Distribution and ecology of the Russian Wheat Aphid, *Diuraphis noxia* Mordvilko (Homoptera: Aphididae) in western Asia and northern Africa

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Abstract

Miller, R. H., K. S. Pike, L. K. Tanigoshi, L. L. Buschman and S. Kornosor. Distribution and ecology of the Russian Wheat Aphid, Diuraphis noxia Mordvilko (Homoptera: Aphididae) in western Asia and northern Africa. Arab J. Pl. Prot. 11 (1): 52-45

Throughout most of the rainfed cereal producing region of western Asia and northern Africa the Russian wheat aphid, *Diuraphis noxia* Mordvilko, is a localized pest that causes minor crop losses in drought stressed plants. During normal rainfall years, populations of natural enemies, coupled with poor population performance by the aphid, appear to maintain *D. noxia* at subeconomic levels. Crop losses attributable to *D. noxia* become more serious during periods of prolonged drought, which are frequently coupled with below normal winter temperatures. In Ethiopia and South Africa, *D. noxia* is reported to be a more economically serious and chronic pest in rainfed cereals. Development of *D. noxia* resistant cereal varieties and the enhancement of non-chemical pest control strategies for wheat and barley should provide adequate protection against *D. noxia* in these areas. Details of surveys and crop loss estimates, with emphasis on the region's less developed countries, are discussed.

Introduction

The Russian wheat aphid, *Diuraphis noxia* Mordvilko, has gained recent notoriety because of its devastating effect on grain yield in barley and wheat in North America and other parts of the world. Individual plant losses in the field as high as 90% have been reported (11). The aphid was originally described in the Caucasus region in 1900 (15) and has probably spread to Africa from western Asia (40). *D. noxia* was first encountered in Ethiopia in 1973, a period which corresponded with the onset of serious drought in the northern part of the country (16). Small plot studies in Ethiopia revealed yield losses due to *D. noxia* ranging from 41% to 71% in barley grown in high elevation areas (above 2000 m) (18) and 68% in wheat. *D. noxia* was first reported in South Africa in 1978 and rapidly spread throughout wheat-producing regions. It is presently considered the most serious pest of small grains in South Africa, causing annual monetary losses of about 5% of the total crop value (1) and is the focus of a research thrust specifically directed toward *D. noxia* management (41).

D. noxia's center of origin probably corresponds with that of its host grasses, primarily the semi-arid hills and mountains of south-central and western Asia, including countries bordering the eastern Mediterranean rim (40). While significant amounts of information have been generated by and for countries of the developed world, relatively little information is available on the status and impact of *D. noxia* in the developing countries of the Mediterranean rim and western Asia. The diverse environments of these countries are home to nearly every disease and insect pest described for wheat and barley. These countries, also have the highest per capita rate of wheat and barley consumption in the world and share one of the most unpredictable growing environments. Abiotic stresses such as drought, heat, cold, poor crop management, and low nutrient availability aggravate losses due to biotic stresses such as *D. noxia* (35). The main thrust of this paper is therefore to provide information on the current *D. noxia* distribution in some of the developing countries of Africa and western Asia, highlighting its distribution and potential impact in northern Africa and the eastern Mediterranean rim.

Recent *D. noxia* Distribution and Impact:

Subsequent to the publicity generated by *D. noxia*'s devastating impact in North America, an effort has been made to determine its distribution and impact worldwide, including its destructive potential in wheat producing areas not presently infested with *D. noxia*. In a modelling study intended to forecast the suitability of Australian wheat producing regions for colonization by *D. noxia*, (17) used a climate driven simulation model to designate habitats suitable to *D. noxia* in various world areas. The areas designated as favorable to *D. noxia* generally corresponded to regions where *D. noxia* has subsequently been identified, and included the coastal and high plateau areas of northern Africa along the southern Mediterranean rim, the Ethiopian and Yemeni highlands, central Anatolia, and southern Africa (Fig. 1). They stressed that the validity of their predicted *D. noxia* distributions depended on the availability of weather data over several years from stations representative of the various wheat growing areas and could be refined for Africa and western Asia with more and better data. Similarly, the model's prediction of *D. noxia* in some areas where wheat is not grown was attributed to the use of long term average rainfall data for lack of more detailed information.

