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PLANT PROTECTION

Development of the Cereal Cyst Nematode on Wheat and Barley under Field Conditions in Central Saudi Arabia

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Abstract. The development of the cereal cyst nematode (CCN), *Heterodera avenae*, on wheat cv. Yecora Rojo and barley cv. Justo was studied in the field in central Saudi Arabia. Second-stage juveniles (J_2) were observed in the roots of both hosts within the first week of sowing. However, presence of J_2 in wheat roots continued for about two months after sowing, whereas in barley roots were only for 20 days. Subsequent development of CCN (J_3, J_4, adult females & white cysts) was faster on barley than on wheat by 5-14 days. The nematode life cycle was completed within 74 and 64 days after sowing on wheat and barley roots, respectively.

Keywords : Cereal cyst nematode, *Heterodera avenae*, life cycle, field study, Saudi Arabia.

Introduction

The cereal cyst nematode (CCN) , *Heterodera avenae* Woll. 1924, was detected attacking wheat and barley in different regions of Saudi Arabia in recent years [1-4]. It soon became very damaging pathogen [3-6]. All wheat and barley cultivars grown in Saudi Arabia were found to be susceptible to this nematode [3,4]. Life history of *H. avenae* on cereals has been studied by several workers in different parts of the world. The mean period reported between juvenile invasion of cereal roots and appearance of white cysts of *H. avenae* was 70 days [7-11]. However, studies on life cycle of *H. avenae* on wheat and barley under field conditions are very rare. Sabova *et al.* [12] studied the life cycle of *H. avenae* on winter wheat under field conditions in Slovakia. They noticed that the nematode development (from J_2 to white cysts) lasted 84 days in a year but required only 63 days in the next year when the climate was exceptionally warm and dry. The present study reports the development of *H. avenae* on wheat and barley under field conditions in central Saudi Arabia.

Materials and Methods

The development of *H. avenae* in root tissues of wheat cv. Yecora Rojo and barley cv. Justo was studied under field conditions in central Saudi Arabia. For each crop, a naturally-infested field was chosen in Al-Kharj , a large agricultural region near Riyadh in central Saudi Arabia, (Latitude: N 24° 05-N 24° 15; Longitude: E47° 05-E47° 05; Altitude: 450m). Air and soil temperatures, relative humidity and precipitation in Al-Kharj region during the period of study are summarized in Table 1. The initial populations of nematodes in the chosen wheat and barley fields were 122 and 136 cysts/250 g soil, respectively. After emergence, a sample of 12 plants was carefully collected from each field at about weekly intervals until the end of study. Roots were carefully washed free of soil, examined under a stereomicroscope for the presence of white females and / or cysts, and then fixed in FAA solution (40% formalin,1 ml ; glacial acetic acid,1 ml ; 50 % ethanol,18 ml). Later on, roots were washed in water for 1 hr, and stained with acid fuchsin in lactophenol as described by Hussey [13, pp. 190-193]. After cooling at room temperature, roots were drained and rinsed in tap water for about 1 hr. The roots were then placed in 20-30 ml of glycerin acidified with a few drops of 5 N HCl and heated for destaining until the nematodes became brightly stained and the roots were clear. Roots were finally kept in acidified glycerin until they were examined. At examination, roots were lightly pressed between two glass slides in glycerin and examined under the compound microscope for observation of nematode developmental stages.

Table 1. Monthly means of some climatic data in Al-Kharj Governorate during the period of study

Month	Air temperature (°C)			Relative humidity (%)			Soil temperature (°C)				Precipitation (mm)
	Max.	Min.	Avg.	Max.	Min.	Avg.	5 cm	10 cm	20 cm	50 cm	Avg.
Nov.	18.0	9.5	14.0	85	51	68	19.0	19.7	21.0	24.0	1.8
Dec.	17.0	9.2	20.0	57	23	40	16.5	15.5	17.0	20.0	80.6
Jan.	20.0	8.5	14.0	64	34	49	13.0	13.0	15.0	17.0	52.4
Feb.	25.0	10.0	17.5	74	22	48	17.0	16.0	18.0	19.0	0.0
Mar.	29.0	14.0	21.5	73	23	48	20.0	20.0	22.0	23.0	67.0
Apr.	33.0	16.0	25.0	65	18	42	24.0	23.0	24.0	25.0	1.5

* Source : Min. Agric &Water, Riyadh, Saudi Arabia. Dept. Water Resources Dev. (Station # R 002).

Results

Second-stage juveniles (J_2) were observed inside wheat and barley roots within the first week of sowing (Table 2). Penetration sites were mostly located at or behind the root tips (Fig. 1A). Some juveniles completely penetrated the root cortex paralleling to the longitudinal axis or crossing it with their heads near or in the vascular system (Fig. 1B-D).

