Crop Rotation Effects on Populations of *Porphyrophora tritici* (Bodenheimer) (Homoptera: Margarodidae) in Barley in Northern Syria

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Abstract

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A survey of *Porphyrophora tritici* Bodenheimer was conducted in three long term barley trials in a marginal rainfall environment in northern Syria in which barley was grown every year or was alternated with forage legumes or a clean fallow. Significant differences were noted between densities of second instar cysts on plants among the different rotation schemes. Continuously planted barley was most severely infested by *P. tritici*, followed by rotations of barley-legume and barley-fallow, respectively. Fertilizer applications and tillage schemes employed in the three rotation studies were not correlated with *P. tritici* populations. *P. tritici* infestations in marginal rainfed environments may be managed or prevented from causing economic loss by using either a forage legume or clean fallow to disrupt barley monocultures. For crop rotation to be practical in marginal environments, an acceptable forage legume must be developed as an alternative to barley to permit farmers of low rainfall environments to maintain animals even in drought years.

Key words: Barley, crop rotation, ground pearl, Syria.

Introduction

One of the most serious insect pest problems observed in rainfed wheat and barley in marginal areas is that of the ground pearls, *Porphyrophora tritici* (Bodenheimer) (Homoptera: Margarodidae). Infestations of *P. tritici* have been noted in fields in central Turkey (5) and in barley monocultures in northern Syria (2). Particularly extensive and severe *P. tritici* infestations have occurred in northern Syria in areas receiving 200 to 250 mm annual rainfall, where it currently infests over 100,000 ha. *P. tritici* infestations vary greatly among locations, and may affect 100% of plants in the most severe cases. Insect density per plant also may vary greatly within an infested field. Densities of 5 to 12 insects/plant may be sufficient to kill the plant, depending upon the vigor of the host (2). This threshold may be lowered when pathogens, drought, and low winter temperatures occur during the same season.

P. tritici reproduces both sexually and parthenogenetically (1). Oversummering eggs hatch and larvae emerge from the soil and move onto cereal seedlings in December or January. *P. tritici* feed by sucking fluids from the plant and may be found underneath leaves at the base of tillers. About mid-April the larvae enter a second instar cyst stage, while remaining attached to the crown of the plant. Adults emerge in late May or June. Females burrow into the soil and form an oviposition chamber lined with white wax filaments. A single female may lay from 30 to 330 eggs which hatch the following winter.

Several factors may promote *P. tritici* populations. These include 1) cereal monocultures consisting of continuously planted barley or wheat planted after barley, 2) stubble left in the field after harvest, and 3) planting in marginal environments where plants are subjected to stress.

This paper describes the effects of different rotation schemes on established *P. tritici* infestations in northern Syria, and discusses the necessity of using crop rotation as a pest management tool.

Materials and Methods

Five randomly chosen barley plants were collected from 222 individual barley plots planted in 1993/94 in three separate long-term barley rotation trials where *P. tritici* had been observed in 1987. Plants were collected in the field from 11 to 13 April, 1994, and were immediately dissected in the laboratory where the presence and developmental stage of *P. tritici* was recorded. First and second instars were pooled to compute the number of *P. tritici* per plant.

The barley rotation trials are located on ICARDA's experimental farm near the village of Breda, about 40 km southeast of Aleppo. This area is characterized by an annual rainfall of 280 mm, falling primarily between the months of October and May. In 1993/94, 290 mm were recorded. Soils in the study area are calcareous clays (calcixerollic xerechrepts), varying in depth from 1.2 m to > 2 m.

Each trial had a unique rotation scheme. In Rotation Trial 1 the barley cultivar, Tadmor, was sown at 90 kg/ha and alternated each year with a clean fallow. The experimental plots measured 6.5 X 12.5 m. Treatments applied to individual plots were initially assigned randomly, and subsequently rotated between fallow and barley since establishment of the trial for the 1986/87 cropping season. Nitrogen, in the form of ammonium nitrate (NH_4NO_3) and triple superphosphate fertilizer were applied to the plots in the barley phase at 0, 60, and 120 kg N/ha and 0, 45, and 90 kg P_2O_5/ha, respectively.

Rotation Trial 2 was established during the 1982/83 cropping season. In this trial the barley variety Arabi Aswad, sown at 90 kg/ha, was alternated with a legume. The legumes used were either *Lathyrus sativus* L. or *Vicia narbonensis* L. sown at 150 kg/ha, or *Vicia sativa* L. sown at 120 kg/ha. Plots measured 6.5 X 12.5 m. Nitrogen and phosphate were applied in the barley phase at rates of 0, 20, and 40 kg N/ha and 0 and 60 kg P_2O_5/ha, respectively.

