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How wide is the distribution of Russian wheat aphid in northern NSW and is sorghum an alternative summer host?

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Key findings

- Russian wheat aphid (RWA) was found in northern NSW in 2019 in barley, wheat, durum and barley grass. To date, Tamworth is the most northern site where the aphid has been confirmed in Australia.
- Sorghum (Sentinel IG) is an alternative summer host. RWA survival in sorghum in northern NSW depends on climatic conditions. High temperature and humidity can supress RWA survival and reproduction in sorghum.
- Millet (Jandowae) is not a suitable host for RWA.
- Severe symptoms on young sorghum plants include red tips on the leaves and patches at the place of feeding.
- Wheat and barley are the most suitable host and where the highest RWA population developed, followed by oats, sorghum and triticale.
- Typical RWA damage is found on its primary hosts (barley and wheat), while little or no symptoms were observed in its secondary hosts (oats, sorghum, triticale).

Introduction

Russian wheat aphid – *Diuraphis noxia* (Kurdjumov) (Homoptera: Aphididae) is known worldwide as a pest of cereals. It originates from central Asia, the Middle East and southern Russia; its presence has been confirmed across cereal growing regions in Asia, Europe, Africa, North and South America and, since 2016, in Australia (Kindler and Springer, 1989; Hughes, 1996; Yazdani et al., 2018). The RWA's primary hosts are barley, wheat and durum wheat, but it can infect triticale, rye and oats. Its host range also includes winter, and some summer wild grasses.

The RWA is easily distinguishable from other cereal aphids such as the oat aphid (*Rhopalosiphum padi*), corn aphid (*Rhopalosiphum maidis*) and rose-grain aphid (*Metopolophium dirhodum*). RWA is a small, pale green, spindle-shaped aphid, which is often covered with fine wax. It has dark eyes, antennae shorter than half its body length, almost invisible cornicles and an appendage above the cauda giving it the appearance of having two tails (Figure 1).

Figure 1 Russian wheat aphid – *Diuraphis noxia*.

It feeds on plant sap and affects host plants by injecting toxins while probing and feeding. In response, cereal plants start to develop various symptoms including chlorosis, necrosis, wilting, stunting, leaf streaking with whitish, yellow and purple longitudinal leaf markings, and rolled leaves. If probing occurs when the head is being formed, trapped awns or bleached heads could develop, or flowering might not occur (Figure 2).

Figure 2 Developed symptoms (a) leaf strips, rolled leaves; (b) trapped awns.

Wheat and barley are suitable hosts for RWA for a large part of the year. However, wild grasses are also very important for persistence of populations over summer and provide a bridge for cereal infestations over autumn. This study was conducted to identify the distribution of RWA in northern NSW, potential hosts and the possibility of migration, survival and reproduction on sorghum, the major summer cereal grown in the northern region.

Methods

Distribution survey

The distribution survey was carried out on autumn-sown cereals, volunteer crops and winter grasses in order to determine the presence of RWA in northern NSW. Samples collected were: wheat (*Triticum aestivum*), barley (*Hordeum vulgare*), durum wheat (*Triticum durum*), barley grass (*Hordeum leporinum*), prairie grass (*Bromus cathartions*), oats (*Avena sativa*), couch grass (*Cynodon dactylon*), Johnson grass (*Sorghum halepense*), phalaris (*Phalaris aquatica*), liverseed grass (*Urochloa panicoides*), and Queensland blue grass (*Dichanthium sericeum*). Samples were cut at ground level, collected and transported in plastic bags, and placed in Berlese funnels in the laboratory for three to four days. Extracted insects were observed under a stereomicroscope and the results were included in an interactive RWA map (http://www.cesaraustralia.com/sustainable-agriculture/rwa-portal/).

RWA sorghum field study

The preliminary RWA field study was conducted on irrigated paddocks near the Tamworth Agricultural Institute. This was to examine RWA over-summering and reproduction habits on the major summer grains in northern NSW: sorghum (Sentinel IG) and millet (Jandowae). The experiment was set up in summer 2019–2020 under aphid-proof tents, with two replicates. The first inoculation of RWA on both sorghum and millet was at the 3-leaf growth stage. One plant per tent was inoculated with 10 wingless aphids. The second inoculation was at the 5-leaf growth stage.