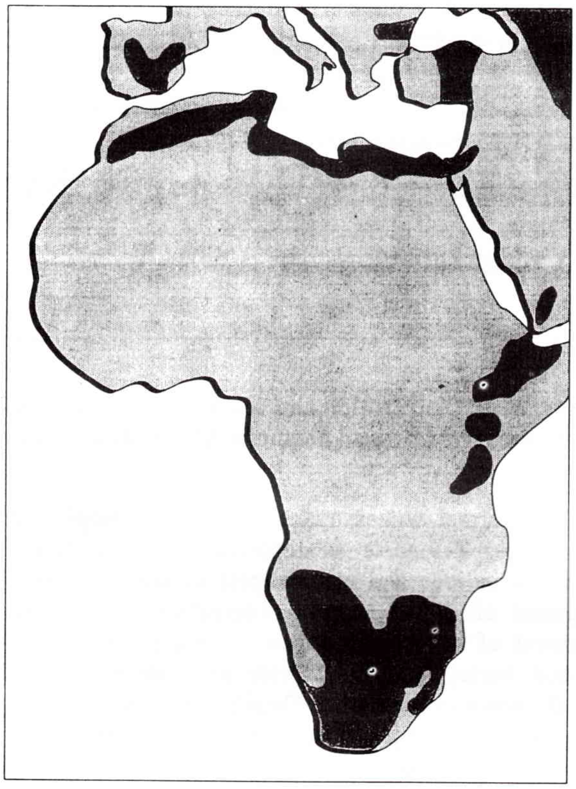

Figure. 1. Areas (shaded darker) of western Asia, Africa, and Europe delineated by Hughes and Maywald (17) as favorable to *Diruaphis noxia* (Mordvilko) based on a climate-driven simulation model, CLIMEX (24, 36).

Several surveys in northern Africa and western Asia have been conducted since Hughes and Maywald (17) (Fig. 2). These studies were designed to locate *D. noxia* infestations, estimate their impact on wheat and barley yield, and estimate the abundance and effectiveness of natural enemies in regulating *D. noxia* populations. Other reports from pest and breeders' surveys not particularly directed toward *D. noxia* have also provided valuable information and are summarized later.

Pike and Tanigoshi (29) conducted the first survey mission in the eastern Mediterranean specifically directed toward *D. noxia*. They located *D. noxia* infestations in Jordan in early May along the central hilly and highland plateau region that runs parallel to the Jordan Valley from north to south. This area was comprised of small, intermittent patches of wheat and barley amid sparsely vegetated rangeland. They also located *D. noxia* in center pivot irrigated wheat fields on the Rum Agricultural farm near Disi in southern Jordan. Here, *D. noxia* was found along the drought stressed periphery of sprinkler irrigated fields and in drought stressed patches created when the sprinkler delivery system malfunctioned. Infestations at times reached levels of 50%. They also collected a number of natural enemies and noted that *Leucopis* sp. (Diptera: Chamaemyidae) was the most common and effective predator in the highlands at that time. *Aphidius* sp. (Hymenoptera: Braconidae), and syrphids, chrysopids, and coccinellids were widely distributed but not abundant. The coccinellids were not effective at penetrating curled leaves

