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Niche and Temporal Differences in Colonization of Wheat Varieties by Three Species of Cereal Aphids

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Abstract: Cereal aphids infest plants in distinct patterns both in spatial and temporal terms. The distribution patterns of *Rhopalosiphum padi* (Linnaeus), *Metopolophium dirhodum* (Walker) and *Schizaphis graminum* (Rondani) in time and space on wheat varieties Fahari, Mbega and Duma were studied in field plots and sampled at six growth stages. The experiment was done during the long seasons of 2001 and 2003. Results showed that aphid species differed in their time of colonisation. *R. padi* appeared at two leaf growth stage followed by *S. graminum* at the two tiller stage. *M. dirhodum* came later at the stem elongation stage. Aphid abundance differed among the species, wheat varieties and crop growth stages. The aphid species *R. padi*, wheat variety Duma and the flowering growth stage had the highest aphid population. The aphid species also differed in their points of colonisation. *R. padi* was most abundant on stems of wheat at seedlings, lower leaves, flag leaf and the spike as the crop matured. *S. graminum* mainly colonised the lower leaves. *M. dirhodum* was mainly on the underside of upper leaves including the flag leaf. The studies showed a crop growth stage and feeding site preferences among cereal aphids.

Key words: Aphids, cereals, colonisation, wheat

INTRODUCTION

Kenya has the potential to produce enough wheat for local consumption which is estimated at 600,000 MT annually (GoK, 1997). However, the average annual national production of wheat is about 250,000 MT (Cereal Growers Association of Kenya, 2001). Pests and diseases are major factors that have significantly contributed to the low yields of wheat (Arama and Wanjama, 1998). Aphids are the major pests of small grain cereals such as wheat, barley, oats and triticale in Kenya (Wangai *et al.,* 2000). They affect plant growth directly through sap sucking and indirectly as vectors of Barley Yellow Dwarf Virus (BYDV) which can cause yield losses of 8-54% in the field (Wangai and Torres, 1991). According to Muthangya *et al.* (1991) and Wangai (1994), the most important and commonly found species of aphids on cereal crops in Kenya are English grain aphid *(Sitobion avenae* F.), Rose grain aphid *(Metopolophium dirhodum* W), Bird cherry aphid (*Rhopalosiphum padi* L.) and the Greenbug (*Schizaphis graminum* R).

Cereal aphids infest plants in distinct patterns, both in spatial and temporal terms (Gianoli, 2000). Adults of each species are more selective than juveniles in determining suitable locations for settlement, feeding and reproduction. Feeding site preferences are considered important, particularly in relation to the type and amount of damage caused by various aphid species (Vickerman, 1979). Research by Leather and Dixon (1981), Wiktelius (1987) and Wiktelius *et al.* (1990) in discussing patterns of within-plant distribution of *R. padi* considered factors such as nutritional value of tissues and avoidance of extreme temperature in the field.

The type of host plant and its growth stage markedly affect colonization and the subsequent rate of increase in aphid abundance on crops (Guildemond *et al.*, 1998). Yield reduction in crops caused by virus infection is influenced by the growth stage at which a plant is infested by the vectors. Greatest damage is caused when plants are infested at early growth stages (Watson, 1942; Doodson and Saunders, 1970).

Cereal aphids also have differential performance on different hosts even at the varietal level. Hesler *et al.* (1999), found that MV4 wheat variety lowered the intrinsic rate of natural increase of *R. padi.* He also showed that the proportion of alate *R. padi* was greater on variety MV4 than most other accessions indicating that the former is not a suitable host for the pest. Cultivar and aphid species interact with plant growth stage in increase in abundance of aphids (Guldemond *et al.*, 1998).

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The patterns of increase in abundance of different cereal aphids on a wheat crop in Kenya have not been documented. This phenomenon can be better understood by studying the movement of individuals or colonies on the plants. Information on population fluctuations of cereal aphids is essential for determining control strategies. When the pattern of aphid infestation of crops is well documented, specific recommendations on date of planting, time and method of chemical application and other management strategies can be developed. This study sought to investigate wheat varietal differences through the pattern of infestations and increase in abundance of three cereal aphids namely; *R. padi*, *S. graminum* and *M. dirhodum.*

MATERIALS AND METHODS

Three wheat varieties (Duma, Mbega and Fahari) were planted using a factorial Randomised Complete Block Design (RCBD) replicated four times during the long rains of 2001 and 2003 at KARI-Njoro. The experimental plots were 1.5×6 m with an inter-row spacing of 20 cm. The plots and replications were separated by 0.5 m and 1m gap respectively. Di-ammonium phosphate (DAP) 18:46:0 (NPK) fertilizer at a rate of 90 kg ha^{-1} was hand drilled into the soil and well mixed before hand planting the wheat at a rate of 90 kg ha^{-1} of seeds. Weeding was done by hand at growth stage 16 (Zadok *et al*., 1974).

