Screening of Maize Genotypes against Maize Leaf Aphid *Rhopalosiphum maidis* (Fitch) under Field Condition at Chitwan, Nepal

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**ABSTRACT**

Thirty maize genotypes including five hybrids, eight quality protein (QPM) and seventeen full season open pollinated (OP) were screened for their resistance against maize leaf aphid (*Rhopalosiphum maidis* Fitch) at the research field of National Maize Research Program, Rampur, Chitwan, Nepal during the year 2019 and 2020. The design of the experiment was randomized incomplete block with three replications. The plot size was 2 rows of 5 m long with the spacing of 60 cm × 25 cm. The recommended dose of fertilizer for full season OP and QPM were 120:60:40 and for hybrid maize 180:60:40 N: P₂O₅: K₂O kg/ha with farm yard manure 10 t/ha and seed rate was 20 kg/ha. Data on aphid incidence, severity, yield and yield components were recorded. Maize hybrids RML-95/RML-96 (18%) and Rampur Hybrid-10 (22%), two quality protein maize (QPM) S00TLYQ-AB (22%) and S99TLYQ-A (23%) and two full season OP genotypes TLBR507F16 (24%) and ZM 627 (26%) were less susceptible to aphid infestation and resulted in higher grain yield. The findings could aid in the selection of maize genotypes for the development of aphid resistant and high-yielding maize varieties.

**Keywords:** aphid, genotype, maize, resistance.
INTRODUCTION

Maize aphid, *Rhopalosiphum maidis* (Fitch), an economically important pest associated with maize production, is phloem sap-sucking ubiquitous polyphagous pest attacking more than 182 plant species (Alam et al 2014). *Rhopalosiphum maidis* is responsible for causing infestation in all parts of maize with major damage in the tassel causing varying degree of barrenness, grain yield loss and virus transmission (Carena and Glogoa 2004). The pest cause direct damage to the plant by sucking the phloem nutrients and hindering the photosynthesis as a result of sooty mould. It is reported to cause yield loss as high as 40% (Everly 1960). A number of biotic and abiotic stresses during different crop stages are the factors that impede maize production (Neupane and Subedi 2019). In Nepal, aphid become more severe on maize in last week of January to third week of march (NMRP 2020). This pest has become a severe threat and emerging pest of maize during the last 3-4 years in Nepal (NMRP 2020).

Aphid infestation in maize causes damage in pollination and introduces various disease causing microorganisms in plant parts as a vector with the yield loss of about 10-20% annually in maize crops (Subedi 2015). Most of the maize farmers in Nepal faced the problem of heavy feeding by aphids prior to tasseling leads to ears without grain or kernels that do not properly develop and result yield loss ranging from 10 to 20% (NMRP 2019). The colonies of maize aphids can be found on or near tassels or whorl leaves in most maize fields and some farmers’ fields may have up to 50% plant infestation at mid hill and terai region of Nepal particularly during winter season (NMRP 2020). Although there are various insecticides for chemical control of maize aphid, it is imperative to identify cheaper, eco-friendly and sustainable measure of pest management for which utilization of host-plant resistance probably best measure for combating economic pests (Esele 2003). Therefore, the research was conducted to analyze and evaluate the level of resistance of different maize genotypes against maize aphid for identification of superior aphid resistant genotypes which can be utilized in future maize breeding programs.

MATERIALS AND METHODS

The screening activities were organized following alpha lattice design with three replications during spring season of 2019 and 2020 under natural infestation at field condition of National Maize Research Program (NMRP) Rampur, Chitwan. The geographical location of NMRP, Rampur, Chitwan is in 27˚40’ N latitude, 84˚19’ E longitude at an altitude of 228 meter above sea level. It has humid and subtropical climate with cool winter and hot summer. The soil is generally acidic (pH 4.6-5.7), light textured and sandy loam. The average total annual rainfall was 2215.30 mm with a distinct monsoon period (>75% of annual rainfall) from mid June to mid-September. Thirty maize genotypes were sown on September 29 of 2019 and September 30 of 2020 in 2 rows of 5 m long with the spacing of 60 cm × 25 cm Among thirty; five were hybrids (Rampur Hybrid-4, Rampur Hybrid-6, Rampur Hybrid-10, RML-95/RML-96 and RML-86/RML-96), eight were Quality protein Maize (QPM) (S99TLQY-A, S99TLQY-HGAB, SO0TLQY-B, SO1SIYQ, Poshilo Makai-1, Poshilo Makai-2, S03TLQY-AB-02 and S00TLQY-AB) and rest seventeen were Open Pollinated Full Season maize (OPVs) (KSYNF10, BGBY-Pop, SO128, P3522, Manakama-3, Mankamana-7, ZM-627, RPOP-2, Rampur 4, RampurSI13F26, ZM-401, 05SADVI, 07SADVI, HG-A, TLBRS07F16, Rampur Composite and Deuti). The source of all released and promising maize genotypes were maize breeding program of NMRP, Rampur. The recommended dose of fertilizer for full season open pollinated and quality protein maize was 120:60:40 and for hybrid maize 180:60:40 N: P₂O₅:K₂O kg/ha with farm yard manure 10 t/ha and seed rate 20 kg/ha. Most of the cultural practices were followed as recommended.