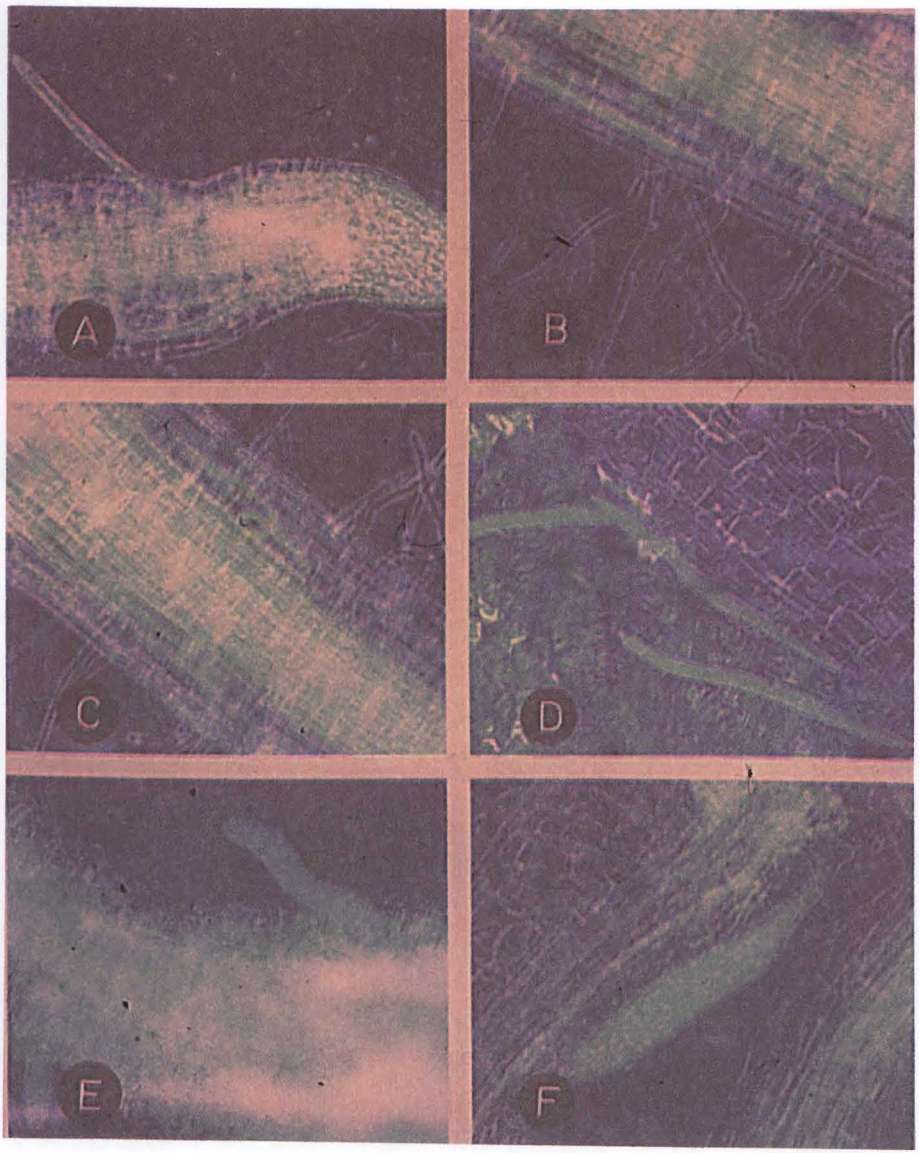

Fig. 1. The developmental stages of *Heterodera avenae* on wheat. A) J_2 penetrating behind root tip. B, C) J_2 within root cortex with heads near the stele. D) J_2 inside the root tip meristem. E) J_3 attatched to the root, and half body partly protruding out. F) Late J_3 completely inside the root.

