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THE BIOLOGY OF *PORPHYROPHORA TRITICI* (HEMIPTERA: COCCOIDEA: MARGARODIDAE) AND THE EFFECT OF SOME FARMING PRACTICES ON ITS POPULATIONS IN KERMANSHAH, IRAN.

ABSTRACT

THE BIOLOGY OF *PORPHYROPHORA TRITICI* (HEMIPTERA: COCCOIDEA: MARGARODIDAE) AND THE EFFECT OF SOME FARMING PRACTICES ON ITS POPULATIONS IN KERMANSHAH, IRAN.

This paper describes the life cycle of *Porphyrophora tritici* Bodenheimer on wheat in the Kermanshah region of Iran, and the effect of various farming practices (irrigation, harvesting, rotations and time of ploughing) on its survival. It is concluded that the manipulation of the time of ploughing may be the most economical management method of those tried.

Key words: barley, control, weeding, natural enemies, *Lithophylus* sp., ground pearls, damage, grazing.

INTRODUCTION

Porphyrophora tritici Bodenheimer (Hemiptera: Coccoidea: Margarodidae) is one of the "ground pearls", a name which refers to the 2nd-instar nymph which forms a protective cyst (the "pearl") on the root-collar of plants. *P. tritici* is a pest of wheat and barley in the Mediterranean, North Africa and Western Asia and is particularly important in Iran, Turkey and Syria, where, in some years, it causes stunting or death of shoots of wheat and barley grown on non-irrigated fields (Borchsenius, 1973; Duran, 1971; Miller, 1992; Shojaei & Bahador, 1987; Vahedi, 1992). *P. tritici* infests 95% of the barley in Syria and sometimes causes losses of more than 40% in winter wheat (grain and forage) in Iran (Safar-Alizadae & Bahador, 1987), where it has spread across the arid wheat and barley growing areas in the West (Vahedi, 1992).

Infestations of *P. tritici* are highly unpredictable, both between fields and between localities, with widespread heavy infestations in some years while, in other years, very limited and isolated populations have been found (Miller & Jones, 1998; Vahedi, 1992). Cultivation using disc-harrows has been found to decrease infestations by 95% (Miller & Jones, 1998). Crop rotation has also been found to reduce populations (Miller *et al.*, 1994).

LIFE CYCLE

P. tritici is a univoltine species. It overwinters as crawlers within the dry body of the adult female in a ovisac in the subsoil at a depth of about 4cm. Early in the spring (generally in late March in Iran), the crawlers emerge from the ovisac and disperse to the soil surface, where they settle at the base of the root-collar between the leaf-sheaths of seedlings of some grass and weed species and start feeding. At this stage, the wheat is near the end of the tillering stage and stem extension is just starting. As the 1st-instar nymphs feed, they becomes paler. By late April, the female nymphs have moulted to form the 2nd-instar cyst stage, which initially has well-developed legs and antennae but these appear to shrink with age. The cyst is covered in a thin, shiny brown wax, and is rather brittle and easily crushed. The emergence of the adults is closely linked to plant phenology, with maximum growth of the cyst-stage occurring when the cereal hosts are entering the milk-ripening stage. Thus, in grassland where the plants develop rather earlier, the emergence of the adults is also earlier. The reddish adult females emerge from the cyst stage in late April or early May and lack mouthparts and so they cannot feed. Thus, there appears to be three female stages.

During male development, only the 1st- and 2nd-instars feed, all later stages lacking mouthparts. Two to three days after forming the glassy puparium some 3-4cm down in the soil near the roots, the 2nd-instar males moult to form the prepupa and then, after a further 2-3 days, they again moult to give the pupa. The adult males emerge 2 to 3 days later and thus there are 5 male stages. The red adult males are weak fliers and live for about 3-4 days. The mature adults (male and female) usually appear in early May prior to the ripening of the wheat.