Data collection and analysis

Data on aphid incidence (aphid colony per plant), severity (1-5 scale) developed by Lu and Brewbaker (1999), aphid infested plant per plot, yield components (number of ear, rotten ear, final plant stand and thousand kernel weight in g) and yield (t/ha) were recorded. All data were analyzed statistically using Microsoft Excel 2010 and GENSTAT 18th edition computer package programs.
RESULTS

In 2019/20, the analysis of variance revealed highly significant differences among the evaluated maize genotypes for aphid infested plant/plot, aphid colony/plant, aphid score, aphid infested plant percentage, final plant stand, no of ear, no. of rotten ear, grain yield and thousand kernel weight (Table 1). The aphid infested plant/plot ranged from (4-17) with the mean average of 10 ± 0.58, aphid colony/plant (2-7) with the mean average of 4 ± 0.15, aphid score (2-5) with the mean average of 4 ± 0.12, aphid infested plant percentage (13-42) with the mean average of 28 ± 1.27, final plant stand (22-47) with the mean average of 38 ± 1.05, no of ear (22-46) with the mean average of 35 ± 1.13, no of rotten ear (3-16) with the mean average of 7 ± 0.59, grain yield (3.88-15.89 t/ha) with the mean average of 6.4 ± 4.21 t/ha and thousand kernel weight (355-567 g) with the mean average of 431 ± 8.28 g (Table 1).

**Table 1. Statistical parameters on aphid (Rhopalosiphum maidis) infestation, yield and yield components of maize genotypes evaluated at Rampur, Chitwan, Nepal during 2019/20**

| Parameters                        | Mean ± SEM | Range  | P- value | LSD (0.05) | CV, (%) |
|-----------------------------------|------------|--------|----------|------------|---------|
| Aphid infested plant/plot         | 10 ± 0.58  | 4-17   | <.001    | 2.35       | 13.71   |
| Aphid colony/plant                | 4 ± 0.15   | 2-7    | <.001    | 0.97       | 15.37   |
| Aphid score (1-5)                 | 4 ± 0.12   | 2-5    | <.001    | 0.79       | 13.35   |
| Aphid infested plant (%)          | 28 ± 1.27  | 13-42  | <.001    | 6.32       | 13.79   |
| Final plant stand                 | 38 ± 1.05  | 22-47  | <.001    | 4.85       | 7.88    |
| No of ears                        | 35 ± 1.13  | 22-46  | <.001    | 10.03      | 17.33   |
| No. of rotten ears                | 7 ± 0.59   | 3-16   | 0.013    | 5.75       | 47.28   |
| GY (t/ha)                         | 6.4 ± 4.21 | 3.88-15.89 | <.001 | 3.58       | 34.04   |
| TKW (g)                           | 431 ± 8.28 | 355-567 | 0.008   | 77.35      | 10.85   |

<br>Means of 3 replications, SEM= standard error mean, GY= grain yield, TKW= thousand kernel weight, %- percentage, t/ha=ton per hectare, g= gram

During 2020/21 also similar trends were reported and data revealed that statistically highly significant differences for the parameters aphid infested plant/plot, aphid colony/plant, aphid score, aphid infested plant percentage, no of ear, no. of rotten ear, grain yield and thousand kernel weight among the tested maize genotypes (Table 2).

