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Research Article

Screening of wild and synthetic wheat genotypes for resistance against corn leaf aphid, *Rhopalosiphum maidis* (Fitch)

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Abstract

Among different aphid species attacking wheat crop, corn leaf aphid *R. maidis* (Fitch) severely threaten wheat production. A total of twenty eight genotypes of wheat including *Aegilops tauschii*, synthetic wheat and *Ae. ovata* were screened for two years against corn leaf aphid. In the first year of screening (2021-22), one highly resistant, nine resistant (R) and 14 moderately resistant (MR) and four susceptible wheat accessions were identified. Further screening done in second year (2022-23), identified one highly resistant, 13 resistant, 12 moderately resistant and two susceptible wheat accessions against corn leaf aphid. The majority of wheat accessions were found moderately resistant or resistant to corn leaf aphid. Overall, the two years of screening identified one highly resistant (*Ae. tauschii* 3744b), six moderately resistant (*Ae. tauschii* 33, 13764 and 3744a; synthetic SYN4 and SYN47; *Ae. ovata* 87), five resistant (*Ae. tauschii* 9807, 3769 and 13762; synthetic SYN55, and *Ae. ovata* 2) and two susceptible accessions (*Ae. tauschii* 3757 and synthetic SYN21) against corn leaf aphid.

Key words: Screening, resistant, wheat, aphid, accessions.

1. Introduction

Wheat (*Triticum aestivum* L) is one of the most widely grown cereal crop around the world (Wei et al., 2022). It is also known as "king of cereals". Although, it is widely grown cereal crop, however there are multiple biotic and abiotic factors which cause a substantial decrease in wheat production (Ahmad et al., 2022). Among the biotic constraints, insect pests like aphids, pink stem borer, termites, gujhia weevil, cut worms and army worms etc. are responsible for causing a considerable yield reduction in wheat. Among these insect-pests, aphids are considered as one of the major biotic threat to food production causing significant (3.5–21.0 per cent) grain yield reduction (Li et al., 2021). More than 11 aphid species are reported to attack wheat crop, out of which four species namely *Sitobion avenae* (Fabricius), *Sitobion miscanthi*, *Rhopalosiphum padi* and *Rhopalosiphum maidis* are reported to be most predominant (Singh and Jasrotia, 2020). Among these, the corn leaf aphid (CLA), *R. maidis* is most serious aphid species of North-Western plains.

It is a small size, green color aphid attacking wheat crop from seedling stage onwards. It appears on wheat during October-November and the population reaches its peak during February-March at ear ripening stage. Aphids cause damage by sucking the cell sap from leaves at vegetative stage causing chlorosis (Wang et al., 2021). As the ear emerges, they move to ears to suck sap from them due to which either grains will not developed and if developed they remain shrivelled. Aphids secrete a sugary material which is known as "honey dew". On this honeydew, black sooty mould developed that interferes with photosynthetic activities of the plant and ultimately reduce the grain yield (Simon et al., 2021). They can cause the direct yield losses to the tune of 20-30% by sucking the plant sap (Singh et al., 2020) and indirect losses of around 5-80%

by transmission of viral and fungal diseases (Aradottir et al., 2021). Economic threshold level for wheat aphids was established as 5 aphids/earhead or 10 aphids/flag leaf.

Currently in most of wheat growing regions aphid management is done primarily through the application of commonly used systemic insecticides (Devrani et al., 2018). Furthurmore, these insecticides can provide sufficient protection against aphid problem but the drawbacks lies with their irrational use resulting in emerged problems of induced resistance among aphids to several groups of chemicals besides disrupting their natural biological control and environmental pollution (Foster et al., 2014). All these factors affecting wheat food security, has increased the focus on alternative methods of aphid control. In this regard, eco-friendly approaches must be adopted as a valid alternative to the synthetic chemical pesticides. It is, therefore, advisable to screen wheat accessions possessing resistance against aphids. Also the screening of wheat germplasm has resulted in identification of varying level of aphid resistance in different countries (Wains et al., 2014). Keeping in view the above facts, the present study was conducted with the objective to screen various available genotypes of wheat showing resistant and susceptible response to aphids.

2. Materials and Methods

To identify potential wheat genotypes against corn leaf aphid, *R. maidis* a total of 28 genotypes of synthetic wheat (*T. aestivum*) and wild wheat (*Ae.* spp) were screened during 2021-22 and 2022-23 rabi season under filed conditions at ICAR-IIWBR, Karnal. These 28 genotypes under study included 10 synthetic wheat genotypes and 18 wild wheat accessions comprising 13 accessions of *Ae. tauschii* and 5 from *Ae. ovata*. The list of wheat genotypes screened during the study is listed below in Table 1.