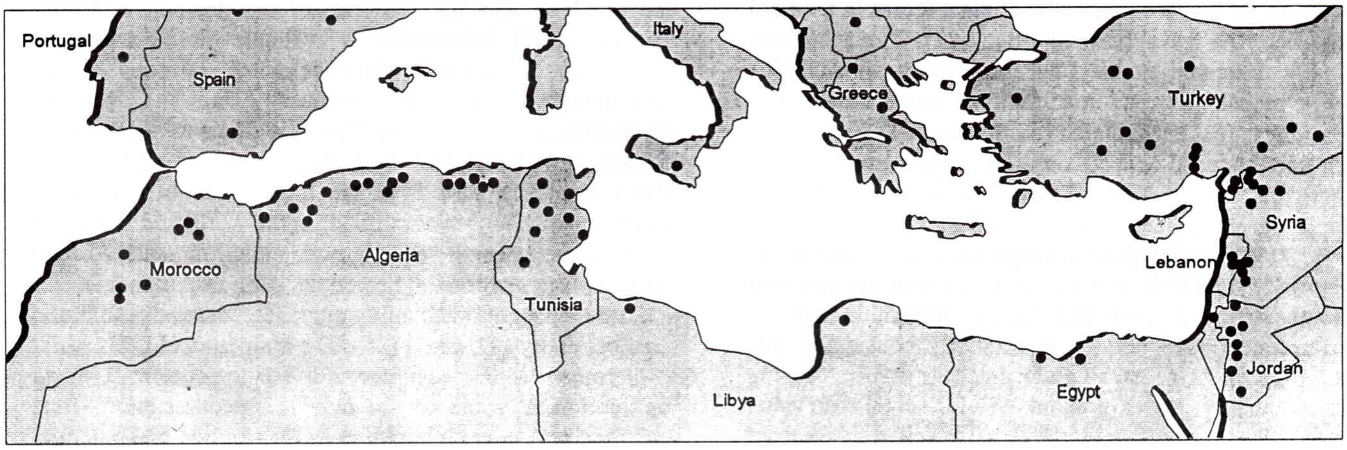

Figure 2. *Diuraphis noxia* (Mordviko) sites of detection (●) in West Asia, northern Africa, and southern Europe [documentation for sites not otherwise addressed in this paper: Greece, Macedonia, and Spain [in part], K. Hopper, EBCL, USDA-ARS, Montpellier, France, personal communication; Palestine (6, 13, 39), Sicily (27), Portugal (21, 23, 32), Spain (4, 7, 25, 34)].

where *D. noxia* was located. Pike and Tanigoshi (29) surmised that *D. noxia* was not an economically serious pest in Jordan but that the area was a rich site for collecting natural enemies from diverse habitats that might prove useful in biological control programs in the USA and elsewhere.

In 1990 Washington State University teamed with the International Center for Agricultural Research in the Dry Areas (ICARDA) and with the Projet Aridoculture of the United States Agency for International Development (USAID)/Mid-America International Agricultural Consortium (MIAC)/Insitut National des Recherches Agronomiques (INRA) in Morocco to survey North Africa and eastern Mediterranean countries for *D. noxia* and natural enemies. Countries included in the survey, conducted in early April, included Morocco, Jordan, Syria, and south central Turkey (26, 30). In general, *D. noxia* density was low to moderate in all the regions sampled, although some sites had a high percentage (about 80%) of infested plants and natural enemies in localized areas. *D. noxia* was most likely to be found in low humidity areas where plants were sparse and subjected to moderate drought stress. *D. noxia* was least likely to be found in humid environments with high plant density and vigorous plant growth.

In Morocco, the highest *D. noxia* populations were observed in the Middle Atlas Mountains (elevation 1200 m to 1500 m) near Annoceur, where the weather was cooler than on the adjacent coastal plain. In Jordan, *D. noxia* was common but not considered economically serious as it occurred in small, sparsely planted wheat and barley patches subject to drought stress and along the peripheries of irrigated wheat fields in the southern part of the country. *D. noxia* also was found in the Jordan Valley near the villages of Ash Shugur about 390 m below sea level near the northern shore of the Dead Sea, and near Ash Shuna 120 km to the north in hills bordering the Yarmouk River. In Syria, *D. noxia* and high parasitism were observed on domesticated and wild barley (*Hordeum vulgare* L., *Hordeum bulbosum* L.) in small terraced patches cleared from rocky terrain and subject to drought stress. In Turkey, *D. noxia* was observed in fallow fields with volunteer wheat plants and in small wheat fields in the dry canyons of the eastern side of the coastal mountain range behind Iskenderun. No aphids were found along the Mediterranean coast, although greenbug, *Schizaphis graminum* Rondani, and bird-cherry oat aphid, *Rhopalosiphum padi* L., were common.