**Table 2. Statistical parameters on aphid (Rhopalosiphum maidis) infestation, yield and yield components maize genotypes evaluated at Rampur, Chitwan, Nepal during 2020/21**

| Parameters                        | Mean ± SEM | Range  | P- value | LSD (0.05) | CV, (%) |
|-----------------------------------|------------|--------|----------|------------|---------|
| Aphid infested plant/plot         | 12 ± 0.59  | 6-19   | 0.006    | 5.76       | 29.05   |
| Aphid colony/plant                | 5 ± 0.16   | 2-6    | 0.012    | 1.69       | 22.80   |
| Aphid score (1-5)                 | 4 ± 0.12   | 2-5    | <.001    | 0.83       | 14.15   |
| Aphid infested plant( %)          | 39 ± 1.98  | 20-68  | 0.007    | 19.12      | 29.63   |
| Final plant stand                 | 31 ± 0.42  | 26-36  | 0.436    | 6.34       | 12.35   |
| No of ears                        | 31 ± 0.61  | 25-41  | 0.006    | 6.72       | 13.15   |
| No. of rotten ears                | 6 ± 0.41   | 3-15   | <.001    | 2.38       | 23.78   |
| GY (t/ha)                         | 5.14 ± 1.97| 2.86-7.89 | <.001 | 6.39       | 7.58    |
| TKW (g)                           | 433 ± 8.12 | 355-558 | <.001   | 69.23      | 9.74    |

<br>Means of 3 replications, SEM= standard error mean, GY= grain yield, TKW= thousand kernel weight, %- percentage, t/ha=ton per hectare, g= gram

The aphid infested plant/plot ranged from (6-19) with the mean average of 12 ± 0.59, aphid colony/plant (2-6) with the mean average of 5 ± 0.16, aphid score (2-5) with the mean average of 4 ± 0.12, aphid infested plant percentage (20-68) with the mean average of 39 ± 1.98, no of ear (25-41) with the mean average of 31 ± 0.68, no of rotten ear (3-15) with the mean average of 6 ± 0.41, grain yield (2.86-7.89 t/ha) with the mean average of 5.14 ± 1.97 t/ha and thousand kernel weight (355-558 g) with the mean average of 433 ± 8.12 g (Table 2).

The combined mean performance of maize genotypes to the aphid damage parameters, yield and yield components during 2019-2021 (Table 3). Statistically significant and highly significant differences were observed for the parameters aphid infested plant/plot, aphid colony/plant, aphid...
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score, aphid infested plant %, final stand, no of ear, and grain yield among the tested maize genotypes in combined analysis for two consecutive years. The aphid infested plant/plot ranged from (6-16), aphid colony/plant (2-6), aphid score (2-5), aphid infested plant percentage (18-49), final stand (26-41), no of ear (25-42), no of rotten ear (4-16), grain yield (4.10-11.81 t/ha) and thousand kernel weight (355-562 g) (Table 3). The lower percentage of aphid infestation were recorded in genotypes RML-95/RML-96 (18%), Rampur Hybrid-10 (22%), S00TLYQ-AB (22%), S99TLYQ-A (23%), TLBRS07F16 (24%) and ZM 627 (26%). Similarly, the top five high yielding maize genotypes were RML-95/RML-96 (11.81 t/ha), Rampur Hybrid-6 (9.53 t/ha), Rampur Hybrid-10 (7.36 t/ha), RML-86/RML-96 (6.75 t/ha) and Deuti (6.69 t/ha) (Table 3).

Table 3. Combined mean performance of maize genotypes to the aphid damage parameters, yield and yield components during 2019-2020 at Rampur, Chitwan, Nepal