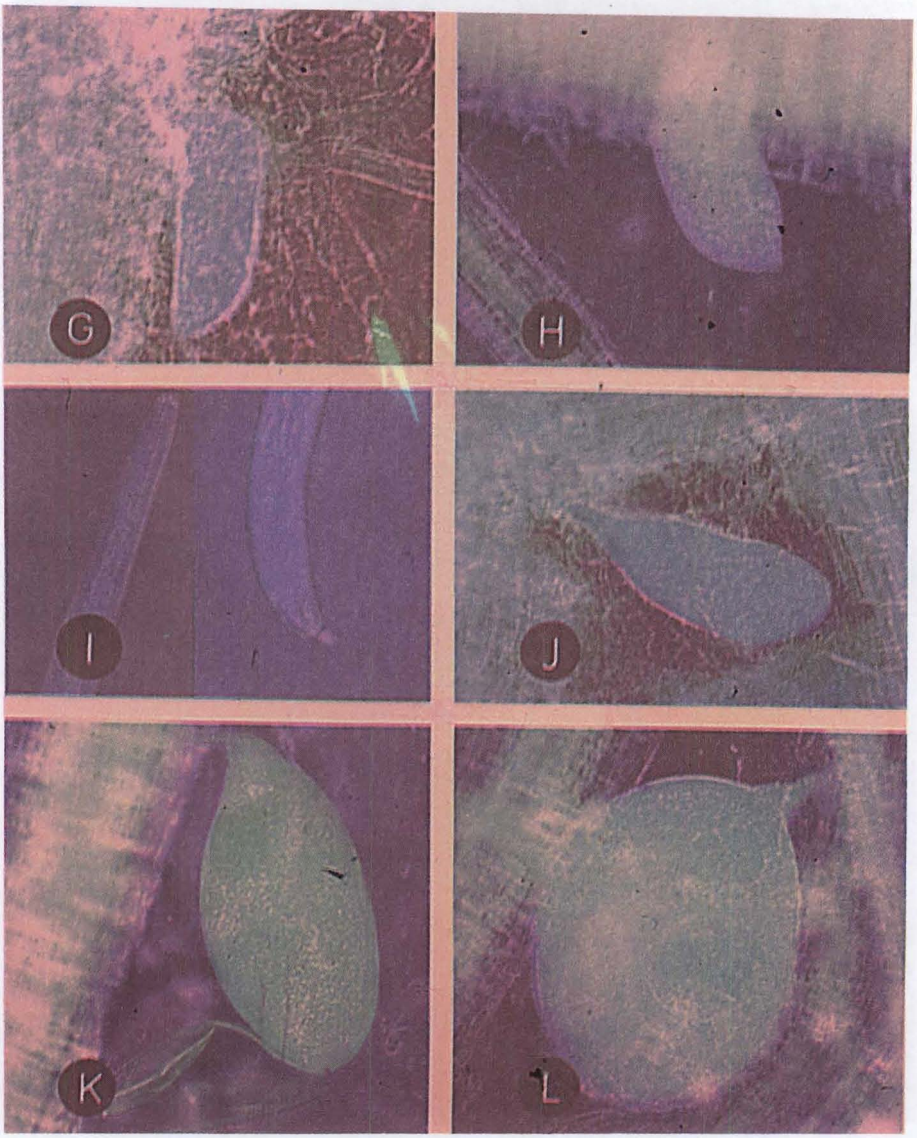

Fig 2. Contin. G) Flask-shaped J_4 inside root cortex. H) late J_4 with half body protruding out of the root. I) Anterior and posterior ends of a male. J) young female. K, L) White (gravid) female and white cyst attatched to the root.

Presence of J_2 in wheat roots continued for about two months after sowing, whereas in barley roots J_2 were observed only for 20 days (Table 2).

Table 2. Development of *Heterodera avenae* on wheat cv. Yecora Rojo and barley cv. Justo under field conditions

Devlopmental stage	Days after sowing*	
	Wheat	Barley
Second-stage juv.	7** - 56	7 - 20
Third-stage juv.	19 - 56	15 - end
Fourth-stage juv.	37 - 56	27 - end
Male	49	42 - end
Adult female	49 - 56	42 - end
Gravid female	56 - 74	49 - end
White cyst	74	64

* Date of sowing: barley, Nov. 20 th ; wheat, Dec. 17 th.
** First observed.

Third-stage juveniles (J_3), with more stouter bodies than J_2, were observed inside wheat (Fig. 1 E&F) and barley roots at 19&15 days after sowing , respectively (Table 2). Development of gonads was initiated at this stage and appeared as V shape.

Some other juveniles (J_2&J_3) were observed attatched to the roots with half of their bodies partly protruded out of the roots. This may indicate a semi-endo as well as endoparasitic habits of *H. avenae* on wheat and barley (Fig. 1 A&E).

Flask-shaped fourth stage juveniles (J_4) were observed in wheat (Fig. 1 G&H) and barley roots at 37&27 days after sowing , respectively (Table 2). The female bodies of J_4 began to round posteriorly and had well-developed ovaries.

Lemon-shaped young females, with reflexed and coiled ovaries (Fig. 1 J), and white mature (gravid) females with many eggs (Fig. 1 K) were observed in the roots of wheat at 49&56 days after sowing, respectively. These two stages were observed in barley roots 42&49 days after sowing, respectively (Table 2). Males were found in the soil of wheat (Fig. 1 I) and barley at 49&42 days after sowing, respectively (Table 2). However, we could not detect their earlier presence in the roots. White cysts, full of eggs, were observed on the roots of wheat (Fig 1 L) and barley at 74&64 days after sowing, respectively (Table 2).