RWA winter grains field study

The 2020 RWA winter grains study was established to analyse the possible migration of aphids from winter to summer cereals (sorghum). Aphid-proof tents were half sown with wheat (LongReach Lancer$^{\Phi}$) or barley (Commander$^{\Phi}$). The other half of each tent was sown with sorghum (Sentinel IG) at the end of the 2020 winter season, before the wheat and barley were ready to be harvested. At the tillering stage, 10 wheat/barley plants in each tent were infested with 10 wingless RWA. The RWA colonisation and distribution on winter, as well as migration onto summer grain hosts were studied till December 2020.

RWA host preference study

Both the amount of damage and the RWA host preference was investigated in the glasshouse on barley (Commander$^{\Phi}$), wheat (LongReach Lancer$^{\Phi}$), oats (Yiddah$^{\Phi}$, Mannus$^{\Phi}$, Nile), sorghum (Sentinel IG), and triticale (Endeavour$^{\Phi}$). Ten plants from each host were infested with 10 wingless adults. Adults and nymph counts were observed two, seven and 14 days after infestation (DAI).

Results and discussion

Distribution survey

Since the first report of RWA in South Australia in 2016 (Yazdani et al., 2018), it has spread rapidly through the eastern grain belt including South Australia, Victoria, parts of southern New South Wales and Tasmania (Yazdani et al., 2018). The data from 2019 showed that Tamworth was the most northern site where RWA has been confirmed in Australia (Figure 3). Out of 21 collected samples in 2019 there were three positives in barley, one positive in wheat, one positive in durum wheat, and three positives in barley grass. In 2020, 58 cereal and grass samples collected from various sites in the Liverpool Plains showed no positives. The RWA population suppression could be explained by the hot, dry 2019 summer and the lack of an over-summer green bridge. Australia's warmest and driest year on record, 2019, with the dry summer followed by the coolest and wettest autumn in New South Wales since 2012 (BOM, 2020 a, b).

A temperature over 20 °C is unfavourable for RWA and it cannot survive at temperatures over 37 °C. Furthermore, RWA prefers relatively warmer, drier climates, where summer rainfall is 300–400 mm. Heavy rainfall can wash aphids off the upper leaves and 30 mm rainfall can cause 50% mortality (Huges, 1996; GRDC, 2017).

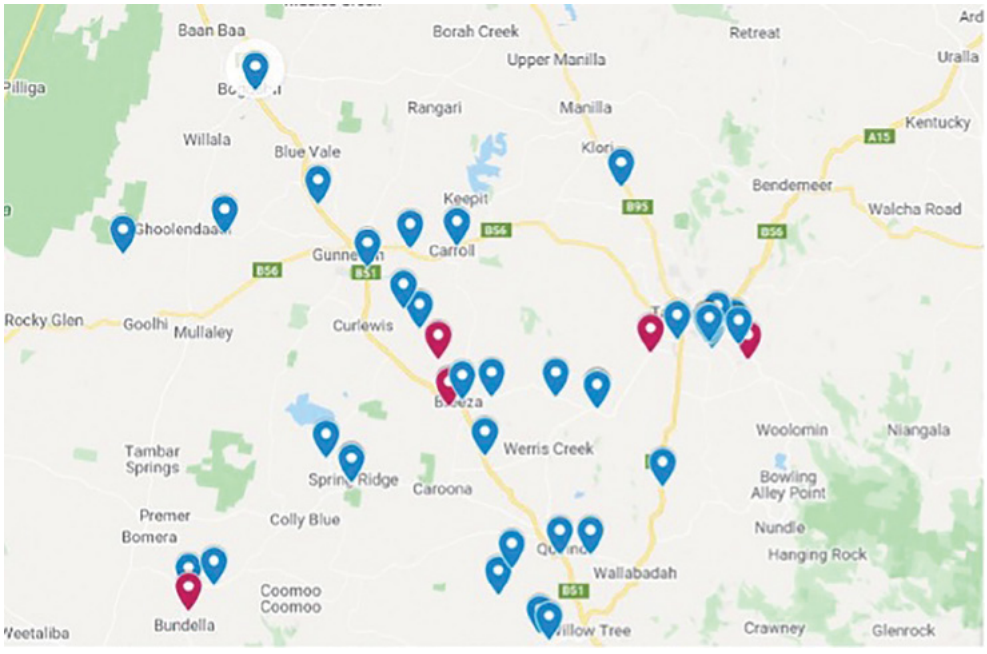

Figure 3 Detail of map of RWA positive (📍) and negative (📍) samples in 2019 and 2020.