Rotation Trial 3 was initiated in 1989/90. Rotation schemes incorporated into it were continuous barley and barley followed by a vetch. The barley variety Arabi Aswad was sown at 100 kg/ha. *V. sativa* was sown alternately with barley at 120 kg/ha. Plot size was 12.5 X 45 m. Nitrogen and phosphate were applied to the barley at rates of 0, 20, and 40 kg N/ha and 0 and 60 kg P_2O_5/ha, respectively.

A tillage and residue management sequence, not used in Rotation Trials 1 or 2, was superimposed on Rotation Trial 3. Five treatments consisting of removing or leaving straw, grazing or leaving stubble, and cultivating in June or October, or no tilling were employed.

Rotation trials 1 and 2 have also been planted at ICARDA's main research headquarters near Tel Hadya, Syria, about 30 km south of Aleppo (elevation 284 m; 36° 01'N, 36° 56'E; 330 mm mean rainfall). No *P. tritici* was found in these trials and they were not intensively sampled.

Statistical analyses were performed using ANOVA as described for the SAS GLM Procedure (3). Duncan's multiple range tests were performed on main effect means that were significantly different at $P \leq 0.05$.

Results and Discussion

There were minor differences in the mean number of *P. tritici* per plant between rotation trials (Table 1). Very few first instar *P. tritici* were collected, most insects being second instar cysts. Plant development, measured according to Zadoks, *et al.* (6), ranged from 38 to 40 and did not influence insect densities.

Table 1. Number of *P. tritici* per plant (mean±SE) and plant developmental stage at time of sampling.

	1st Instar Larvae	2nd Instar Cysts	Plant Development (Zadoks *et al.*, 1974)
Rotation Trial 1	0.00	4.12±0.24	39
Rotation Trial 2	0.00	5.93±0.20	40
Rotation Trial 3	0.23±0.03	5.97±0.23	38
Pooled Trial Data	0.09±0.02	5.41±0.13	39

There were some significant differences observed in the number of *P. tritici* per plant between rotation treatments within a rotation trial (Table 2). Plots continuously planted to barley experienced the highest *P. tritici* infestations in all three rotation trials. Barley plots following a legume rotation or a clean fallow were consistently less heavily infested and did not differ significantly either in Rotation Trial 2, which contained continuous barley, barley-legume, and barley-fallow rotations or when data from all three rotation trials were pooled. The barley-legume rotation had significantly lower *P. tritici* density per plant than the continuous barley in Rotation Trial 3. Differences in insect densities between continuously planted barley and the barley-fallow rotation in Rotation Trial 1 were not significant, although the continuous barley rotation was higher than the rotation containing a fallow.

There were significant differences in the mean number of *P. tritici* per plant in plots with different application rates of N and P_2O_5 (Table 2). However, these differences were not correlated with application rate of the fertilizer and the effect of fertilizer rate on *P. tritici*, if any, is not clear.

There was a significant difference in *P. tritici* per plant between Trt 1 and Trt2, and Trt 5 in Rotation Trial 3 (Table 3). In Trt 1, straw was removed and no grazing or tillage occurred. Trt 2 differed from Trt 1 only in that tillage occurred in October. Tillage also occurred in October and straw was removed in Trt 5, but the stubble was removed as well. Two diametrically opposed tillage schemes did not differ in their effect on *P. tritici*. Trt 3, in which straw was not removed and no grazing or tillage occurred, experienced the same average second instar cyst density as Trt 4 in which straw was removed, the stubble grazed, and tillage occurred in June when females were ovipositing under the soil surface. Differences among other tillage schemes were not significant. One would expect that tillage would cause egg and larval mortality in the soil, reflected in a decreased insect density the following cropping season. However, this was not observed in the present study.

Results of this study suggest that barley grown in monoculture, especially that grown in relatively low rainfall environments, is more susceptible to *P. tritici* than barley grown in a rotation with appropriate legumes or a clean fallow. These results also suggest that current infestations of *P. tritici* in low rainfall environments may be susceptible to management by fallowing or introducing

Table 2. Results of ANOVA showing plant density differences[1] in first instar and second instar cysts in plots with different rotations and fertilizer levels.