A third survey by Washington State University, in collaboration with Cukurova University (Adana, Turkey) and ICARDA, was conducted in early May, 1992. *D. noxia* and numerous natural enemies were again located in drought stressed, isolated plants in northern Syria near Aleppo, although in lower densities than in 1990 because of the unusually cool, rainy spring weather in 1992. In Turkey, *D. noxia* was found in sparsely planted wheat and rye fields in the Tarsus-Aladaglar Range near Pozanti at about 1200 m elevation and in foothills north of Tarsus. A heavy infestation devoid of natural enemies other than syrphids was found in a patch of wheat located east of Kahramanmarash near the village of Narli. No *D. noxia* were found on the Anatolian Plateau from Konya to Nevsehir, probably becasue of the severe winter and cool spring in 1992. Concurrently with the third survey, *D. noxia* was identified in wheat at ICARDA's Terbol research farm in Lebanon's Beka'a Valley, near Zahle, and on a nearby farm operated by the American University of Beirut.

D. noxia has been recently reported in Algeria, Tunisia, Libya, and Egypt by various ICARDA and national program scientists. The 1987/88 season was the first year of a three year drought in North Africa that affected the rainfed wheat growing region of Algeria and Tunisia and resulted in extremely high *D. noxia* infestations in those countries.

In Algeria, *D. noxia* was first noticed in March 1989, in isolated patches near M'Sila and Setif, about 300 km southeast of Alger, on the high plateau where most of the country's rainfed wheat and barley is grown (R.H. Miller, ICARDA, PO Box 5466, Aleppo, Syria, unpublished data). The following February, 200 ha of wheat in the same field near Setif were nearly 100% infested by *D. noxia* (M. Tahir, ICARDA, PO Box 5466, Aleppo, Syria, personal communication), and in March of that year heavy *D. noxia* infestations were observed from Sidi Bel Abbes, in western Algeria, southward to Saida (M. Matougi, ITGC, BP 59, Sidi Bel Abbes, Algeria, personal communication) and eastward to Tiaret (M. Mekni, ICARDA, BP 2335, Fes, Morocco, personal communication). Since the end of the drought in Algeria in 1991, *D. noxia* has commonly been found in patches eastward to Constantine but its economic impact has not been determined and is estimated to be minimal.

In Tunisia, the development of *D. noxia* infestations followed the same development pattern in rainfed wheat and barley-growing areas as in Algeria. In 1989 no *D. noxia* was observed near government and university research farms at Beja and El Kef in northeastern Tunisia, whereas Hessian fly (*Mayetiola destructor* Say) was common. However, in 1990 breeders' plots at Beja were about 70% infested with *D. noxia* and late-planted wheat in farmers fields near El Kef was 100% infested with *D. noxia* (R.H. Miller, ICARDA, PO Box 5466, Aleppo, Syria, unpublished data). Hessian fly was present but insignificant when compared with *D. noxia*. *D. noxia* infestations across Tunisia were highest in wheat at 78% (40 sampling sites) compared to 54% in barley (26 sampling sites). *D. noxia* infestations in wheat in Zaghouan, Kef, and Siliana provinces of the Northern Zone (22 sampling sites) did not differ significantly from those in Kairouan, Sfax, and Kasserine provinces of the Central Zone (13 sampling sites) and in Gafsa province of the Southern Zone (5 sampling sites) (A. Kamel, ICARDA, BP 84, Ariana 2049, Tunis, Tunisia, personal communication). *D. noxia* infestations in barley, however ranged from 36% in the Central Zone (11 sampling sites), to 64% and 75% in the Northern Zone (11 sampling sites) and the Southern Zone (4 sampling sites), respectively. As in Algeria, the actual impact of *D. noxia* could not be separated from the effects of severe drought, but the end result was that wheat and barley in many *D. noxia*-infested fields was not harvested and was grazed by sheep. The return of normal rainfall to Tunisia and Algeria in 1991 reduced *D. noxia* infestations, but *D. noxia* is still commonly found in drought-stressed patches of wheat and barley throughout both countries.