Table 1: List of wild and synthetic wheat genotypes under investigation

Sr. no.	Species	Accession no.	Sr. no.	Species	Accession no.
1	*Ae. tauschii*	62	15	Synthetic	SYN4
2	*Ae. tauschii*	3761	16	Synthetic	SYN81
3	*Ae. tauschii*	33	17	Synthetic	SYN38
4	*Ae. tauschii*	3744	18	Synthetic	SYN51
5	*Ae. tauschii*	9807	19	Synthetic	SYN52
6	*Ae. tauschii*	13764	20	Synthetic	SYN55
7	*Ae. tauschii*	45	21	Synthetic	SYN47
8	*Ae. tauschii*	9788	22	Synthetic	SYN42
9	*Ae. tauschii*	3744	23	Synthetic	SYN21
10	*Ae. tauschii*	13781	24	*Ae. ovata*	24
11	*Ae. tauschii*	3769	25	*Ae. ovata*	20
12	*Ae. tauschii*	13762	26	*Ae. ovata*	82
13	*Ae. tauschii*	3757	27	*Ae. ovata*	87
14	Synthetic	SYN7	28	*Ae. ovata*	2

Each genotype was sown in one meter row with row to row spacing of 30 cm (3 replications; 2 rows per replication) in randomized block design (RBD). The crop was grown by following the all recommended package and practices except plant protection measures. Each genotype was tagged with their genotype name and accession number. The screening test against aphid infestation in terms of number of aphids per shoot, leaf chlorosis and leaf rolling were conducted. The observations were recoreded three times from the five randomly selected plants from each genotype row during the season. The categorization of wheat genotypes was done on the basis of grading system suggested by Zhu et al. (2005). Based upon mean number of aphids per shoot and leaf chlorosis, the wheat genotypes were categorized as immune (I), highly resistant (HR), resistant (R), moderately resistant (MR), and susceptible (S) while on the basis of leaf rolling, the wheat genotypes were categorized as resistant (R) and susceptible (S).

3. Results and Discussion

Screening of wild and synthetic wheat genotypes against R. maidis under field conditions during 2021-22

Data presented in Table 2 described the various categories of resistance response of 28 wild as well as synthetic wheat genotypes against corn leaf aphid, *R. maidis.* On the basis of aphids/shoot, among the 13 *Ae. tauschii* accessions, only one accession was highly resistant, 4 accession were resistant, 6 accessions were moderately resistant, and 2 accessions were found to be susceptible. On the basis of leaf chlorosis, 1 accession was resistant, and 12 accessions were moderately resistant. On the basis of leaf rolling, 9 accessions were resistant and 4 accessions were susceptible. Thus among *Ae. tauschii* accessions, the accession '3744b' was found to be highly resistant while the accessions '62 and 3757' were found to be susceptible on the basis of aphids/shoot. Among the 10 synthetic wheat genotypes, based upon mean number of aphids per shoot, 3 genotypes were classified to be having resistant response, 5 genotypes were having moderately resistant response and 2 genotypes were having susceptible response toward corn leaf aphid, *R. maidis* infestation. No genotype was found to be highly resistant and immune against the aphid infestation. On the basis of leaf chlorosis, 3 genotypes were resistant, and 7 genotypes were moderately resistant while 6 genotypes were resistant and 4 genotypes were susceptible based upon leaf rolling. Among the 5 *Ae. ovata* accessions, on the basis of aphids/shoot, 3 accessions were moderately resistant, and 2 accessions were found to be resistant. On the basis of leaf chlorosis, similar trend was observed while on the basis of leaf rolling, 3 accessions were found to be resistant and 2 accessions were susceptible.

