SCREENING OF MAIZE GENOTYPES AGAINST MAIZE WEEVIL (*Sitophilus zeamais* Motsch.) IN LABORATORY CONDITION

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ABSTRACT

Maize (*Zea mays*) is the second-most important staple food crop in Nepal. However, it suffers from severe post-harvest losses. Maize weevil (*Sitophilus zeamais* Motschulsky) is one of the major storage pests of economic importance. Thus, an experiment was conducted in a Completely Randomized Design with three replications to screen 10 maize genotypes (Manakamana-4, Arun-4, Rampur Hybrid-4, CAH- 1715, Rampur Hybrid-6, Rampur Composite, Khumal Hybrid-2, Arun-2, Rampur Hybrid-10, and Poshilo Makai-1) against *S. zeamais* for tolerance and their effects on progeny emergence, grain damage, and weight loss in no-choice condition at National Entomology Research Centre, Khumaltar during November 2020 to May 2021 Among tested genotypes, least number of progeny emergence was observed in Rampur Composite (1.00) and Khumal Hybrid-2 (1.00) and highest was observed in Manakamana-4 (6.66) followed by Poshilo Makai-1 (3.00). The lowest percent grain damage was recorded in Khumal Hybrid-2 (1.03) followed by Rampur Hybrid- 4 (1.28) and Rampur Composite (1.29) showing their tolerance to maize weevil. Similarly, the highest percent grain damage was recorded in the genotypes Manakamana-4 (6.57) and Poshilo Makai-1 (2.58) showing their susceptibility to maize weevil attack. The highest and lowest percent weight loss was recorded in Manakamana-4 (4.86) and Rampur Hybrid-4 (1.48) respectively. The other remaining genotypes were intermediate types. This finding is helpful to improve maize grain protection in storage and varietal improvement program.

Keywords: Maize, storage, susceptible, tolerance.

INTRODUCTION

Maize (*Zea mays*) is one of the important staple food sources in Nepal with a contribution of around 3.15% of the total Gross Domestic Product (Pandey & Basnet, 2018). The total area of production under maize was 9, 57,650 ha in 2020 with production and productivity of 28, 35,674 MT and 2.96 MT/ha respectively (MoAD, 2020). It is the world's biggest supplier of calories (19.5%) for body growth followed by rice (16.5%) and wheat (15%) (FAO, 2019).

However, its production is limited by various insect pests under field and storage conditions resulting in its low production and germination potential (Bhandari *et al.*, 2015). On average, around 20-80% of crop loss is estimated due to maize weevils in tropical countries (Pingali & Pandey, 2001). In Nepal, the maize weevil (*Sitophillus zeamais*) is the most important storage pest (Manandhar & Mainali, 2001). Around 10-100% of crop loss and damage due to weevils have been recorded here by many researchers depending upon storage structure and physical environment (Shivakoti & Manandhar, 2001). The appropriate management practices against weevils are deficient in storehouses in Nepal. The use of deleterious chemical compounds like Celphos (Aluminum Phosphide) is a common practice all over the country (Tiwari *et al.,* 2018). The haphazard use of these synthetic pesticides is a great threat to the environment and human health due to their residual property (Abd El-Salam, 2010). So, alternative methods for its better management need to be explored. Many literatures have emphasized the use of insect-resistant genotypes as an economical and easy way of minimizing crop loss and damage hence improving both quality and quantity (Muzemu *et al.*, 2013). In Nepal, maize genotypes like Rampur Composite, and Manakamana-6 have shown tolerance to weevil attacks (Sharma *et al.,* 2010).

Thus, considering the economic importance of maize in the country as well as the destructive nature of S. zeamais to the crop, this study was conducted in the laboratory of the National Entomology Research Centre, Khumaltar with the main objective of screening different maize varieties for tolerance against the maize weevil in storage.

MATERIALS AND METHODS

Maintenance of pure culture of maize weevil

Manakamana-4, a susceptible maize variety was oven dried at 60°C for 4 hours to make them free from insects and excess moisture (Charles & McGillivray, 2007). The moisture content of maize was maintained at 14% as per the method explained by Dorsey-Redding *et al.* (1990). Male and female weevils were separated as per the method described by Halstead (1963). Maize grains (200g) were kept in a glass jar of 500g capacity to which 50 pairs of sexed *S. zeamais* were introduced for oviposition. They were removed after one week of inoculation. The mouth of the glass bottles was covered with a black muslin cloth on the top. The setup was replicated two times and samples were observed daily until the emergence of F1 progenies. The average temperatures and relative humidity of the laboratory were recorded at 26.9 ± 1.76 ºC and 35.6 ± 7.32 % by temperature hygrometer (HTC-1, Instrumentics, India) respectively. The culture so maintained was used for further research.