In Libya, a *D. noxia* survey was carried out in the eastern and western rainfed cereal regions in conjunction with an annual disease survey by national program scientists from Algeria and Morocco and ICARDA scientists (A. Shredi, ARC, PO Box 132. Tripoli, Libya, personal communication). Of 6 wheat fields surveyed in western Libya, 3 were infested by *D. noxia*, and 7 of 13 wheat fields surveyed in eastern Libya were infested. Infestations were lower in barley fields: 4 of 22 fields surveyed in the east were infested with *D. noxia* and 3 of 19 fields in the west were infested.

D. noxia and barley expressing *D. noxia* symptoms were observed in isolated patches on rainfed barley along Egypt's northwestern coast near the village of Burg El Arab, 60 km west of Alexandria in March 1990 (R. Miller, ICARDA, PO Box 5466, Aleppo, Syria, unpublished data). *D. noxia* was independently observed a few days later in the same area (A. Haile, IAR, Holetta Research Center, PO Box 2003, Addis Abeba, Ethiopia, personal communication). There have been unconfirmed reports of *D. noxia* in wheat in the Nile River Delta and in Middle Egypt near Beni Suef (M. El Hariry, ARC, Plant Protection Research Institute, 26 Nadi El Seid Street, El Dokki, Egypt, personal communication). *D. noxia* is not considered an economic threat to cereal production anywhere in Egypt.

D. noxia and its natural enemies in Yemen were extensively studied by Erdelen (14), who described *D. noxia* biology in the highlands above 1500 m elevation near Sanaa. Ba-Angood (5) suggested that natural enemies of wheat in southern Yemen contributed to overall control of wheat aphids, although he did not consider *D. noxia* a pest in the mainly irrigated wheat regions he examined. However, it is likely that reservoir populations of *D. noxia* and its natural enemies may be present in southern Yemen on small wheat or barley patches in the mountains.

D. noxia continues to be a serious economic pest in the barley- and wheat-producing highlands of Ethiopia (A. Haile, IAR, Holetta Research Center, PO Box 2003, Addis Abeba, Ethiopia, personal communication). Infestations frequently are high during the short winter growing season that lasts from February to early April, especially during drought years. If the drought persists so that the summer monsoon rains are delayed or do not come, then *D. noxia* populations remain high throughout the main wheat and barley growing season that extends from late May to October. During years of normal rainfall, *D. noxia* is observed on young plants at the beginning of the summer growing season, but disappears with the onset of heavy rains.

Discussion and Future Impact:

D. noxia is widespread throughout the rainfed wheat and barley producing areas of western Asia and northern Africa. Its impact on production in these regions appears to be closely linked to precipitation received during the growing season. In years of normal rainfall, *D. noxia* is relegated to isolated reservoir populations along the edges of irrigated fields and in drought stressed patches on the eroded hills and in the isolated canyons that abound in the region. During periods of prolonged drought, *D. noxia* populations expand to infest large areas, threatening the most productive wheat and barley growing areas. However, the actual impact of *D. noxia* during these years is difficult to separate from crop losses associated with abiotic stresses. In addition, *D. noxia* symptoms frequently have been, and often still are, confused with those of drought, heat, and cold which makes impact assessment difficult. As wheat and barley are planted in more increasingly marginal cereal producing environments with low average rainfall, *D. noxia* may become a more serious annual pest.