Contemporarily, the grouping of the 28 wheat genotypes under investigation are depicted and described in Table 2 and Figure 1 respectively. Out of total wheat genotypes, on the basis of aphid population, only one accessions was highly resistant, 9 accessions were resistant, 14 accessions were moderately resistant, and 4 accessions were found to be susceptible (Fig. 1a). Thus, 3.57% accessions were highly resistant, 32.14% were resistant, 50.00% were moderately resistant and 14.28% were found to be highly resistant. The accession no. 3744b (*Ae. tauschii*)) was found to be susceptible while the accession no. 62, 3757, (*Ae. tauschii*) and SYN21, SYN 42 (synthetic) were found to be susceptible. On the basis of leaf chlorosis, 6 accessions were resistant, and 22 accessions were moderately resistant while on the basis of leaf rolling, 18 accessions were resistant and 10 accessions were susceptible. Thus, 21.43% were resistant, 78.57% were moderately resistant (Fig. 1b) and 64.29% were resistant and 35.71% were found to be susceptible (Fig. 1c) based upon leaf chlorosis and leaf rolling respectively.

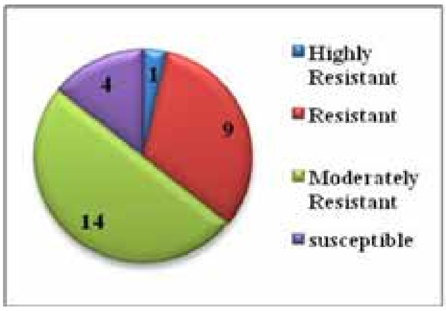

Fig. 1 (a)

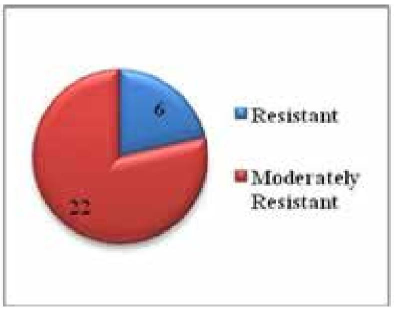

Fig. 1(b)

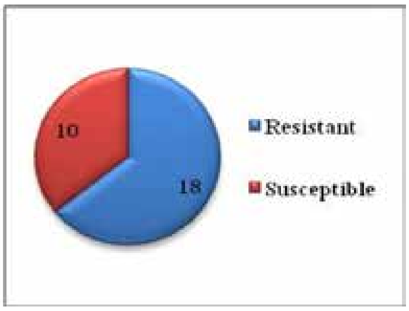

Fig. 1(c)

Figure 1 Characterization of wild and synthetic wheat genotypes into different categories of resistance based on (a) aphids/shoot, (b) leaf chlorosis and (c) leaf rolling under field conditions during 2021-22

Table 2. Characterization of wild and synthetic wheat genotypes based on aphids/shoot, leaf chlorosis and leaf rolling under field conditions during 2021-22

Species	Accession no.	Based on aphid population		Based on leaf chlorosis		Based on leaf rolling	
		Grade	Reaction*	Grade	Reaction*	Grade	Reaction*
Ae. tauschii	62	5	S	4	MR	2	R
Ae. tauschii	3761	3	R	4	MR	3	S
Ae. tauschii	33	4	MR	3	R	2	R
Ae. tauschii	3744a	4	MR	4	MR	2	R
Ae. tauschii	9807	3	R	4	MR	2	R
Ae. tauschii	13764	4	MR	4	MR	2	R

Ae. tauschii	45	4	MR	4	MR	2	R
Ae. tauschii	9788	4	MR	4	MR	2	R
Ae. tauschii	3744b	2	HR	4	MR	3	S
Ae. tauschii	13781	4	MR	4	MR	3	S
Ae. tauschii	3769	3	R	4	MR	2	R
Ae. tauschii	13762	3	R	4	MR	3	S
Ae. tauschii	3757	5	S	4	MR	2	R
Synthetic	SYN7	4	MR	3	R	3	S
Synthetic	SYN4	4	MR	3	R	2	R
Synthetic	SYN81	4	MR	4	MR	2	R
Synthetic	SYN38	3	R	4	MR	2	R
Synthetic	SYN51	3	R	4	MR	2	R
Synthetic	SYN52	4	MR	4	MR	3	S
Synthetic	SYN55	3	R	4	MR	3	S
Synthetic	SYN47	4	MR	4	MR	2	R
Synthetic	SYN42	5	S	4	MR	2	R
Synthetic	SYN21	5	S	3	R	3	S
Ae. ovata	24	3	R	4	MR	2	R
Ae. ovata	20	4	MR	3	R	2	R
Ae. ovata	82	4	MR	4	MR	3	S
Ae. ovata	87	4	MR	3	R	3	S
Ae. ovata	2	3	R	4	MR	3	R

*Reaction: I=Immune; HR=Highly resistant; R=Resistant; MR=Moderately Resistant; S=Susceptible

