=5).

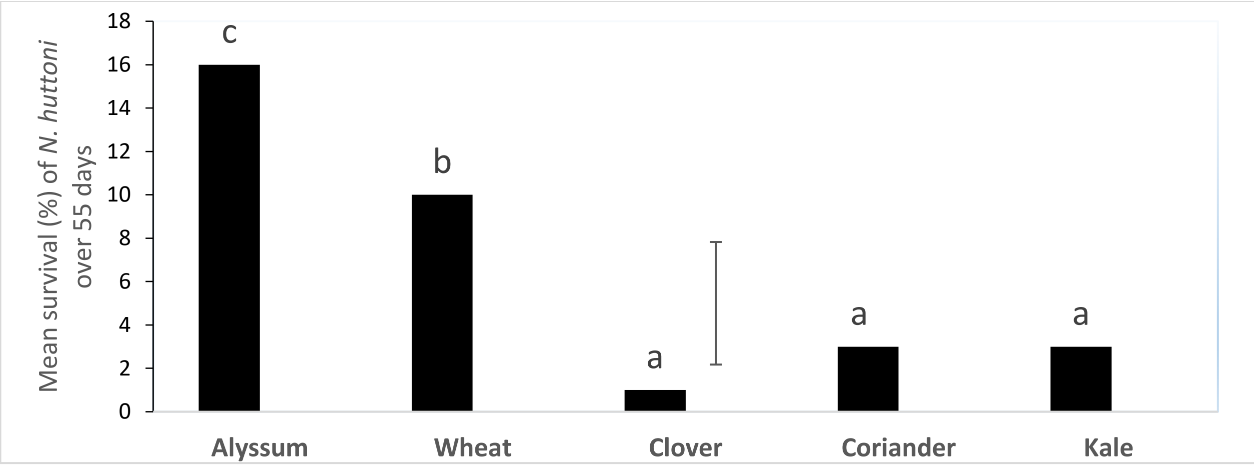

Fig. 2. Mean survival (%) of *N. huttoni* adults on five plant species in field cages over 55 days of wheat bug introduction. The vertical bar is the least significant difference, LSD (5%). Means with no letters in common are significantly different (Unprotected LSD; P<0.05) (n=5).

Highest survival was recorded on Alyssum followed by wheat, both of these plant species were significantly different from each other and to other plant species. The survival on clover, coriander and kale did not differ significantly (Fig. 2).

The survival rates across the plant species over 55 days were significantly different (P<0.05).

Discussion

The study was conducted to select the potential trap crops of the wheat bug in semi- field conditions. Alyssum and wheat were the recently identified potential trap crops of this pest under laboratory condition (Tiwari *et al*., 2018). In this experiment, wheat bug adults and nymphs were significantly more abundant in alyssum trap crops compared with kale and other potential trap plants. *N. huttoni* noticeably favours the alyssum plant followed by wheat which were significantly suitable than coriander, white clover and kale (Table 1 and Fig. 1. The significantly highest survival was also recorded in alyssum plant (P<0.05) followed by the wheat, both of them were significantly superior than on kale.

Brassicaceae family group of plants contains rich source of glucosinolates which may play an important role in plant defence mechanisms and possess the negative effect on a range of invertebrates (Textor and Gershenzon, 2009). However, some invertebrates may stimulated and attracted by glucosinolates (Hopkins *et al*., 2009). The preference of alyssum plant by the wheat bugs could be physical and chemical cues (Badenes-Perez *et al*.,2004). This alyssum plants, do not only trap the bugs but can also provide resources such as shelter, nectar, alternative food and pollen (SNAP) for pollinators and other beneficial arthropods, which provide ecosystem (nature's) services on- and off-farm.

However, various trap cropping protocols have been developed for the management of Hemipteran bug such as use of squash plant (*Cucurbita pepo* L.) for the management of squash bug (*Anasatristis* (De Geer) in watermelon (*Citrullus lanatus* Thunberg, Matsumura and Nakai) (Dogramaci *et al*., 2004), alfalfa (*Medicago sativa* L.) in cotton field (*Gossypium arboreum* L.) for the management of the green mirid bug (*Creontiades dilutes* Stal) (Mensah and Khan, 1997), alfalfa (*M. sativa*) in cotton (*G. arboretum*) to manage the *Lygus* bug (*Lygus hesperus* Knight) (Godfrey and Leigh, 1994), (Rea *et al.* 2002) etc. Hence, trap crops have the potential to manage the agricultural pest by keeping them into below the economic threshold level. However, there are handful successful control examples of trap cropping for control of 11 major insect pests in commercial scale in cotton, soybean, potato and cauliflower (Hokkanen, 1991). Trap crops have attracted more attention in developing countries where cosmetic standards for damage to cash crops are generally lower than in developed countries (Shelton and Nault, 2004).The finding can be utilized for bahavioral manipulation (e. g. trap cropping) as a component of integrated pest management strategies in open field (Hokkanen, 1991).

In summary, such a trap cropping protocol in forage brassicas potentially reduces the pesticide use while promoting multiple ES and sustainable practices, which are certainly needed for future farming. The study showed that there is ample opportunity to maintain the alyssum stripes at the edges of Brassica field to reduce the *N. huttoni* population in main field before they move onto the kale field.

Conclusion

Wheat bug is a serious Brassica insect pest in New Zealand. Pesticide use is the common practices for this management. Pesticide use is directly linked to biodiversity loss and environment pollution. Hence, use of trap crop has been realized as a good management tool for its integrated management. Alyssum plant is the best trap crop of the wheat bugs. They can be deployed in the field to reduce their damage. Alyssum has the potentiality to provide multiple ecosystem services in field. Such flowering plants also potentially provide shelter, nectar, alternative food and pollen (SNAP)to natural enemies and increase their fitness. This finding is important to develop the integrated management protocol for other brassica pest and other crop pests.

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Conflict of Interest

The author declares that there is no conflict of interest.

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