A case in point is the situation observed in northern Syria since ICARDA's establishment in 1979. *D. noxia* was first identified in 1986 from a collection of aphids made at ICARDA's main research farm at Tel Hadya about 24 km south of Aleppo (36°01'N, 36°56'E, elevation 284 m) (letter from V. Eastop to K. Makkouk, ICARDA, PO Box 5466. Aleppo, Syria, dated 17 September 1986). However, plant damage observed in the field was not attributed to *D. noxia* until spring of 1989 when *D. noxia* was found infesting wheat isolines in ICARDA's quarantine nursery (19). The 1988/89 season was the first of a three year drought (Fig. 3)

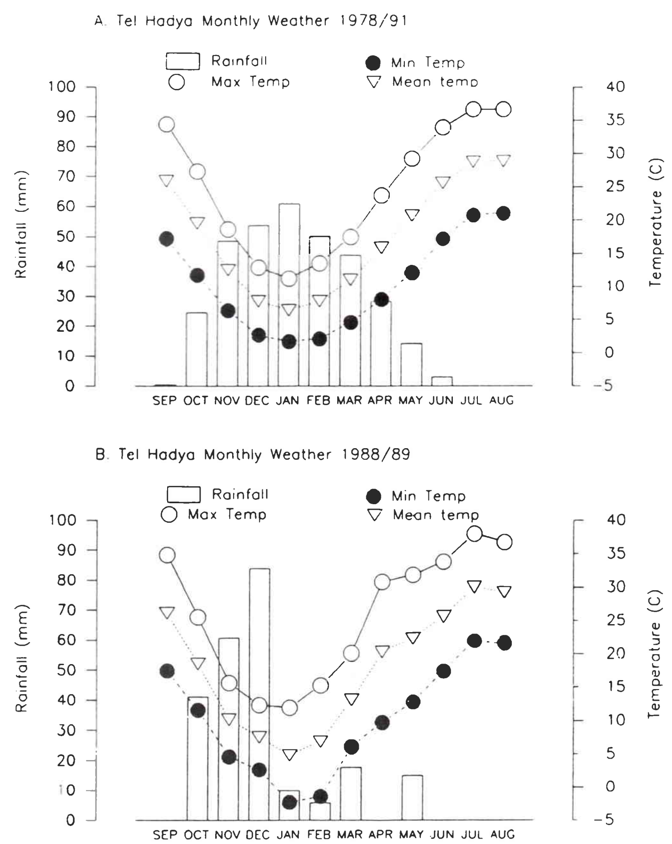

Figure 3. Average monthly weather data for 1978-1991 (A) and 1988-1989 (B) collected from ICARDA's main research farm, Tel Hadya, Syria.

that severely affected rainfed crops throughout Syria and the Middle East. In the 1989/90 season about five ha of bread wheat in breeders' yield trials were infested by *D. noxia*, and in the 1990/91 season over ten ha in bread wheat, durum wheat, and barley were infested in November after seeding in October, and again in the spring. The Syrian national program also reported losses in wheat due to *D. noxia* in the rainfed growing areas of northern Syria east of Aleppo, the first time *D. noxia* had been reported by government workers. The drought was broken during the 1991/92 growing season with rainfall nearing the long-term average for northern Syria, although temperatures were cooler than normal. *D. noxia* was observed on a single barley field in November at Tel Hadya, but disappeared following rain and cool weather during the winter months. Small patches of *D. noxia* were observed in mid-June in another sparsely planted stand of drought stressed barley, but never returned to the field originally infested.

A situation similar to that observed in Syria probably occurred in Turkey in the early 1960s. Tuatay and Remaudiere (38) reported *D. noxia* present at several sites, extending from Ahlat in eastern Anatolia in 1959 to Yalvac and Ergridir in 1962, east of Konya in central Anatolia (Fig. 2). Infestations in 1962 apparently were quite high, causing 25% to 50% crop loss in the Konya region (12). Losses attributed to *D. noxia* in subsequent years must have returned to negligible levels because *D. noxia* was not further documented in Turkey until collecting missions searching for biological control agents for use in the US located it in northern Anatolia near Ankara (31, 33), where it was found in small, isolated patches. Further survey missions have found it widespread, but usually infesting small patches of sparsely planted, drought-stressed wheat, barley or rye as described previously.