The distribution and numbers of developmental stages of *H. avenae* in the roots of both crops during the period of the study are summarized in Tables 3&4.

Discussion

Infective J_2 were detected in the roots of both crops within the first week of sowing. This is expected since the used cultivars of both crops were very susceptible

to *H. avenae* [1, 3, 4]. However, presence of J_2 in wheat roots continued for about two months after sowing, whereas in barley roots presence of J_2 was only for about three weeks. Subsequent nematode development (J_3, J_4, adult females, gravid females&white cysts) was always faster on barley than on wheat by 5-14 days. The life cycle was completed (white cysts) on barley at 64 days after sowing, but required 10 more days on wheat. This different rate of development may reflect the relative nematode preference (or relative host suitability) between the two crops or cultivars. However, the numbers of white females or cysts on roots of both crops were approximately equal (Tables 3&4) and agrees with previous findings [3].

The duration of *H. avenae* life cycle recorded in our study is in agreement with those reported by several workers [7, 8, 10, 11, 12] who observed that 56-84 days were elapsed between juvenile invasion of oat or wheat roots and the appearance of white cysts. In Egypt, a semi-arid neighbor country, Ibrahim [11] reported 77 days for *H. avenae* to reach the white cyst stage containing eggs on wheat roots.

Table 3. Distribution of developmental stages of *Heterodera avenae* on wheat cv. Yecora Rojo under field conditions

Days after sowing	No. of nematodes/2 g fresh root						
	J2	J3	J4	Male	Adult female	White female	White cysts
7	45	--*	--	--	--	--	--
12	71	--	--	--	--	--	--
19	56	11	--	--	--	--	--
29	40	23	--	--	--	--	--
37	37	25	10	--	--	--	--
44	40	29	16	--	--	--	--
49	5	11	12	3	14	--	--
56	21	8	6	--	6	10	--
74	--	--	--	--	--	11	18

* No nematodes of the indicated developmental stage were observed at that date.

Table 4. Distribution of developmental stages of *Heterodera avenae* on barley cv. Justo under field conditions

Days after sowing	No. of nematodes/2 g fresh root						
	J2	J3	J4	Male	Adult female	White female	White cysts
7	49	--*	--	--	--	--	--
12	46	--	--	--	--	--	--
15	24	24	--	--	--	--	--
20	33	31	--	--	--	--	--
27	--	10	21	--	--	--	--
34	--	8	36	--	--	--	--
42	--	16	35	4	24	--	--
49	--	6	16	4	8	16	--
56	--	8	34	4	11	12	--
64	--	5	21	5	7	8	18

* No nematodes of the indicated developmental stage were observed at that date.

Climate is an important and major factor that affects life cycle of nematodes and other organisms. In a field study in Slovakia, Sabova *et al.* [12] concluded that warm climate had shortened the duration of all stages of *H. avenae* on wheat, and consequently shortened the life cycle of that nematode by 11 days. At the time of our study, the weather was colder than usual, and heavy rain storms occurred frequently (Table 1). These unusual climatic conditions might have relatively prolonged the duration of *H. avenae* life cycle reported in our study.

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تطور نيماتودا حوصلات الحبوب *Heterodera avenae* على القمح والشعير تحت الظروف الحقلية بوسط المملكة العربية السعودية

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ملخص البحث. تمت دراسة تطور نيماتودا حوصلات الحبوب *H. avenae* على نباتات القمح صنف "يكورا روجو" والشعير صنف "جستو" تحت الظروف الحقلية بأحد الحقول الملوثة بها بمحافظة الخرج-منطقة الرياض. شوهدت يرقات الطور اليرقي الثاني للنيماتودا خلال الأسبوع الأول من البذار في كلا الصنفين، وقد استمر ظهور هذا الطور داخل جذور القمح لمدة شهرين من البذار بينما استمر في جذور الشعير لمدة عشرين يوما فقط. أوضحت النتائج أيضا أن تطور النيماتودا (الطور اليرقي الثالث، الطور اليرقي الرابع، الإناث الكاملة، والحوصلات البيضاء) كان أسرع في جذور الشعير منه في جذور القمح بحوالي ٥-١٤ يوما. اكتملت دورة حياة نيماتودا حوصلات الحبوب (أول ظهور الحوصلات البيضاء) بعد ٧٤ و ٦٤ يوما من بداية البذار في جذور القمح و الشعير على التوالي.