Screening of wild and synthetic wheat genotypes against R. maidis under field conditions during 2022-23

Data given in Table 3 shows the screening of wild and synthetic wheat genotypes during 2022-23. The grouping of 13 *Ae. tauschii* accessions based upon aphids per shoot concluded that on the basis of mean no. of aphids per shoot, one accession was found to be highly resistant, 6 accession were resistant, and 6 accessions were moderately resistant indicating that there were neither immune nor susceptible wheat genotypes. On the basis of leaf chlorosis, 7, 5 and one accessions were resistant, moderately resistant and susceptible while on the basis of leaf rolling, 8 accessions were resistant and 5 accessions were susceptible. Among the 10 synthetic wheat genotypes evaluated, on the basis of aphid population per shoot, 3 genotypes were resistant, 6 genotypes were moderately resistant and only one genotype was found to be susceptible. On the basis of leaf chlorosis, 6 genotypes were found to be resistant and 4 genotypes were moderately resistant. However on the basis of leaf rolling, 8 genotypes were resistant and 2 genotypes were susceptible. Likewise, among the 5 *Ae. ovata* accessions, on the basis of aphid population, 3 accessions showed resistant, and 2 accessions showed moderately resistant reaction. On the basis of leaf chlorosis, 3 accessions were resistant, and 2 accessions were moderately resistant while 4 accessions were resistant and only one accessions was susceptible based upon the criteria of leaf rolling.

Among the 28 wild and synthetic wheat genotypes, on the basis of aphid population, 1 accessions was highly resistant, 13 accessions were resistant, and 12 accessions were moderately resistant and 2 accessions were found to be susceptible. This concluded that there were neither immune nor susceptible wheat genotypes. On the basis of leaf chlorosis, 16 accessions were resistant, 11 accessions were moderately and only one accession was susceptible while on the basis of leaf rolling, 20 accessions were resistant and 8 accessions were found to be susceptible. Thus, among the 28 wild and synthetic wheat genotypes, on the basis of aphid population, 3.57% were highly resistant, 46.43% were resistant, 42.85% were moderately resistant, and 7.14% were susceptible (Fig. 2a). Likewise on the basis of leaf chlorosis, 57.14% were resistant, 39.29% were moderately resistant and 3.57% were susceptible (Fig. 2b) and on the basis of leaf rolling, 71.43% were resistant and 28.57% were found to be susceptible (Fig. 2c).

Fig. 2 (a)

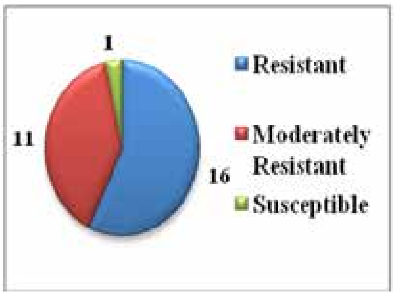

Fig. 2 (b)

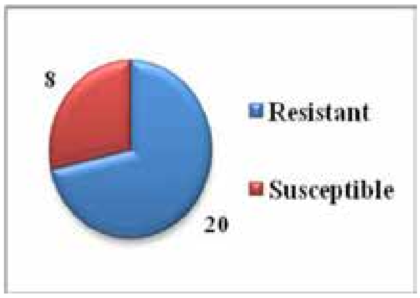

Fig. 2 (c)

Figure 2 Characterization of wild and synthetic wheat genotypes into different categories of resistance based on (a) aphids/shoot, (b) leaf chlorosis and (c) leaf rolling under field conditions during 2022-23

Table 3. Characterization of wild and synthetic wheat genotypes based on aphids/shoot, leaf chlorosis and leaf rolling under field conditions during 2022-23