We feel that *D. noxia* will probably continue to be a marginal pest in most areas of Africa and western Asia, with the exception of southern Africa, Ethiopia, Yemen, and perhaps the Maghreb states of North Africa where its past performance suggests that it can cause serious economic loss unless managed properly. *D. noxia* will probably become a more serious pest if wheat and barley are sown in increasingly marginal rainfed environments, as is currently the trend in the cereal deficient countries of western Asia. In South Africa, well developed government and private resources have intensively studied *D. noxia* and have taken the lead in developing *D. noxia* resistant varieties (8, 9, 10), in investigating the potential for enhancing and preserving natural enemies (2, 3), and in developing proper chemical control methodologies (11).

The situation is more difficult throughout the rest of Africa and much of western Asia. Severe shortages of resources and difficulties in communicating with other researchers complicate pest managment efforts. There are relatively few cereal entomologists in the national programs of northern Africa and West Asia, since wheat and barley are considered low-input crops and attract minimal research support compared with the high value crops of cotton, olives, and citrus. Those workers in government ministries and universities assigned to work on cereals generally are assigned to work on other pests besides *D. noxia*. These include Hessian fly in North Africa, other cereal aphids in the Nile Valley countries, sunn pest in western Asia, and barley shoot fly in Ethiopia. It is unlikely that *D. noxia* research in these countries will be given high priority unless significant damage is experienced for several years.

Administrative difficulties also hinder *D. noxia* and other pest managment programs. Agricultural research in some countries may be delegated to one directorate while the responsibility for plant protection is assigned to another. There may be little cooperation between research and plant protection workers and competition for scarce government funds between directorates is keen. University staff are often relegated to a purely teaching role, although specific limited research responsibilities may be delegated to them if ministry directorates are overloaded.

Some *D. noxia* resistant wheats and barleys have been screened at ICARDA for use in the Mediterranean region, but almost all exotic varieties have proven highly susceptible to local diseases and maladapted to the unpredictable, harsh climate typical of the region (20). Significant efforts will be required to incorporate *D. noxia* resistance genes into genetic backgrounds suitable for use in northern Africa and western Asia. With this in mind, ICARDA has initiated crossing programs to combine *D. noxia* resistance with heat and drought tolerance and with disease resistance in both wheat and barley. The use of *D. noxia* resistant varieties, coupled with the preservation and enhancement of endemic natural enemies, will likely provide adequate protection against *D. noxia* outbreaks in the low input wheat and barley production areas of the region.

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الملخص

ميلر، روس، وكيت بايك، ولينل تانيفوشي، ولورنس بوشمان وسربيل كورنوسور. 1993. توزّع وبيئية منّ القمح الروسي Mordvikov *Diuraphis noxia* (فصيلة Aphididae ورتبة متشابهات الأجنحة في غربي آسيا وشمالي أفريقيا. مجلة وقاية النبات العربية. 11 (1):45-52.

يعتبر منّ القمح الروسي Mordvikov *Diuraphis noxia* آفة محلية، تحدث خسائر محصولية قليلة في النباتات المتعرضة لإجهادات الجفاف، وذلك في معظم المناطق البعلية لإنتاج الحبوب في غربي آسيا وشمالي أفريقيا. حيث تتمكن مجتمعات الأعداءالطبيعية، أثناء السنوات المطيرة العادية، جنباً الى جنب مع الأداء الضعيف لمجتمعات المنّ من السيطرة على *D. noxia* وإيقائها عند مستويات لاتحدث أضراراً إقتصادية. وتغدو الخسائر المحصولية التي تحدثها هذه الآفة شديدة الخطورة في الفترات التي يسود فيها الجفاف لمدة طويلة والتي تكون مترافقة غالباً بدرجات حرارة في الشتاء أخفض من المعدل. والآفة مسجلة في إثيوبيا وجنوب إفريقيا على أنها من الآفات المزمنة في الزراعات البعلية. إن تطوير أصناف حبوب مقاومة لمنّ القمح الروسي، وتحفيز خطط المكافحة غير الكيماوية لمحصولي القمح والشعير من شأنها تأمين وقاية كافية من الآفة في تلك المناطق. وتناقش المقالة تفصيلات عمليات المسح وتقديرات خسائر الغلة، مركزة على دول المنطقة الأقل تطوراً.

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