| Genotypes         | AIP/plot | AC/ plant | AS (1-5) | AIP % | FS | No. of Ear | Rotten Ear | GY (t/ha) | TKW (g) |
|-------------------|----------|-----------|----------|-------|----|------------|------------|-----------|---------|
| Rampur Hybrid-4   | 13       | 4         | 3        | 39    | 36 | 35         | 5          | 6.31      | 415     |
| Rampur Hybrid-6   | 11       | 4         | 3        | 32    | 37 | 42         | 7          | 9.53      | 554     |
| Rampur Hybrid-10  | 8        | 3         | 3        | 22    | 38 | 39         | 5          | 7.36      | 562     |
| RML-95/RML-96     | 6        | 2         | 2        | 18    | 35 | 36         | 6          | 11.81     | 355     |
| RML-86/RML-96     | 15       | 4         | 4        | 42    | 36 | 37         | 5          | 6.75      | 454     |
| S99TLYQ-A         | 8        | 4         | 4        | 23    | 36 | 35         | 8          | 5.88      | 392     |
| S99TLYQ-HGAB      | 12       | 4         | 4        | 35    | 35 | 29         | 8          | 4.19      | 393     |
| SOOTLYQ-B         | 9        | 5         | 4        | 32    | 29 | 28         | 5          | 5.30      | 420     |
| SO1SIYQ           | 16       | 4         | 4        | 47    | 36 | 30         | 8          | 5.16      | 423     |
| Poshilo Makai-1   | 12       | 5         | 4        | 35    | 34 | 32         | 8          | 5.18      | 419     |
| Poshilo Makai-2   | 11       | 4         | 4        | 36    | 32 | 29         | 5          | 4.62      | 419     |
| S03TLYQ-AB-02     | 13       | 4         | 4        | 36    | 38 | 36         | 5          | 5.10      | 435     |
| KSYNF10           | 14       | 4         | 3        | 39    | 37 | 33         | 8          | 6.21      | 425     |
| BGBY-Pop          | 13       | 5         | 4        | 38    | 34 | 33         | 10         | 5.99      | 415     |
| SO128             | 14       | 4         | 4        | 49    | 30 | 28         | 12         | 4.10      | 417     |
| P3522             | 14       | 4         | 4        | 42    | 35 | 34         | 16         | 5.64      | 389     |
| Manakama-3        | 11       | 3         | 3        | 39    | 28 | 26         | 4          | 4.46      | 377     |
| Mankama -7        | 9        | 4         | 4        | 29    | 32 | 31         | 5          | 4.68      | 457     |
| ZM-627            | 8        | 5         | 4        | 26    | 32 | 32         | 5          | 6.00      | 495     |
| RPOP-2            | 10       | 5         | 4        | 27    | 37 | 35         | 7          | 5.52      | 445     |
| Rampur 4          | 11       | 4         | 4        | 33    | 35 | 33         | 5          | 4.26      | 450     |
| RampurS13F26      | 15       | 4         | 4        | 41    | 36 | 32         | 5          | 4.54      | 397     |
| ZM-401            | 10       | 4         | 4        | 32    | 31 | 29         | 10         | 5.10      | 451     |
| 05SADV1           | 14       | 4         | 3        | 39    | 36 | 34         | 6          | 5.34      | 435     |
| 07SADV1           | 15       | 4         | 4        | 38    | 38 | 37         | 8          | 6.32      | 431     |
| HG-A              | 11       | 4         | 3        | 32    | 36 | 39         | 4          | 6.24      | 435     |
| TLBRS07F16        | 9        | 3         | 4        | 24    | 37 | 37         | 8          | 4.62      | 395     |
| Rampur Composite  | 8        | 5         | 4        | 31    | 26 | 25         | 5          | 4.55      | 463     |
| Deuti             | 12       | 6         | 5        | 29    | 41 | 40         | 5          | 6.69      | 435     |
| S00TLYQ-AB        | 7        | 4         | 3        | 22    | 33 | 33         | 7          | 5.76      | 417     |
| Grand mean        | 11       | 4         | 4        | 34    | 34 | 33         | 7          | 5.77      | 432     |
| Min               | 6        | 2         | 2        | 18    | 26 | 25         | 4          | 4.10      | 355     |
| Max               | 16       | 6         | 5        | 49    | 41 | 42         | 16         | 11.81     | 562     |

Genotype (G) <.001 <.001 <.001 <.001 <.001 <.001 <.001 <.001 <.001 <.001 <.001 Year (Y) <.001 <.001 0.712 <.001 <.001 <.001 <.001 0.001 <.001 0.72 Year × Genotypes <.001 0.013 <.001 0.002 <.001 <.005 0.379 0.031 1.00 LSDK<sub>0.05</sub> (G) 2.95 0.96 0.55 9.62 4.02 5.80 3.06 1.78 48.61 LSDK<sub>0.05</sub> (Y) 0.76 0.25 0.14 2.49 1.04 1.50 0.79 4.59 12.55 LSDK<sub>0.05</sub> (G×Y) 4.18 1.36 0.78 13.65 5.68 8.20 4.33 2.51 68.79 CV, % 22.90 20.04 13.49 25.02 10.21 15.26 39.64 26.90 9.80