Observations were made on the times and locations of colonisation by the three species of cereal aphids (*R. padi*, *S. graminum* and *M. dirhodum*) on the three varieties of wheat at six growth stages. The wheat growth stages used were: GS 12 (2-leaf stage), GS 22 (2-tiller stage), GS 32 (stem elongation stage) GS 45 (booting stage, GS at 69 (flowering stage) and GS 91 (ripening stage) (Zadok *et al.,* 1974). Data was collected from ten plants selected randomly in each plot.

Data on the mean number of aphids of each species on three wheat varieties at six growth stages was transformed using the square root (1+x) to homogenise and stabilise the variance. General linear model (GLM) was used to help analyse the data (SAS Institute; 1996). Means were compared using the Least Significant difference (LSD) tested at the 5% level. Point of colonisation was analysed using descriptive analysis.

RESULTS

Abundance of *R. padi* on the three varieties of wheat was significantly greater ($p<0.05$), compared by those of *M. dirhodum* and *S. graminum* in both 2001 and 2003 (Table 1). Abundance of all the three species of cereal aphid was greatest at growth stage 69 (flowering) in both years. There were no significant differences in abundance of *M. dirhodum* and *S. graminum* before flowering stage in 2003. There was however some differences in abundance between the two species at 2-tiller and stem elongation in 2001. Abundance of all the three aphid species decreased abruptly at growth stage 91(ripening) during the two years but more distinctively in 2003.

Table 1 also reveals that there were distinct differences in the time of colonisation among the three species of aphid. *R. padi* appeared earlier, at the 2-leaf stage, followed by *S. graminum* at the 2-tiller stage and last was *M. dirhodum* at stem elongation. *S. graminum* and *M. dirhodum* disappeared after the crop flowered in 2003. The order and time of colonisation of the three cereal aphids did not differ significantly among the three varieties of wheat both in 2001 or 2003.There were mixed results in the abundance of aphids among the wheat varieties except for Duma, which was consistently infested with more aphids (Table 2) during the two years.

R. padi changed sites of greatest colonization with the age of the plant. *R. padi* was mainly on the stems of wheat seedling, the aphids moved to the leaves and the leave sheaths during the stem elongation stage. At the latter stages, *R. padi* was mainly observed on the flag leaves and spikes. *M. dirhodum* was found on the underside of the middle and flag leaves. *M. dirhodum* shared a niche with *R. padi* on the top green leaves including the flag leaf at ripening stage in 2001. Rarely did *M. dirhodum* move to the spikes. *S. graminum* colonies were found on the upper side of the lower leaves

Table 1: Three cereal aphid species numbers per ten plants at six wheat growth stages

Aphid species	Number of aphids 2001 Wheat growth stages 1	2	3	4	5	6	2003 Wheat growth stage 1	2	3	4	5	6
RP	2.7(6)a	4.1(16)a	5.2(26)a	7.1(49)a	20.0(399)a	8.4(69)a	1.7(2)a	2.2(4)a	5.3(27)a	8.3(68)a	9.3(85)a	2.4(5)a
SG	1.0(0)b	1.7(2)b	3.3(10)b	4.9(23)b	11.1(122)c	2.4(5)b	1.0(0)b	1.4(1)b	2.8(7)b	3.0(8)c	3.4(10)b	1.0(0)b
MD	1.0(0)b	1.4(1)b	1.7(2)c	4.9(23)b	16.0(255)b	4.7(21)b	1.0(0)b	1.0(0)b	3.1(9)b	6.3(639)b	8.7(75)a	1.0(0)b
LSD	0.40	0.78	1.3	2.2	2.6	2.4	0.23	0.42	1.08	0.97	3.45	0.27

Table 2: Number of aphids per ten plants of three varieties of wheat

	Number of aphids											
	2001 Wheat growth stages						2003 Wheat growth stage					
Variety	1	2	3	4	5	6	1	2	3	4	5	6
Duma	1.7(2)ab	2.4(5)a	4.3(18)a	7.1(49)a	16.6(275)a	7.5(55)a	1.4(1)a	1.7(2)a	4.2(17)a	6.9(47)a	6.8(45)a	1.7(2)a
Fahari	1.4(1)b	2.3(4)a	2.8(7)ab	5.3(27)a	16.6(275)a	4.5(19)b	1.4(1)a	1.4(1)a	3.5(11)a	5.8(33)b	5.7(31)a	1.4(1)b
Mbega	2.0(3)a	2.0(3)a	3.2(9)a	4.5(19)b	13.9(192)b	3.7(13)b	1.4(1)a	1.4(1)a	3.5(11)a	5.0(24)b	8.9(78)a	1.4(1)b
LSD	0.40	0.78	1.3	2.2	2.6	2.4	0.23	0.42	1.08	0.97	3.45	0.271.