Selection and preparation of maize sample

Ten different maize genotypes were collected from National Maize Research Program (NMRP), Rampur, Chitwan, and Agriculture Botany Division (ABD), Khumaltar for screening against *S. zeamais* on the basis of availability.

Table 1. Maize genotypes for screening against *S. zeamais* in Khumaltar, Lalitpur, 2021

Treatment	Selected genotypes	Procured from	Remarks
T1	Manakamana-4	ABD, Khumaltar	Normal season maize
T2	Arun-4	NMRP, Rampur	Early maturing maize
T3	Rampur Hybrid-4	NMRP, Rampur	Hybrid maize
T4	CAH- 1715	NMRP, Rampur	Pipelines
T5	Rampur Hybrid-6	NMRP, Rampur	Hybrid maize
T6	Rampur Composite	NMRP, Rampur	Normal season maize
T7	Khumal Hybrid-2	ABD, Khumaltar	Hybrid maize
T8	Arun-2	NMRP, Rampur	Early maturing maize
T9	Rampur Hybrid-10	NMRP, Rampur	Hybrid maize
T10	Poshilo Makai-1	NMRP, Rampur	Normal season maize

Inert materials and infested grains were separated from the collected maize samples. They were oven dried at 60^{0}C for 4 hours to make them free from insects. The grain moisture content (GMC) of oven-dried maize samples was determined by using a WILE 65- Moisture meter (Farmcorp, Finland) and then adjusted to 14% moisture for all the genotypes.

Experimental procedure

The experiment was conducted in no-choice tests under the laboratory condition (average room temperature: 26.9 ± 1.76 ºC and relative humidity: 35.6 ± 7.32 %) at National Entomology Research Centre, NARC, Khumaltar. For this test, 40g of clean, healthy, and sterilized maize samples were kept in each plastic bottle of 100g capacity. Then, 4 pairs of freshly emerged sexed weevils were released onto it. Holes of 1.5-2 cm in diameter were made in the lid of each bottle and then, they were covered with a black muslin cloth to enhance the air circulation in the bottles. The experiment was conducted in a completely randomized design (CRD) with 3 replications and 10 treatments. The observation on the number of progeny emergence, grain damage (on a number and weight basis), and weight loss were recorded from November 2020 to May 2021. Data were recorded at 60, 90, and 120 days after the application of treatments.

Data entry and analysis

Data were compiled and subjected to analysis of variance by using MS-excel 2013. They were analyzed using GENSTAT 18 statistical package. Means were separated by using Duncan's Multiple Range Test (DMRT) at a 5% level of significance. The variance heterogeneity within the treatments was reduced by transforming percentage data into angular (Arc sine) values (Snodecor & Cookran, 1967). The angular transformation was improved by replacing 0/n = 0 with 1/4n and n/n=1 with 1- 1/4n, where n is the total number of units under observation. Numerical data into square root system using the formula (x+0.5) as suggested in the book of Gomez & Gomez (1984).

RESULTS AND DISCUSSION

Progeny emergence

The progeny emergences at different dates were found to be significant at a 5% level of significance (P<.001) among 10 maize genotypes (Table 2). In 60 days, the highest progeny emergence was observed in Manakamana-4 (8.00) followed by Poshilo Makai-1 (4.66) indicating their susceptibility to *S. zeamais.* The progeny emergence in the remaining genotypes was at par. A similar trend was recorded in 90 days of observation. Likewise, in 120 days of observation highest progeny emergence was observed in Manakamana-4 (6.66) followed by Poshilo Makai-1 (3.00), and the lowest was observed in Rampur Composite (1.00) and Khumal Hybrid-2 (1.00). This result is supported by the findings of Paneru & Thapa (2017) where mean adult emergence was recorded low in Rampur Composite and high in Poshilo Makai-1. Sharma *et al.* (2010) also reported Rampur Composite and Manakamana-6 as the least susceptible varieties to weevil attack. According to Sharma & Tiwari (2016) the genotypes, Deuti and Manakamana-4 were observed susceptible to weevil attacks with a higher number of progeny emergence.

