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A field study on the effects of the herbicide Tribenuron methyl on biodiversity of wheat aphids (Homoptera: Aphididae) in Mashhad, NE Iran

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Abstract

To identify the impacts of chemical control of weeds on wheat aphids community, a field experiment was conducted in a completely randomized design with two factors, each in three replicates in a 20-ha wheat field. The herbicide treatment used Tribenuron methyl, a broadleaf–selective herbicide and the control treatment not treated with herbicide. All other agricultural practices were the same for both treatments during the season. Standard weekly sampling of the aphids associated with aerial parts of wheat plants commenced a week after herbicide application and continued for seven weeks. Among the seven aphid species collected in this study, *Sitobion avenae*, *Methopolophium dirhodum* and, *Schizaphis graminum* were the most abundant species. After square root transformation and normality test, analyzing data showed greater number of aphids in herbicide treatment than in control, but this difference was not significant. However, whether these differences can be explained by differences in density and diversity of weeds needs tritrophic interaction studies: weeds-aphids and natural enemies of aphids.

Keywords: Aphids, Herbicide, Wheat field

Introduction

Vegetation diversity has been regarded as an important factor in insect population regulation, especially for phytophagous insects (Bach, 1980; Marshall et al., 2003, Perfecto, 1992). Increased plant diversity in an agroecosystem has been frequently touted as a mean of reducing herbivore populations, either by dimishing herbivore colonization and tenure-time on host plants, or bolstering natural enemy populations (Tonhasca & Byrne, 1994; Landis et al., 2000).

Improved crop management techniques including herbicides have resulted in good control of weeds and steadily increasing crop yields, but reducing the abundance of many weed species may affect associated insects and other taxa (Freeman & Boutin, 1995; Altieri, 1999). Although herbicides are not expected to harm insects significantly, at least some have been shown to affect them in several ways. Reviewing the literature on the side effects of 2, 4-D, for example, Cox (1999) noted that oat fields treated with 2, 4-D amine had more aphids than expected due to a reduction in ladybird numbers (Coccinellidae). She also cited that in a field study the number of corn-leaf aphids was twice as great on treated corn plants compared with untreated ones, and stem corn- borers were also more abundant on treated plants. Reviewing the literature, Marshall et al. (2003) concluded that "weeds have a role within agroecosystems in supporting biodiversity more generally".

Changes in the biotic components such as crop and weed of the agroecosystem can considerably influence other biotic components of the agroecosystem, e.g. insect abundance, population dynamics, and species diversity (Norris & Kogan, 2005).

Taxonomically diverse plant habitats often provide microclimates, greater availability of food sources (prey, pollen and nectar), alternative hosts, and shelter sites that encourage colonization and population build up of natural enemies. In agroecosystems, weeds may play some and perhaps all of these roles, providing diversity, ecosystem functions and supporting many other species. Wild plants within crops can be important reservoirs for beneficial insects as well as pests. But, numbers of insects recorded vary markedly between weed species, with some, such as *Veronica persica* Poiret, with very few records, whereas *Stellaria media* (L.) Vill. supports over 70 insect species (Marshall et al. 2003).

One of the commonest approaches used for reducing weeds in wheat fields in Iran is the application of a broadleaf-selective herbicide, usually 2,4-D and Granstar DF 75% (Tribenuron methyl). According to Baqestani and Zand (2003), over a period of 10 years (1980-1990) herbicide-treated areas in Iran increased

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from 500,000 ha up to two million ha. Despite this increased usage of herbicides in Iran, there has been no attempt to investigate the ecological effects of these chemicals, especially the interaction between chemical control of weeds and insect diversity and abundance. This study aimed to investigate the effects of application of the herbicide, Tribenuron methyl on diversity and abundance of aphids on aerial parts of wheat plants.

Materials and Methods

This study was conducted at the Research and Educational Farm of the Faculty of Agriculture, Ferdowsi University of Mashhad, Iran, an area of about 200 ha located 5 km east of Mashhad (59° 40' E, 36° 14'N). The experiment was conducted in a completely randomized design with two treatments, each in three replicates in a 20-ha wheat field. The experimental field was divided into six equal-sized plots (each plot about 3 ha.) which on 12 April three of which were treated with Granstar DF 75% (Tribenuron methyl, Synjenta, Switzerland), a broadleaf-selective herbicide (applied at a rate of 15 g/ha), hereafter is referred to as herbicide treatment and the other three plots were not treated with herbicide, referred to as the control treatment. All other agricultural practices during the season were the same in all treatments.