Shortly after mating, the female retreats underground to a depth of about 4cm, where she produces white wax filaments to form an ovisac into which the eggs are laid (mean preoviposition period 7 days; mean oviposition period 8 days). Each female lays about 200 eggs. Sandy-clay or light soils are preferred for egg-laying. The eggs hatch after about 3-4 months and the reddish, first-stage nymphs then overwinter within the ovisac and in the space made free by the shrinking of the abdomen of the dead female. Young wheat plants or tillers become stunted if initially infected by more than two nymphs but appear unaffected by a single nymph. Maximum damage is done at the seedling stage by the 2nd-instar cyst and plants at the third-leaf stage may be killed outright. Heavily infested fields have reduced yields, with poor quality grain.

Time of ploughing

Because the crawlers which emerge in the spring quickly colonise suitable plants, any crop or volunteer hosts which are present at this time quickly become infected. Therefore, this experiment looked at the time of ploughing on the survival of the crawlers. The trial had three ploughing dates and a control (unploughed). After ploughing, the ground was left fallow until the following autumn, when it was planted to wheat. In the spring of the following year (about 12 months after ploughing), five plants from each of four $1m^2$ plots from each treatment were sampled and the number of *P. tritici* counted.

Table 1. Mean ± SE *P. tritici* per 20 plants/treatment on winter wheat approximately one year after ploughing on three dates and an unploughed control.

Dates of ploughing	24th March	4th April	14th April	Unploughed control
Means/20 plants the following year	4.0 (0.913)	3.8 (0.75)	7.25 (0.63)	7.75 (0.63)

Table 1 summarises the results. There was a significant ($P<0.01$) increase in the number of *P. tritici* present on the plants when ploughed after the 4^{th} April, suggesting that early ploughing, followed by a fallow period, could substantially reduce the population. In addition, it is considered that delaying ploughing until late April (i.e. until later than the latest date in Table 1) might allow the crawlers to colonise volunteer plants and to moult to the cyst stage before being ploughed in, again providing good potential control through starvation as the cyst-stage cannot move.

Irrigation

Because some winter wheat crops in Iran are irrigated, this experiment was designed to see what effect irrigation might have on the *P. tritici* populations. Ten $1m^2$ plots were marked out, five in an area which was flood irrigated along furrows, so that the soil was wet to about 10cm, and five in a non-irrigated area nearby. All irrigated plots were irrigated on the 4^{th} April and then 10 plants were sampled from plot 1 and from a control plot; plots 2-5 were then irrigated a second time on 9th April and plot 2 (and the corresponding control plot) sampled on 14th April; plots 3-5 were then irrigated a third time on 14th April and sampled on the 19th April, and so on (see Table 2).

Table 2. Number of *P. tritici* cysts per 10 winter wheat plants (at the end of tillering stage) in five irrigated and five non-irrigated plots, Kermanshah, Iran, 1990.

Date irrigated	4 April	9 April	14 April	19 April	24 April	Overall Mean
Date sampled	4 April	14 April	19 April	24 April	29 April	
Irrigated	15.0	19.5	23.5	18.0	18.5	17.0
Non-Irrigated	14.0	17.0	24.0	19.0	17.5	17.5

ANOVA tests on these data for the two treatments showed that there were no significant effects from irrigation ($P>0.05$). However, as *P. tritici* is at the cyst stage in April, this is perhaps not surprising. Indeed, it might even be that the increased growth of the host-plants caused by irrigation could improve the quality of the sap for the scale. Populations in warm wet seasons have been reported to be greater than in warm dry seasons (Sevumian & Sarkisov, 1981).

Harvesting

The efficiency of harvesting can have a marked effect on subsequent populations, because inefficient harvesting implies more volunteer plants the next spring. Two methods of harvesting are commonly used in Iran - traditional hand harvesting and mechanical harvesting using old combine harvesters. The latter methodology is much less clean and is followed by numerous volunteer plants. These methodologies were compared in 1993 to see what effect they had on subsequent populations of *P. tritici.* The results, in terms of the number of subsequent volunteer plants in field trials in 1994, are shown in Table 3. It is clear that combine harvesting was inefficient and was followed by substantially more volunteer plants than when the grain was harvested by hand ($P<0.05$).

