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Resistance sources for wheat aphid : An update

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ABSTRACT

Wheat (*Triticum aestivum* L.) is a major crop with largest area under cultivation in India and plays a significant role in economic stability of the country. Many insect pests attack wheat in India, severe damage is caused by aphids as serious pest of wheat crop which cause yield losses either directly (35-40%) by sucking the sap of the plants or indirectly (20-80%) by transmitting viral and fungal diseases. They can multiply very rapidly under favourable conditions on leaves, stems and inflorescence. The infestation causes severe distortion of leaves and inflorescence and can significantly decrease the yield through direct feeding. The production of chlorophyll (green colour) is prevented by the attack of aphid resulting in curling of leaves and delayed head emergence causing improper maturity of grains. The aphid incidence level differed in different cultivars of wheat. The resistance of crop is an index of the balance that exists between the preference of the pest for crop and its antibiosis against it. The mechanical barriers possessed by the plants which prevented insects from feeding or ovipositing on them. The infestation significantly affected the root dry weight, number and height of tillers and number of spikes per head. Leaf epicutticular wax, ultra structure and leaf trichome were different on susceptible wheat cultivar and resistant cultivar. Leaf trichome density and position may act as a physical obstracle to the Russian wheat aphid feeding. An increased amount of glutamic acid, glutamine, alpha amino butyric acid, phenylalanine and proline and less methionine, produce resistance in wheat plants against aphids. Hydroxamic acids (Hx) have been shown to be a major biochemical mechanism of resistance of wheat to aphids, acting through antibiosis and feeding deterrency.

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INTRODUCTION

Wheat (*Triticum aestivum* L.) is a major crop with largest area under cultivation in India and plays a significant role in economic stability of the country. Low yield of wheat per hectare in India compared to the other advanced countries is due to several abiotic and biotic

factors, such as traditional methods of cultivation, varieties, lack of irrigation facilities, soil fertility and incidence of insect pests and diseases. Although many insect pests attack wheat (*Triticum aestivum* L.) in India, severe damage is caused by aphids. The greenbug, *Schizaphis graminum*, is an aphid that causes spectacular destruction of wheat. It is a serious pest of wheat due to the fact that it injects a toxin while feeding. The other aphids *viz.*, *Microsiphim avenae* (English grain aphid) and *Rhopalosiphum padi* (Oat aphid) may cause limited injury due to feeding but they do not secret/inject a toxin which stunts the plant growth. Aphids cause yield losses either directly (35-40%) by sucking the sap of the plants or indirectly (20-80%) by transmitting viral and fungal diseases. Population density of aphids also depends on the abiotic factors. The wheat crop is generally infested with aphids during the growth stages when both the adults and nymphs take a heavily suck cell sap which reduces the vitality of the plants. The infested leaves turn pale, wilt and wear a silky appearance. Some species also have toxins in their saliva and dense infestation may kill young shoots. Honey dew excretion is often prolific and sooty moulds usually accompany aphid infestation which eventually affects the rate of photosynthesis in plants. The poor yield of wheat crop is mainly attributed to its instability to aphids attack. The aphids are considered as serious pest of wheat crop. They can multiply very rapidly under favourable conditions on leaves, stems and inflorescence. The infestation causes severe distortion of leaves and inflorescence, and can significantly decrease the yield through direct feeding.

Wheat is one of the preferred hosts of Russian wheat aphid (RWA) *Diuraphis noxia* (Mordvilko). Infestations on leaves, stems, awns and heads have been severe, causing necrosis and blackening of these parts during the last few years. Necrosis and blackening affect grain yield. The production of chlorophyll (green colour) is prevented by the attack of aphid resulting in curling of leaves and delayed head emergence causing improper maturity of grains. Therefore, the early detection is important (Karren, 1989). It was also reported that each 1 per cent infestation level will result in a 0.5 per cent yield loss at harvest (Karren, 1989). Shea *et al*. (2000) pointed out that the flag leaf is rolled and the emerging heads and awns are trapped by aphid attack resulting in poor pollination. Aphid attack starts from emergence and continues upto maturity (Shea *et al*., 2000).

The aphid incidence level differed in different cultivars of wheat (Wratten and Redhead, 1976). Aheer *et al*. (1993) reported that advanced lines of wheat differed significantly with respect to population of aphids and grain yield. The aphid population attained peak level in the mid of March (Aheer *et al*., 1993). Amjad and Ali (1999) narrated that aphid population varied on test cultivars of wheat during the months of February to April 2001 and peak level of aphids was noted during third week of March. 50 and 76 per cent losses in grain weight per year in winter and spring wheat, respectively, have been reported (Kuroli and Nemeth, 1987). Kieckhefer and Gellner (1992) reported losses ranging from 35 to 40 per cent at 15 aphids per plant (2.3-2.7% per aphid). Aheer *et al*. (2006) reported mean densities of the wheat aphids to be 2.29, 2.07, 2.41, 2.23 and 2.22 per tiller on wheat

Sources of resistance:

Sources of resistance to the Russian wheat aphid (RWA) *Diuraphis noxia* (Mordvilko), have been found in wheat and related species. This study was conducted to determine the inheritance of resistance to the RWA in an amphiploid derived from crosses between *Triticum tauschii* and *T. turgidum* and to identify new sources of RWA resistance in *T. tauschii*. Many *Triticum tauschii* lines and amphiploids derived from crosses between *T. tauschii* and *T. turgidum*,*T. tauschii* and *T. timopheevii*, and *T. ventricosum* and *T. turgidum* have been screened for resistance to the Russian wheat aphid in greenhouse tests. The results of this study confirmed that resistance of these amphiploids is derived from *T. tauschii*, *T. timopheevii*, and *T. ventricosum*. New sources of RWA resistance were identified in *T. tauschii* species. A resistant amphiploid (synthetic hexaploid wheat. l derived from a cross between *T. tauschii* and *T.turgidum*, was crossed with two susceptible common wheats (*T. aestivum* L.) 'Yorkstar' and 'Norstar' to study the inheritance of RWA resistance derived from *T. tauschii*. F_1 and F_2 reactions indicated that resistance to the RWA in this amphiploid is simple and recessive. The gene symbol Dn3 is proposed for resistance in *T. tauschii* 5Q24.