Species	Accession no.	Based on aphid polpulation		Based on leaf chlorosis		Based on leaf rolling	
		Grade	Reaction*	Grade	Reaction*	Grade	Reaction*
Ae. tauschii	62	4	MR	3	R	2	R
Ae. tauschii	3761	4	MR	3	R	2	R
Ae. tauschii	33	4	MR	3	R	3	S
Ae. tauschii	3744a	4	MR	3	R	3	S
Ae. tauschii	9807	3	R	4	MR	3	S
Ae. tauschii	13764	4	MR	3	R	2	R
Ae. tauschii	45	3	R	3	R	2	R
Ae. tauschii	9788	3	R	4	MR	2	R
Ae. tauschii	3744b	2	HR	5	S	2	R
Ae. tauschii	13781	3	R	4	MR	2	R
Ae. tauschii	3769	3	R	4	MR	3	S
Ae. tauschii	13762	3	R	3	R	3	S
Ae. tauschii	3757	5	S	4	MR	2	R
Synthetic	SYN7	3	R	3	R	3	S
Synthetic	SYN4	4	MR	3	R	3	S
Synthetic	SYN81	3	R	4	MR	2	R
Synthetic	SYN38	4	MR	4	MR	2	R
Synthetic	SYN51	4	MR	3	R	2	R
Synthetic	SYN52	3	R	4	MR	2	R
Synthetic	SYN55	3	R	4	MR	2	R
Synthetic	SYN47	4	MR	3	R	2	R
Synthetic	SYN42	4	MR	3	R	2	R
Synthetic	SYN21	5	S	3	R	2	R
Ae. ovata	24	4	MR	4	MR	2	R
Ae. ovata	20	3	R	4	MR	2	R

Ae. ovata	82	3	R	3	R	2	R
Ae. ovata	87	4	MR	3	R	3	S
Ae. ovata	2	3	R	3	R	2	R

*Reaction: I=Immune; HR=Highly resistant; R=Resistant; MR=Moderately Resistant; S=Susceptible

Present study revealed that neither of the 28 wild and synthetic wheat genotypes evaluated were found to be immune even in both years investigation based upon all three grading criteria. These findings are in line with results of Zhang et al. (2022) who investigated the response of six wheat cultivars toward wheat aphid, but are in contradiction with the finding of Wains et al. (2014) who reported that out of 464 accessions screened against aphids, 71 accessions exhibited an immune response, 87 varieties/lines were found resistant, 127 moderately resistant, while 141 accessions were graded as tolerant, although not all genotypes same as used in the current study against *R. maidis.* Most of the wild wheat genotypes screened in the current study have not been screened by any other workers in the past except a few. Three years of screening identified one resistant (*Aegilops tauschii* 14096) and six moderately resistant accessions (*Aegilops tauschii* 14135, 14232, 14339, 14348, 14576 and 3733) against foliage feeding wheat aphids (Singh et al., 2018) support the present findings. Also, Liu et al. (2018) carried out a field screening tests to evaluate the *S. avenae* resistance of 527 wheat landraces and the results indicated that 25 accessions (4.74%) were resistant to *S. avenae* in the three consecutive seasons. Considerable variations in aphid response on different wheat species was exhibited by present study is consistent with the finding of Qamar Zeb et al. (2015) who reported a differential resistance in wheat and barley against Russian wheat aphid and with Aradottir et al. (2017) who also reported significant variation in aphid performance among different wheat collections. These findings are also confirmed by other studies. For instance, Akhtar et al. (2010) evaluated wheat lines/varieties resistance against *R. padi* and found that five varieties were resistant, thirteen were moderately resistant and two were susceptible. Jan et al. (2018) screened eleven wheat genotypes and found that shafaq 2006 and V-12120 were more susceptible while Punjab-2011 and 11C023 were exhibiting resistance against wheat aphids. Among the varieties tested for wheat aphid resistance based on the number of aphid/tillers, the variety UP-2526 and UP-2869 was most resistant and DPW-62150 was most susceptible (Devrani et al., 2018).The result of seedling bulk test revealed that varieties namely NIAW 917, NIAW 301, NIAW 34, NIAW 1415, HD 2189 and LOK-1 were found moderately resistant and varieties namely A-9-30-1, NIDW 295 and GW 496 were found susceptible against wheat aphid (*Rhopalosiphum padi* L) (Vare et al., 2018).

Conclusion

From the present study it can be concluded that there was no genotypes with immune reaction towards *R. maidis* however, one highly resistant (*Ae tauschii* 3744b), and six resistant (*Ae tauschii* 9807, 13764, 3769 and 13762; synthetic SYN55; *Ae. ovata* 2) accessions in two consecutive years were identified. This collection from diverse sources of resistance provides noval source of resistance and may help to reduce aphid problem in wheat as resistant cultivar deployment is an effective method for cereal aphid management. This will further ensure food security for world's rapidly growing population.

Author Contributions

PK & PJ prepared the manuscript and preparing the final version of the manuscript and correspond to the journal.

Ethical Approval

This article does not contain any studies involving human or animal participants performed by any of the authors.

Conflicts of Interest:

The authors declare no conflict of interest.

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