Table 2. Mean number of *S. zeamais* progeny emergence in selected maize genotypes at Khumaltar, Lalitpur, 2021

Selected genotypes	No. of weevil population (days after treatments)		
	60	90	120
Manakamana-4	8.00 (2.86) [a]	6.66 (2.57) [a]	6.66 (2.64) [a]
Arun-4	1.33 (1.34) [c]	1.66 (1.44) [bc]	1.33 (1.34) [b]
Rampur Hybrid-4	1.00 (1.22) [c]	1.00 (1.22) [c]	2.00 (1.55) [b]
CAH 1715	1.33 (1.34) [c]	2.00 (1.52) [bc]	2.00 (1.52) [b]
Rampur Hybrid-6	1.33 (1.34) [c]	1.00 (1.22) [c]	2.33 (1.64) [b]
Rampur Composite	1.00 (1.22) [c]	1.00 (1.22) [c]	1.00 (1.22) [b]
Khumal Hybrid-2	1.33 (1.34) [c]	1.00 (1.22) [c]	1.00 (1.22) [b]
Arun-2	1.00 (1.22) [c]	1.66 (1.44) [bc]	3.00 (1.81) [b]
Rampur Hybrid-10	1.00 (1.22) [c]	1.33 (1.34) [c]	1.33 (1.34) [b]
Posilo Makai-1	4.66 (2.25) [b]	4.00 (2.11) [ab]	3.00 (1.85) [b]
F-test	<.001	0.003	0.004
CV (%)	17.5	24.6	22.4
Sem ±	0.15	0.21	0.20

Values are means of three replications; means followed by the same letters within a column are not significantly different by DMRT at <0.05 level; CV: coefficient of variation; Sem: Standard Error of Mean. Figures in parentheses are the sq. root of (x + 0.5) transformed value of the original value.

Grain damage % (number basis)

Statistically significant differences were observed among the tested genotypes at a 5% level of significance for percent grain damage (number basis). At 60 days of observation, the mean percent of holes was high in Manakamana-4 (7.33) followed by Poshilo Makai-1 (3.73). Whereas, it was less in Rampur Hybrid-4 (1.00). The genotype Arun-4 was statistically at par with the genotype Rampur Hybrid-4. All other remaining genotypes were statistically insignificant from each other. A more or less similar trend was observed in 90 days of observation. Whereas in 120 days, the lowest grain damage was observed in the genotype Arun-4 (1.23%) followed by Rampur Composite (1.47%) and Khumal Hybrid-2 (1.55%), and the highest was observed in Manakamana-4 (7.77%). Similar kind of findings was reported by Sharma and Tiwari (2016) where higher grain damage was recorded in genotypes Deuti and Manakanamana-4. Poshilo Makai-1 was reported as susceptible to maize weevil with higher grain damage percentage by Paneru *et al*. (2019).

Table 3. Grain damage % (no. basis) in selected maize genotypes by *S. zeamais* at Khumaltar, Lalitpur, 2021

Selected genotypes	Percent grain damage (no. basis) at indicated days after treatments		
	60	90	120
Manakamana-4	7.73 (15.79) [a]	7.76 (15.82) [a]	7.77 (15.95) [a]
Arun-4	1.23 (6.15) [c]	1.07 (5.93) [b]	1.23 (6.28) [b]
Rampur Hybrid-4	1.00 (5.67) [c]	1.25 (6.36) [b]	1.76 (7.59) [b]
CAH 1715	1.82 (7.37) [bc]	1.59 (6.99) [b]	1.82 (7.65) [b]

Rampur Hybrid-6	2.06 (8.06) [bc]	0.92 (5.42) [b]	1.83 (7.68) [b]
Rampur Composite	1.47 (6.96) [bc]	0.73 (4.91) [b]	1.47 (6.96) [b]
Khumal Hybrid-2	1.82 (7.47) [bc]	1.04 (5.76) [b]	1.55 (7.17) [b]
Arun-2	1.59 (7.22) [bc]	1.37 (6.34) [b]	2.28 (8.54) [b]
Rampur Hybrid-10	1.28 (6.44) [bc]	1.29 (6.28) [b]	1.80 (7.68) [b]
Posilo Makai-1	3.73 (10.67) [b]	2.29 (8.67) [b]	2.10 (8.28) [b]
F-test	<.001	<.001	<.001
CV (%)	27.5	28.6	19.5
Sem ±	1.30	1.19	0.94

Values are means of three replications; means followed by the same letters within a column are not significantly different by DMRT at <0.05 level; CV: coefficient of variation; Sem: Standard Error of Mean. Figures in parentheses are the sq. root of (x + 0.5) transformed value of the original value.

Grain damage % (weight basis)

Statistically significant differences were observed at 5% level among 10 maize genotypes for grain damage (weight basis). In 60 days of observation, the highest loss was recorded in Manakamana-4 (7.01%) followed by Poshilo Makai-1 (4.07%). All other remaining genotypes were statistically insignificant among each other. More or less, the same trend was observed at 90 days of observation. Likewise in 120 days, the highest grain damage was recorded in Manakamana-4 (6.57%) and the lowest was recorded in the genotypes Khumal Hybrid -2 (1.03%), Rampur Hybrid-4 (1.28%) and Rampur Composite (1.29%). Among 24 tested maize genotypes, Rampur Composite and Hill Pool Yellow were observed tolerant to weevil attacks (Sharma *et al.,* 2010). According to Paneru and Thapa (2017), maize genotypes Khumal Hybrid-2, Manakamana-3 and Ganesh-2 were found tolerant to weevil attacks with less grain damage. But the genotypes, Poshilo Makai-1, RML 32/17, Poshilo Makai-2, Deuti, and Manakamana-4 were found susceptible to weevil attack with higher grain damage.