RWA sorghum field study

A second inoculation in the field study in December 2019 was successful in establishing RWA in sorghum, but not in millet, which was found to not be a suitable host plant for RWA.

The aphids were initially observed at the inoculation points of the upper side of the sorghum flag leaf, before migrating to the back side of the leaf, mainly next to the central leaf vein (Figure 4) and starting reproduction. During January 2020, aphids migrated to neighbouring leaves in the lower canopy, which was likely to be due to the better protection from high temperatures with a population up to 30 individuals developed on the inoculated tiller. When the sorghum reached the flowering/grain filling stage (end of February 2020), established RWA colonies were observed on three neighbouring plants out of the 10 plants inside the tents. Although no symptoms were observed, this result demonstrates that RWA was able to survive on sorghum plants during the 2019–20 summer. Similarly, Harvey and Kofoid (1993) found three sorghum lines that supported RWA for at least a month. Since RWA is generally found as a minor pest in sorghum, there is a possibility that the aphids would have moved to more favourable host plants in an open field study.

Figure 4 RWA colony on the back side of sorghum leaf.

RWA winter grains field study

An established population of 3–10 adults of RWA was noticed on all infested plants six days after inoculation on 12 June 2020. The first symptoms were observed in 1–3 out of 10 infested barley/wheat plants per tent. The plant response to the RWA toxic secretion was quick and only a small number of RWA aphids can cause symptoms on plants in less than seven days.

The symptoms were characteristic white to purple stripes, and leaf-rolling on both wheat and barley leaves. At 15 DAI, both wingless and winged forms were found in colonies and after 5–7 days additional plants were infested. One month after infestation 30% of plants showed typical symptoms and two months after infestation all plants inside the tents were infested with moderate to high populations. Later symptoms that developed in barley and wheat included stunted growth, trapped awns, and twisted and distorted heads.

By mid September 2020, both barley and wheat became unfavourable hosts due to ripening and, since the majority of RWA dispersal occurs by flying (Hughes, 1996), high numbers of winged aphids were noticed inside the tents. After the sorghum emerged on 13 October, the winged aphids migrated from barley and wheat to the young sorghum plants and started to reproduce. Both winged and wingless aphids with their progeny were observed on the young sorghum plants (Figure 5a). Symptoms such as red tips on the leaves and patches at the place of feeding (Figure 5b) were observed. Similar to that reported by Harvey and Kofoid (1993), the aphids successfully infested and damaged the susceptible sorghum plants.

The aphids first infested the leaf tips and edges, and then moved to the leaf base leaving skins behind. This type of damage could cause plant death in a short time, however, in October 2020 the daily temperatures inside the tent were too hot for RWA development. Temperatures above 40 °C were recorded for two to six hours in both the morning and early afternoon for most of October, with the highest, 53.15 °C, recorded on 21 October. The RWA population on sorghum quickly decreased, as they cannot survive long enough to reproduce at high temperatures. A few surviving individual adults with a small number of progeny were observed on sorghum in a couple of tents at the end of October. No aphids were observed in November and the sorghum plants recovered. However, this result indicates that with favourable conditions, RWA could use sorghum as alternative host in late spring to early summer.

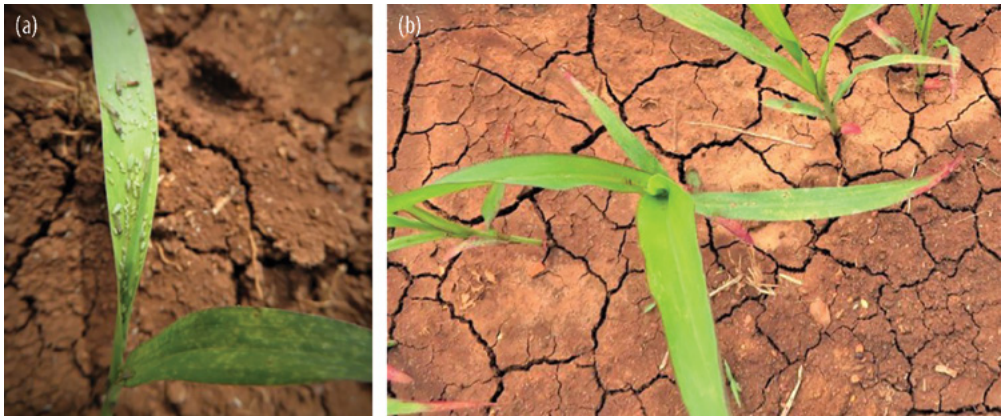

Figure 5 Russian wheat aphid (a) infestation and (b) damage, to young sorghum plant.