Sampling procedure

Sampling aphid density started one week after herbicide application. Samples were taken at approximately weekly intervals and continued for seven weeks. Sampling was carried out in transect at the middle of each plot. For each sample, 50 randomly chosen tillers were carefully cut down and examined for aphids.

Identification of materials

Aphids were identified using Blackman and Eastop (2000) and Hodjat and Azmayeshfard (1987) and confirmed by Dr. Rezvani at Plant Protection Research Institute, Evin Tehran.

Weed species in weedy treatment (control) were mainly Stellaria media (L) Vill., Rapistrum rugosum (L.) All, Polygonum arviculare L., Descurainia sophia (L.) Prantl, Convolvulus arvensis L, Sinapis arvensis L., Chenopodium album L. Cardaria draba (L.) Desv., Acroptilon repens (L.) Dc, Sonchus oleraceus L., Centaura sp., Alhagi camelorum Fisch., Daturea stramonium L., Portulaca oleracea L.,Phalaris minor Retz,. Secale cereale L., Avena fatua L., Cynodon dactylon (L.) Pres., Setaria spp, Cyperus rotundus L. Plant names used here are from Rashed Mohassel et al. (2002).

Data Analyses: To determine the influence of the herbicide on abundance of aphids on aerial parts of wheat plants, data were first square- root transformed to meet the assumptions of normality and homogeneity of variances. Data were then analyzed with a two-way Repeated Measures Analysis of Variance (RMANOVA) on two factors: herbicide and control were considered as treatments and time (sampling date) which were repeated seven times. The means differences were compared using Student Newman-Keuls (SNK) test. Statistical analyses were carried out using SAS (SAS Institute).

The biodiversity of aphid species in different treatments of the experiment was investigated by recording the type and abundance of species on the basis of Margalef's index (Charlotte, 2007).The equation for this index is: $D_m = (S-1) / Ln (N)$. where S is number of species and N is total of all individuals present in the sample.

Results and Discussion

During this study, 7 aphid species were collected and identified as follows: *Sitobion avenae* (Fab.), *Metapolophium dirrhodum* (Walker), *Schizaphis graminum* (Rondani), *Diuraphis noxia* (Mordvilko), *Rhopalosiphum padi* (L.), *Rhopalasiphum maidis* (Fitch), and *Sipha maydis* (Passerini).

The results showed no difference between two treatments in terms of aphid species diversity, except in case, *Sipha maydis* which was found only in Control plots.

In terms of aphid abundance, overall mean aphids density in herbicide treatment (97.04/sample) was higher than that the control one (63.4/sample). However, RMANOVA revealed no significant differences between treatments (Table 1). Only on 3rd, 4th and 6th census dates mean aphid density in herbicide treatment was significantly higher than the control treatment. The aphid population in both treatments gradually increased prior to late May, but from that date the number of aphids decreased, probably due to approaching the harvest time and adverse quality of host plants. The differences in the mean values among the different levels of date were greater than would be expected by chance after allowing for effects of differences in treatment (P= 0.0001). Also, there was not a statistically significant interaction between treatment and date (P = 0.264).

Among the aphid species found in the study site, 6 species were common between herbicide treated and untreated plots. Among them, *Sitobion avenae* (Fab.) with (51%) of the collected individuals of aphids was the most abundant aphid in both treatments, followed by *Metapolophium dirrhodum* (Walker) (21%) and *Schizaphis graminum* (Rondani) (13%). Populations of other species were very low (15%). Biodiversity which takes into account the number of species present, as well as the abundance of each species, was measured for each sampling date. As seen in Figure 1, the index of biodiversity in control plots throughout sampling period was slightly higher than that of herbicide plots. The maximum value of biodiversity obtained for the control plots on 24 May. However, the index in herbicide plots also increased towards end of sampling period.

Table 1- The Two Way Repeated Measures Analysis of Variance on number of aphids per sample (square root transformed data) in herbicide treated and untreated plots over seven sampling dates.

