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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: P_2O_5:K_2O 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 TLBRS07F16 (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

सारांश

मकैको लाही किरा प्रतिरोधी जातको बिकाश साथै पहिचान हेतु ३० वटा सिफारिस र सिफारिस योग्य बर्णशंकर, गुणस्तरीय प्रोटिन युक्त मकै र खुला सेचित मकैका जातहरुलाइ लगातार सन् २०१९ र २०२० मा राष्ट्रिय मकैबाली अनुसन्धान कार्यक्रम, रामपुर, चितवनको अनुसन्धान ब्लकमा, छनोट नर्सरीमा लगाई परिक्षणहरु संचालन गरिएको थियो । परिक्षणहरुलाई रेनडोमाइज्ड इनकम्प्लिट ब्लक ढाँचामा तीन पटक ब्यबस्थित गरिएको थियो । पाँच मिटर लामो २ वटा लाइनहरु जसमा एक लाइन देखि अर्को लाइन बिचको दुरी ६० से.मि. तथा बिरुवा देखि बिरुवा बिचको दुरी २५ से.मि. कायम हुने गरि प्रत्येक प्लटहरुको क्षेत्रफल तय गरिएको थियो । मलखादको मात्रा, खुला सेचित र गुणस्तरीय प्रोटिन युक्त मकैको लागि १२०:६०:४० तथा बर्णशंकर मकैको लागि १८०:६०:४० नाइट्रोजन:फस्फोरस:पोटास के.जी./हे. तथा बिउ दर २० के.जी./हे. कायम गरिएको थियो । लाही किराको प्रकोप, गम्भीरता र उत्पादन सम्बन्धि आँकडाहरुको मापन गरिएको थियो । बर्णशंकर मकै अन्तर्गत आर.एम.एल.-९५/आर.एम.एल.-९६ (१८%) र रामपुर हाइब्रिड-१०(२२%), गुणस्तरीय प्रोटिन युक्त मकै अन्तर्गत एस.ओ.ओ.टि.एल.वाई.क्यु.-ए.बि.(२२%)र एस.९९टि.एल.वाई.क्यु.-ए.(२३%) साथै खुला सेचित मकै अन्तर्गत टि.एल.बि.आर.एस.ओ.एफ.१६ (२४%) र जेड.एम. ६२७(२६%) जातहरु तुलनात्मक रुपमा लाही किरा प्रतिरोधी र उच्च उत्पादन दिने जातहरुको रुपमा पाइए । यस परिक्षणबाट प्राप्त नतिजाहरु, मकैको लाही किरा प्रतिरोधी साथै उच्च उत्पादन दिने जातको छनोट र बिकाशको लागि उपयोगी हुनेछ ।

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 Glogoza 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) (S99TLYQ-A, S99TLYQ-HGAB, SOOTLYQ-B, SO1SIYQ, Poshilo Makai-1, Poshilo Makai-2, S03TLYQ-AB-02 and S00TLYQ-AB) and rest seventeen were Open Pollinated Full Season maize (OPVs) (KSYNF10, BGBY-Pop, SO128, P3522, Manakamana-3, Mankamana-7, ZM-627, RPOP-2, Rampur 4, RampurS13F26, 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: P_2O_5:K_2O 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 ± 8.28g (**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

†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 ± 0.68	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

†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 differenceswere observedfor the parameters aphid infested plant/plot, aphid colony/plant, aphid 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	453
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
Manakamana-3	11	3	3	39	28	26	4	4.46	377
Mankamana -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
05SADVI	14	4	3	39	36	34	6	5.34	435
07SADVI	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
Year (Y)	<.001	<.001	0.712	<.001	<.001	<.001	0.001	<.001	0.72
Year × Genotypes	<.001	0.013	<.001	0.002	<.001	0.005	0.379	0.031	1.00
$LSD_{0.05}$ (G)	2.95	0.96	0.55	9.62	4.02	5.80	3.06	1.78	48.61
$LSD_{0.05}$ (Y)	0.76	0.25	0.14	2.49	1.04	1.50	0.79	4.59	12.55
$LSD_{0.05}$ (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

†Means 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 decreaing 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).

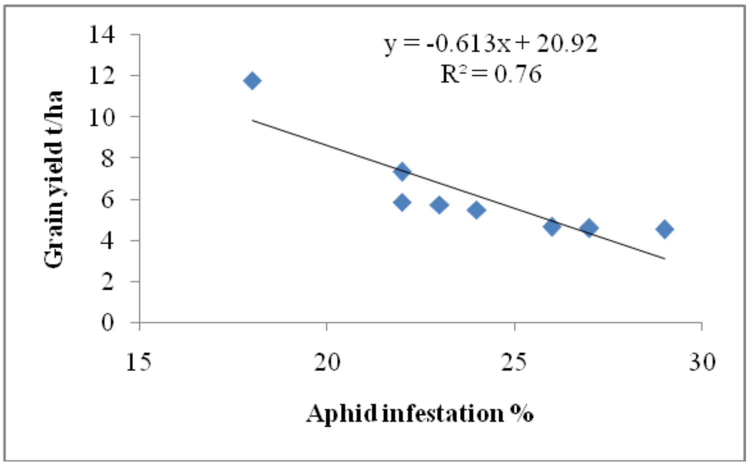

Figure1. Relationship between grain yield (t/ha) and aphid infestation % in less aphid infested and high yielding (top eight) maize genotypes at Rampur, Chitwan, Nepal during 2019-2020.

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 07SADVI, 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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