• Means in the same column followed by the same letter are not significantly different (LSD= 0.05), • Wheat growth stages (1-leaf, 2-tiller, 3-elongation, 4-booting, 5-flowering and 6-ripenining), • Figures in parentheses represent the original data

which turned necrotic within a few days of colonisation. The aphids completely destroyed the lower leaves and progressed upwards to the middle leaves where they settled mainly at the angled points of these leaves. Rarely were the aphids found on the upper and flag leaves. They were completely absent on the spikes in both years.

DISCUSSION

The three species of cereal aphids occupied different feeding sites on the wheat plants. The occurrence of different species of cereal aphids at different growth stages of the crop and at different feeding sites probably to reduces inter specific competition allows aphids to fully exploit the host plant. Results for *R. padi* are consistent with those obtained by others. Holland and Thomas (1997) found this aphid on crops four weeks after planting. Wiktellius *et al.* (1990) observed that *R. padi* arrived first in the season (late spring-early summer) when cereals are in the seedling or early tillering stage. He further noted that abundance peaked during the stem elongation stage and declined during ear emergence. In this study however, abundance of aphids peaked at early flowering and declined abruptly at early ripening stage in 2001 and 2003.

The strategy of early colonisation (seedling) stage makes *R. padi* a pest among cereal aphids. This is confounded by the ability of *R. padi* to exploit a host at different stages of growth i.e., from the tender and nutritious seedling stage to plants at the deteriorating ripening stage, irrespective of variety as observed in this study. This aphid was found to aggregate in colonies on the tender stems during the seedling stage, the middle leaves during the elongation stage and the flag leaf and spike in the latter stages. It is a serious pest since it occurs in large numbers and inflicts serious direct damage through removal of sap. *R. padi* reduced plant biomass dramatically, regardless of the growth stage (Gianolli, 2000).

S. graminum mostly exploits crops at the seedling stage (Wanjama, 1986). It mainly feeds on leaves of the lower half of the plant. Its preferred niche was on the angled points of the leaves probably to avoid extremely hot and dry field conditions (Wiktelius, 1987) or direct impact of rain splash. Direct and side effects of feeding by *S. graminum* damages crops through sap removal and injection of toxic saliva, a few aphids are likely to cause severe crop damage particularly at early growth stages. Riedell and Blackman (1999) found that infestations by *S. graminum* also reduced dry weight, leaf area and chlorophyll concentration of upper and younger leaves. Results from this study showed that offsprings of *S. graminum* had almost killed the plant by six days after infestation; plants were drooping and wilting. Therefore, outbreaks of *S. graminum* are likely to cause devastating crop losses.

M. dirhodum arrived later at stem elongation. Its preference of the cool underside of the dense canopy created by the middle leaves could be avoidance of extreme temperature in the field (Wiktelius, 1987). The abundance of *M. dirhodum* declined abruptly as the foliage thinned out because of crop senescence at the ripening stage. In 2001, *M. dirhodum* shared a niche with *R. padi* on the few top green leaves including the flag leaf at ripening stage but none of these aphids settled on the spike. In 2003 however, this species of aphid was absent at ripening stage. A similar pattern for *M. dirhodum* was observed by Watt (1979) and Howard and Dixon (1992). The latter observed that very many *M. dirhodum* alates (winged forms) develop on mature plants and fly away even when the number of aphids on each plant is very low. The production of winged forms when wheat is mature results from reduced plant nutrition (Dixon and Glen, 1971) caused by aging and hardening of the awns and kernels. In 2003 however, rainfall was greater than in 2001. The rainfall that continued until the ripening stage during this year could have also contributed to the generally slow increase in abundance of all the aphid species and the absence of *S. graminum* and M. *dirhodum* at this stage. Aphid species are greatly reduced by the impact of rain splash (Wiktelius, 1987).

The mixed results in the abundance of aphids in the three wheat varieties (Table 2) may suggest little or absence of resistance for these varieties. Wanjama (1986) however reported some resistance in Kenya Fahari to the greenbug (*S. graminum*) because it was resistant for all mechanisms of resistance tested. Further work is required to establish whether this holds true for other species of cereal aphids.

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