Source of Variance	df	SS	MS	F	P
Subject	**2**	**3.30**	**1.65**		
Treatment	1	29.26	29.26	1.67	0.3249 ns
Treatment × subject	2	34.95	17.47		
Date	6	630.53	105.09	22.38	<0.001**
Date × subject	12	55.24	4.60		
Treatment × date	6	53.74	8.96	1.48	0.2642ns
Residual	12	72.52	6.04		
Total	41	879.54	21.45		

Ns: non significant, ** = p < 0.01.

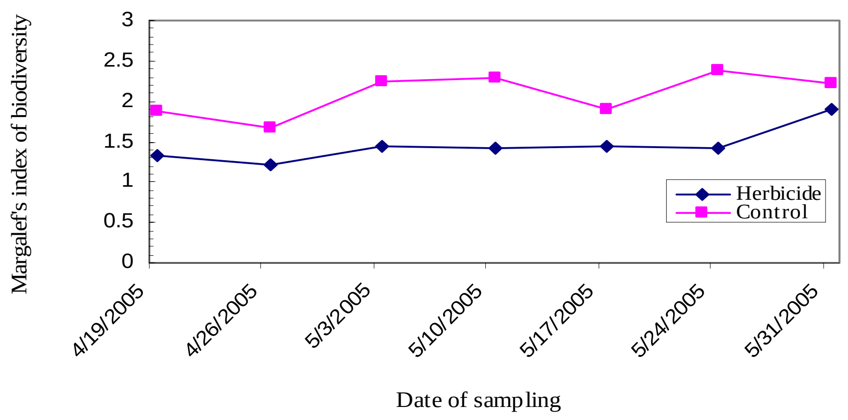

Fig. 1- Dynamics of biodiversity index of aphid species during sampling period in a wheat field in Mashhad (NE Iran)

(2001) demonstrated effects of glufosinate-ammonium at concentrations used in orchards on different life stages of several predatory arthropods. It seems that impacts of herbicides on insects to be mostly indirect effects, mediated through the weed flora.

The protection of the farmer's investment and avoidance of risk have been the driving forces for efficient weed control. However, a new paradigm is to match crop protection with conservation of biological resources and the development of more sustainable systems. Reviewing the literature indicate that certain weeds, such as *Poa annua* L. and *Polygonum aviculare* are more important for biodiversity in arable systems than other weeds, such as *Alopecurus myosuroides* and *Veronica persica* (Marshall et al., 2003). Moreover, some weeds(e.g., *Stellaria media*, *Rapistrum rugosum*, *Convolvulus arvensis*, *Sonchus oleraceus* and *Polygonum aviculare*) might be considered as attractive to beneficial insects and hence worth being cautious about their complete removal from crops, especially in cases such as *Stellaria media* that harbours over 70

The results showed that aphid density in herbicide plots where the diversity and abundance of some vegetations (weeds) was reduced by using herbicide over all sampling times was higher than that the control ones, but the difference between two treatments was less than that cited by some authors (e.g., Cox, 1999). As a reason, it was observed that the herbicide used in this experiment had no effect on grass weeds, and also little effect on some weed species such as C*onvolvulus arvensis*, *Cardaria draba*, *Acroptilon repens* and *Alhagi camelorum*. Moreover, this experiment used herbicide once and early in spring, so the time and number of herbicide application might be not proper or enough and these allowed some weeds grow later in herbicide plots and might be the cause of reducing floral differences between treatments. Also, it is suggested that the higher number of aphids in herbicide treated plots compared with the control ones could, in part, be a response to a reduction in number of aphidophagous insects in herbicide treated plots (Sadeghi, 2007). Direct effects of herbicides on insect species are rare; however Ahn et al.

insect species and is not a strong competitor with crops (Marshall et al., 2003). However, it should be noticed that some flowering plants might be attractive to both pests and beneficial insects.

Although some weed species are strongly preferred by natural enemies (Cowgil et al., 1993a), it is not practical to leave flowering weeds at high densities in crops. However, selective herbicides may be used as ecological tools to leave only some broad-leaved weeds. This conservation approach has had significant conservation benefits in farmland in Europe (Cowgil et al., 1993b). Also, a more relaxed weed control would allow the less competitive species to increase, while controlling the competitive species.

This study did not evaluate the impact of weed competition on crops, or the relative attractiveness of these weeds to natural enemies of aphids, understanding the relationship between weeds and insects needs more detailed studies at three levels: weeds-aphids-aphidophagous insects.

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