1Means of 3 replications, AIP- Aphid infested plant, AC- Aphid colony, AS- Aphid score, FS- Final stand, GY- grain yield, TKW- thousand kernel weight, t/ha-ton per hectare, g-gram
Relationship between aphid infestation (AIP%) and grain yield

The best fit, with adjusted $R^2=72\%$, showed a substantial linear negative association ($r=-0.87$) between grain yield and aphid infestation percentage (Figure 1). Consequently, as aphid infestation increased, grain yield was dropped. The projected linear regression line has a decreasing slope as well i.e. $y = -0.613x + 20.92$, with regression coefficient $R^2=0.76$, where $y$ denoted predicted maize yield (t/ha) and $x$ stood for aphid infestation in percentage (Figure 1).

![Figure 1. Relationship between grain yield (t/ha) and aphid infestation % in less aphid infested and high yielding (top eight) maize genotypes at Rampur, Chitwan, Nepal during 2019-2020.](image)

DISCUSSIONS

The development of resistant maize varieties to the maize aphid might be a solution to achieve constant and efficient protection against this pest infestation. Based on two years result, two hybrids RML-95/RML-96 and Rampur Hybrid-10, two quality protein maize (QPM) genotypes S00TLYQ-AB and S99TLYQ-A and two full season maize genotypes TLBRS07F16 and ZM 627 have less than 25% aphid infestation. In case of grain yield, two promising (RML-95/RML-96 and RML-86/RML-96) and two released (Rampur Hybrid-6 and Rampur Hybrid-10) hybrids yielded more than 7 t/ha. Similarly, one released full season OP variety Deuti and five promising full season OP genotypes 07SADV1, HG-A, KSYNF10, ZM-627 and BGBY-Pop yielded more than 6 t/ha. Two promising QPMs S99TLYQ-A and S00TLYQ-AB yielded about 6 t/ha with lower aphid infestation. Promising hybrid RML-95/RML-96 have significantly lower aphid infestation (<20%) with higher yield (>10 t/ha). Phenotypic and genotypic responses of land races, pure lines and hybrids of maize indicate that resistance to the maize aphid is inherited (Carena and Glogoza 2004). Breeding for aphid resistance in maize continues to be a challenge due to the difficulty in obtaining reliable natural infestations and the presence of genotype by environment interactions. Environmental condition highly governs rate of colony development and grain yield reduction. Carena and Glogoza (2004) mentioned that resistance of maize to aphid is predominantly governed by additive gene effects which imply resistance through multiples genes with large environmental influence. Similar, study was conducted in Hawaii to evaluate aphid resistant shown by sweet corn hybrid Hi38-71 which revealed that resistance to maize aphid was caused due to single recessive gene labeled $aph$ (So et al 2010). Maize genotypes that have tassels exposed quickly from the leaves tend to have the lowest aphid populations (Scinski and Hurej 1996). Narang et al (1997) demonstrated that phenols and leaf surface wax contributed towards resistance as genotypes having high amount of these two constituents supported fewer maize aphid per plant. Eryan and Tabbakh (2004) from Egypt reported that yield loss of 28.4% during the period of 10 leaf stage through tasseling stage at average aphid density of 818 aphid/plant and yield loss during ripening stage was assessed as 16.28% at average aphid density of 1038 aphid/plant. Moreover, percentages of yield losses of corn ears through 10 leaf stage through ripening stage were reported as 14.66, 22.9, 35.28 and 36.03% at average aphid density of 100, 1000, 2000 and 3000 aphids/plant. Koirala et al (2021) reported that hybrids namely CAH1715, RML-86/RML-96, and RML-95/RML-96 should be proposed for release for commercial cultivation as they performed well across the years and locations, and are preferred by farmers, too.
CONCLUSION

Two maize hybrids RML-95/RML-96 and Rampur Hybrid-10, two quality protein maize (QPM) S00TLYQ-AB and S99TLYQ-A and two full season maize genotypes TLBRS07F16 and ZM 627 were less susceptible to aphid infestation and produced higher grain yield. The finding of this study can be useful for selecting suitable maize genotypes for the development of aphid tolerant high yielding maize variety.

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