RWA host preference study

In the host preference study, at 14 DAI, the best RWA establishment was on wheat, with a mean number of 49 adults and 148 nymphs, and barley with 42 adults and 140 nymphs. The highest number of established aphids on oats was found on variety Yiddah$^{\Phi}$ (nine adults and 28 nymphs), followed by Mannus$^{\Phi}$ (nine adults and 26 nymphs) and Nile (five adults and 16 nymphs). The lowest numbers were in sorghum (nine adults and nine nymphs) and triticale (four adults and nine nymphs) (Figure 6). Sorghum appeared as one of the least favourable host plants even though RWA did establish on all the plants tested; further studies are required in order to achieve a clearer result.

Symptoms occurred seven DAI on wheat and barley, but not until later on other host plants. At 14 DAI, both barley and wheat leaves were covered with aphids and the leaf skins, and had developed symptoms including yellow stripes and rolling. Plants started wilting, another symptom making winged adults more noticeable. The secondary hosts showed little or no symptoms. The oat leaves had chlorotic, hardly visible yellow lines with the aphids concentrated on leaf tips, on the upper and back side of the leaf. On triticale, the RWA population remained at the base of the young leaves and inside rolled leaves. Yellow stripes were hardly visible. On sorghum, RWA were usually based on the upper side of the leaf. Red patches developed at the place of feeding on the plants where the RWA became established (Figure 7).