Rotations

Rotations have been shown to have a significant effect on *P. tritici* populations (Miller *et al.*, 1994) in northern Syria. The effect of rotations was studied in Kermanshah in small plots (10m x 2m) with the following rotations: (a) Wheat/Peas/Wheat; (b) Wheat/Spring-wheat/Wheat, and (c) Wheat/Sunflower/Wheat. The populations in the initial wheat crops were similar (Table 4) and so the purpose of the experiment was to see what effect the intervening crops (peas and sunflowers = non-host crops; spring wheat = host crop) would have on the populations in the final wheat crops. Whilst the differences between the three treatments were not significantly different (P>0.05), there was a trend towards more *P. tritici* in the rotation with continuous wheat. The reasons why there is no apparent reduction in the plots with non-hosts is unclear.

Table 3. Mean number of volunteer plants per m^2 in wheat plots in 4 fields in Kermanshah, Iran, 1994, which had been either combine or hand harvested. Five $1m^2$ plots were sampled per treatment per field.

Harvesting method	Field 1	Field 2	Field 3	Field 4	Mean
Combine	174	203	192	211	195
Hand	16	10	26	-	17.3

(where - = no data available)

Table 4. Effect of three rotations on subsequent *P. tritici* populations: all plots had wheat in 1992, followed by either peas or sunflowers (non-hosts of *P. tritici*) or spring wheat (a host of *P. tritici*) in 1993; all plots were sown to wheat in 1994. Data = mean number of *P. tritici* per plot (4 plots per treatment) in 1994. The final populations in 1994 did not differ at P<0.05.

	Intervening crop		
	Peas (non-host)	Sunflower (non-host)	Spring wheat (host)
Initial population (1992)	6.1	4.7	5.2
Subsequent pop. (1994)	4.9	5.0	7.3

NATURAL ENEMIES

P. tritici has some natural enemies, among which is the coccinellid predator *Lithophylus* sp. (Lithophylinae). In Kermanshah, Iran, this coccinellid has substantially reduced *P.tritici* populations at times but, like most predators, it is most effective when prey is abundant.

DISCUSSION AND CONCLUSIONS

P. tritici appears to be spreading through the wheat production areas of Iran where it can cause serious loss (>40%) in some years when there are large populations. This paper describes the biology of *P. tritici* in the Kermanshah region of Iran. As with most other *Porphyrophora* species for which the life cycle is known, it has one generation per year. The damage is caused mainly by the cyst stage, which feeds on the root collar between the leaf-sheaths of the cereal host (mainly wheat and barley).

The effects of various farming practices on *P. tritici* were studied on experimental plots. Factors considered to be particularly important were the timing of ploughing and the number of volunteer seedlings available at the time when crawlers were emerging from their overwintering site in the soil. It was found that the early ploughing in of volunteer plants gave smaller populations in subsequent crops. However, it is also thought that if ploughing was left until late in the spring, the population would also be significantly reduced because the cyst stage would be starved. It was also found that, after combine harvesting, there were many more volunteer plants than after hand harvesting, which tends to be more efficient. Improving the efficiency of the combine harvesters might therefore help, as there would then be fewer volunteer plants in the spring.

Other farming practices considered were rotations and the effect of irrigation. In neither case was there apparently any significant effect. However, in the case of rotations, there was a suggestion that the plots with continuous cereals did have a larger population, although there was not the expected reduction following non-host crops. Rotations had been found to reduce *P. tritici* populations in northern Syria (Miller *et al.*, 1994). With regard to the irrigation experiment, it is possible that, as the irrigation was applied in April when *P. tritici* would have been at the early cyst stage, the lack of an effect was probably because this stage could survive the short periods of irrigation while the plant hosts might have improved qualitatively.

Another cultural factor which could have a significant effect is grazing. When sheep and goats feed on the volunteer plants, it was observed that they tended to tear the young seedlings out of the ground and that this reduced the population of volunteer plants by as much as 90%. Although this was not tested, it is considered that this not only reduced the number of plants available for colonisation by the dispersing crawlers but removed already infested plants as well.

While pesticides have been recommended for the control of *P. tritici* (Duran, 1971), it is here considered that the manipulation of ploughing times could be very effective and much cheaper.

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