New sources of resistance were identified after critical field screening of wheat lines in India. These includes HPW 42, GW 173, K 8027 and VL 738, which

consistently showed >5 aphids/tiller for four years. These constitute first identification for aphid resistance in wheat from India.

Physical and chemical basis of non-preference/ resistance:

The aphid problem can be tackled with the application of commonly used insecticides but the drawback lies with their indiscriminate used which results in the problem of health hazards, environmental pollution and development of resistance in insects. It is therefore, advisable to screen out wheat varieties possessing resistance against aphids. The resistance of crop is an index of the balance that exists between the preference of the pest for crop and its antibiosis against it. The breeders focus their attention to increase the yield potential and evolved number of varieties with higher yields. Unfortunately a little attention has been paid to factors responsible for insect resistance. Initially much attention was devoted to the mechanical barriers possessed by the plants which prevented insects from feeding or ovipositing on them. Hardly recent advances in the knowledge of physiology and biochemistry of plants and insects, it has now become possible to determine the physiological and biochemical nature of the plant resistance. The physical characters of plants were studied at the crop maturity when the plants were green and which were affected by aphids and also its effects on aphids. This physical plant characters are plant height, number of tillers per plant, spike length, number of spikelets per spike, number of grains per spike, number of grains per spikelets, grain yield per tiller, leaf area, trichome density and 1000 grain weight. Among the chemical plant characters moisture percentage in plants, protein, crude fat, ash, carbohydrates and various amino acids affects the population of aphids on wheat according to various wheat varieties.

Karamm and Carrilla (1980) reported that infestation significantly affected the root dry weight, number and height of tillers and number of spikes per head. Kieckhefer and Kanatch (1986) reported that losses in yield were caused by aphid feeding during seedling (2 to 3 leaf stage). Bahlmann *et al*. (2003), examined the leaf epicutticular wax ultra structure and leaf trichome on Russian wheat aphid susceptible wheat cultivar and resistant cultivar. They reported the significantly greater trichomedensity in resistance wheat. Leaf trichome density and position may act as a physical obstracle to the Russian wheat aphid feeding, as the aphids feeds on leaf veins of the adaxil leaf surfaces.

Havlickova (1987) reported that an increased amount of glutamic acid, glutamine, alpha amino butyric acid, phenylalanine and proline and less methionine, produce resistance in wheat plants against aphids. According to Tsumuki *et al*. (1987) the degree of resistance was positively correlated to the amount of surface wax on the leaves and also on the wax composition. They further reported that susceptibility increased with an increasing contains of the sugars and free amino acids, in the leaves. They suggested that the selection of high surface wax amount and low total free amino acids contents, might lead to a increased resistance, even if leaf sugar contents remained high. Nasir (2001) reported that the moisture, protein, fibre, ash, carbohydrades and amino acids in wheat plant were found significantly different in all the varieties of wheat under study and found a significant positive effect of amino acids on the population of aphids. Ciepiela (1989) studied the changes in the free phenylalanine and tyrosine contents, in the years of susceptible and relatively resistant varieties due to aphids. Un- infested plants of the susceptible variety, had higher concentration of phenylalanine and tyrosine than the plants of the resistant cultivar.

Hydroxamic acids (Hx) have been shown to be a major biochemical mechanism of resistance of wheat to aphids, acting through antibiosis and feeding deterrency. Thus, negative corelations have been described between Hx levels in plants and growth rate and intrinsic rate of natural increase of cereal aphids populations (Thackray *et al.,* 1990). Higher Hx levels were found among wild relatives of wheat, thus providing the possibilities of increasing Hx in wheat through wild hybridization (Thackray *et al.,* 1990). Several lines of arguments point to the usefulness of Hx in aphid resistance. i) Hx are capable of reducing aphid population through antibiosis and antixenosis (Nicol *et al*., 1992). ii) Sub-lethal doses of insecticide were more effective on aphids feeding on a high Hx wheat cultivar than on low one (Nicol *et al*., 1992).

Hydroxamic acids are absent from the seed, increase upon germination (peaking at the young seedling stage) and decrease thereafter (Niemeyer, 1988).

National and niphad level efforts:

The promising entries identified from the field experiments and from previous screening along with new lines are sown in two rows, two meter long and replicated thrice. The aphid population is recorded from ten random shoots per replication. The entries which are in grade 2-3 are again evaluated in the screen house under artificial population pressure and germplasm having grading more than this is rejected. The germplasm was rated resistant only after confirmation in the screen house tests. Experiment on yield losses in wheat due to aphids and study on reaction of its against aphids has been started in *Rabi* 2012-13. Work on screening to identify resistance sources to wheat aphids is started since 5 to 6 years.

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