Table 4. Grain damage % (wt. basis) in selected maize genotypes by *S. zeamais* at Khumaltar, Lalitpur, 2021

Selected genotypes	Percent grain damage (wt. basis) at indicated days after treatments		
	60	90	120
Manakamana-4	7.01 (15.08) [a]	5.95 (13.90) [a]	6.57 (14.54) [a]
Arun-4	1.59 (6.98) [b]	1.65 (7.34) [b]	1.96 (7.81) [b]
Rampur Hybrid-4	0.61 (4.44) [b]	0.75 (4.92) [b]	1.28 (6.46) [b]
CAH 1715	1.43 (6.54) [b]	1.37 (6.51) [b]	1.85 (7.66) [b]
Rampur Hybrid-6	1.59 (6.93) [b]	0.77 (4.98) [b]	1.58 (7.09) [b]
Rampur Composite	1.40 (6.81) [b]	0.73 (4.91) [b]	1.29 (6.43) [b]
Khumal Hybrid-2	1.37 (6.50) [b]	0.79 (5.03) [b]	1.03 (5.79) [b]
Arun-2	1.20 (6.27) [b]	1.03 (5.40) [b]	1.76 (7.44) [b]
Rampur Hybrid-10	1.41 (6.74) [b]	1.16 (6.09) [b]	1.65 (7.39) [b]
Posilo Makai-1	4.07 (11.75) [a]	3.95 (11.40) [a]	2.58 (9.17) [b]
F-test	<.001	<.001	0.002
CV (%)	25.9	24.3	24.5
Sem ±	1.16	0.98	1.12

Values are means of three replications; means followed by the same letters within a column are not significantly different by DMRT at <0.05 level; CV: coefficient of variation; Sem: Standard Error of Mean. Figures in parentheses are the sq. root of (x + 0.5) transformed value of the original value.

Weight loss %

There was variation among different genotypes on percent weight loss after 120 days of observation. The highest percent weight loss was recorded in the genotypes, Manakamana-4 (4.86) followed by Poshilo Makai-1 (4.15) showing their susceptibility to maize weevil. Similarly, minimum percent weight loss was observed in Rampur Hybrid- 4 (1.48) followed by Rampur Composite (1.51) showing some level of tolerance against weevil compared to other tested maize genotypes. The remaining tested genotypes were intermediate types. This result is supported by Sharma *et al.* (2010) in which Rampur Composite and Manakamana-6 were found to be least susceptible to weevil attack. Similarly, the highest weight loss was recorded in the genotypes Manakanama-4 and Deuti which supports the findings of Sharma and Tiwari (2016).

Table 5. Weight loss % in selected maize genotypes by *S. zeamais* at Khumaltar, Lalitpur, 2021

Selected genotypes	Weight loss by maize weevil after 120 days
Manakamana-4	4.86 (12.74) [a]
Arun-4	3.11 (10.15) [b]
Rampur Hybrid- 4	1.48 (6.98) [c]
CAH 1715	2.43 (8.93) [b]
Rampur Hybrid- 6	2.33 (8.78) [b]
Rampur Composite	1.51 (7.03) [c]
Khumal Hybrid-2	2.37 (8.85) [b]
Arun-2	2.72 (9.38) [b]
Rampur Hybrid- 10	3.01 (9.98) [b]
Poshilo Makai-1	4.15 (11.75) [a]
F- test	<.001
CV (%)	9.1
Sem ±	0.49

Values are means of three replications; means followed by the same letters within a column are not significantly different by DMRT at <0.05 level; CV: coefficient of variation; Sem; Standard error of Mean. Figures in parentheses are the angular transformed value of the original value.

CONCLUSION

The findings showed that the tested maize genotypes had different responses to maize weevil attacks from tolerance to susceptible level. Among them, Rampur Composite, Khumal Hybrid-2, and Rampur Hybrid-4 showed their tolerance to maize weevil as indicated by fewer progeny emergence, lower grain damage, and lower weight loss. Whereas, the genotypes Manakamana-4 and Poshilo Makai-1 were found susceptible to maize weevil with higher progeny emergence, higher weight loss, and higher grain damage. All other remaining genotypes were intermediated types. This finding is important for developing an eco-friendly approach to maize weevil management in storage to escape the risk of health hazards and environmental pollution from the use of deleterious chemical compounds. Nonetheless, similar types of investigations are recommended from time to time for additional validation and acceptability.

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