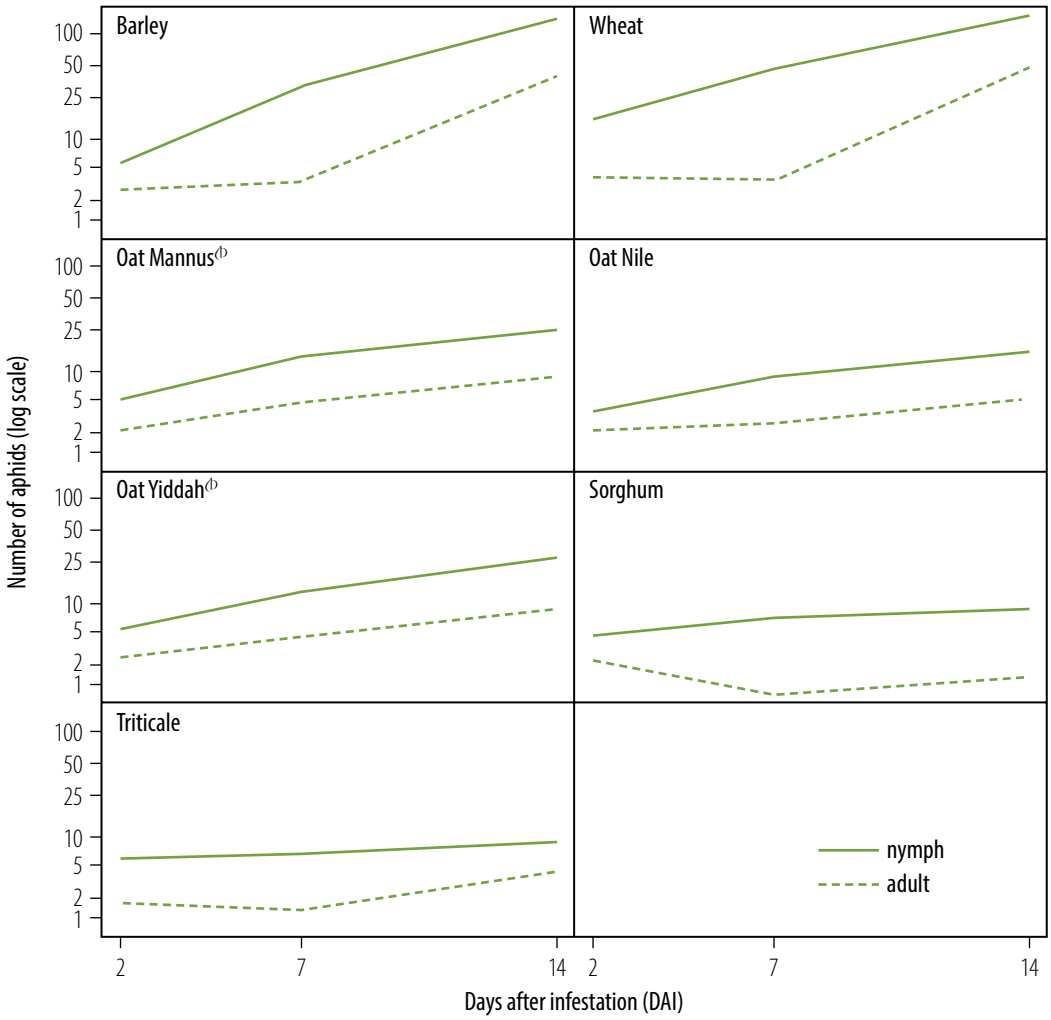

Figure 6 Mean number of RWA adults and nymphs on different hosts at 2, 7 and 14 DAI.

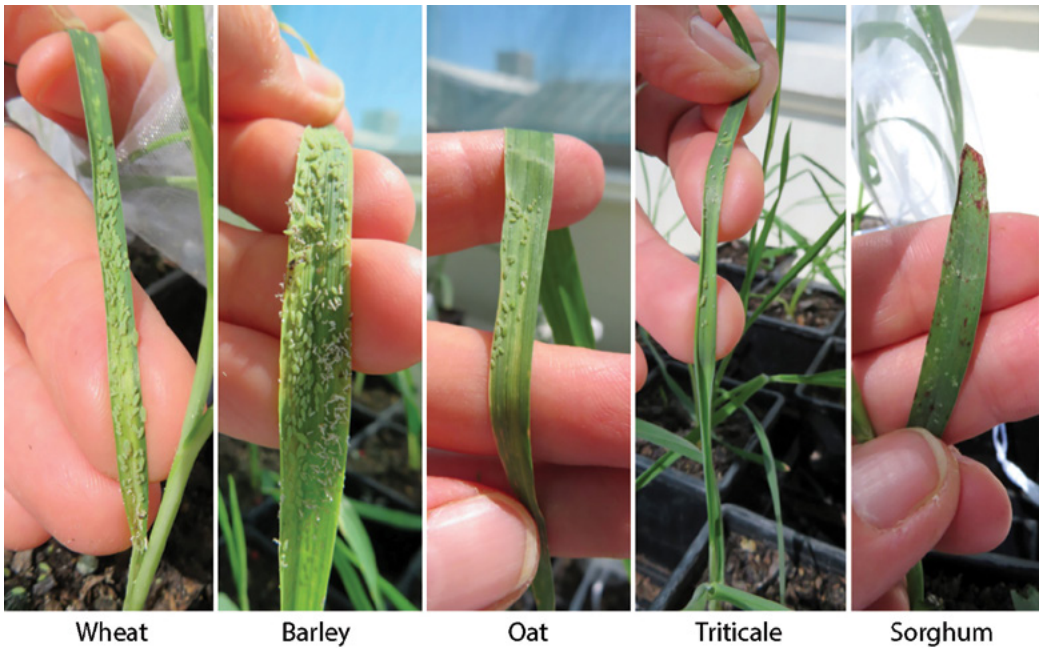

Figure 7 Symptoms caused by RWA at 14 DAI on wheat, barley, oat, triticale and sorghum seedlings.

These studies confirm that wheat and barley are the preferred hosts for RWA, with oats, triticale and sorghum being poor hosts. However, the host range of RWA includes more than 140 species (GRDC, 2017), and there is a great possibility for RWA to maintain its population using these secondary hosts, including oat, triticale and sorghum, during winter and summer and thus providing a green bridge winter cereal infestation.

Conclusion

RWA has been confirmed in South Australia, Victoria, New South Wales and Tasmania. In 2019 it was found in barley, wheat, durum wheat and barley grass in the Tamworth Region.

The results from this study show that sorghum can provide a host for RWA, especially on young plants in late spring and at the beginning of summer. However, additional field studies are needed to address its risk to the northern wheat industry.

While RWA forms well-established colonies and shows typical symptoms on its primary hosts – barley and wheat, the aphid can also maintain small colonies and develop symptoms that include red patches at the place of feeding on sorghum leaves, and barely visible yellow lines and rolled leaves on oat and triticale.

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