Crop Rotation

Rotation Trial 1		Rotation Trial 2		Rotation Trial 3		Pooled Data	
BB	4.3a	BB	7.9a	BB	8.0a	BB	6.4a
BF	3.2a	BL	5.5b	BL	2.6b	BL	4.4b
		BF	5.1b			BF	3.9b

NH_4NO_3 Application (kg/ha in 1993/94)

Rotation Trial 1		Rotation Trial 2		Rotation Trial 3		Pooled Data	
N_0	4.8a	N_{20}	7.7a	N_{20}	6.6a	N_{20}	7.0a
N_{120}	4.3a	N_{40}	5.8b	N_0	6.0a	N_{40}	5.5b
N_{60}	2.9b	N_0	5.2b	N_{40}	5.4a	N_0	5.4b
						N_{120}	4.3c
						N_{60}	2.9d

P_2O_5 Application (kg/ha in 1993/94)

Rotation Trial 1		Rotation Trial 2		Rotation Trial 3		Pooled Data	
P_{90}	5.0a	P_{60}	6.6a	P_0	6.1a	P_{60}	6.2a
P_{45}	4.4a	P_0	4.8a	P_{60}	5.9a	P_{90}	5.0b
P_0	3.0b					P_0	4.7b
						P_{45}	4.4b

[1]means follwed by the same letter are not significantly different at $P \leq 0.05$. BB=barley-barley, BL=barley-legume, BF=barley-fallow.

Table 3. The effect of tillage schemes, and straw and stubble management schemes employed in Rotation Trial 3 on the mean number of *P. tritici* per plant.

Treatment	*P. tritici*
1: Straw removed, no grazing, no tillage	7.1a[1]
2: Straw removed, no grazing, tillage in October	6.0a
3: Straw not removed, no grazing, no tillage	5.8ab
4: Straw removed, stubble grazed, tillage in June	5.8ab
5: Straw removed, stubble grazed, tillage in October	5.1b

[1]means followed by the same letter are not significantly different at $P \leq 0.05$.

a legume crop between barley plantings.

Currently in northern Syria, farmers in low rainfall environments often plant barley year after year, harvesting grain during good rainfall years and grazing stubble with sheep every year. Because the value of the barley as forage equals or frequently exceeds that of barley grain, there is little incentive for the farmer to not grow barley. This situation is exacerbated by the lack of forage legumes with sufficient drought stress to provide adequate sheep forage during years of drought. In current practice barley is still more profitable to grow than other crops or than leaving the ground fallow, even though barley grain may not be produced and the quality and quantity of the straw that is produced may be lowered by drought and *P. tritici*. Chemical insecticides, which have been shown effective against *P. tritici* in parts of southeastern Turkey adjacent to *P. tritici*-infested areas of northern Syria (1) are not economically feasible for use by Syrian farmers (4). Government policies seeking to maximize wheat and barley production through monoculture compound the problem. Research is being undertaken to identify a forage legume with sufficient drought tolerance to provide adequate fodder for sheep during drought and normal rainfall years.

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الملخص

ميللر، روس، هيزل هاريس ومايكل جونز. 1994. أثر الدورة الزراعية في مجتمعات لآلئ الأرض على الشعير في شمالي سورية. مجلة وقاية النبات العربية. 12 (1): 79-75

تم إجراء مسح لتفشي لآلئ الأرض (*Porphyrophora tritici*) في ثلاث تجارب طويلة الأمد لزراعة الشعير في المناطق الهامشية المطرية في شمالي سورية، حيث كان يزرع الشعير كل عام، أو متناوباً مع محصول بقولي علفي أو متناوباً مع البور. وقد لوحظت فروقات معنوية بين كثافات حويصلات الطور الثاني على النباتات في الدورات المختلفة. حيث كانت الزراعات المتكررة للشعير أعلاها إصابة بلآلئ الأرض، مقارنة مع دورة الشعير - محصول علفي والشعير - بور. ولم يكن هناك ارتباط ما بين استخدام الأسمدة وعمليات الحراثة، المتبعة بالدورات الثلاثة، وكثافة مجتمعات الحشرة. وعليه يمكن إدارة مجتمعات *P. tritici* أو منعها من إحداث خسائر إقتصادية، في البيئات المطرية الهامشية، بإدخال محصول رعوي للدورة أو ترك الأرض بوراً لقطع الزراعة المستمرة للشعير. وحتى تكون الدورة الزراعية عملية في المناطق الهامشية، لابد من تطوير محصول علفي كبديل للشعير، بغية توفير مصدر غذائي للحيوانات التي يمتلكها الزراع في المناطق ذات الهطل المطري المنخفض، وبخاصة في السنوات الجافة.

كلمات مفتاحية: لآلئ الأرض، دورة زراعية، شعير، سورية.

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