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Screening of promising maize genotypes against maize weevil (*Sitophilus zeamais* Motschulky) in storage condition

[1]Ram B Paneru and [2]Resham B Thapa

[1]Entomology Division, Khumaltar, Lalitpur
[2]Agriculture and Forestry University, Rampur, Chitwan, Nepal

*Corresponding author email: rbpaneru10@gmail.com
ORCID ID:https://orcid.org/0000-0003-0684-6739

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ABSTRACT

The maize weevil (*Sitophilus zeamais* Motschulsky) is a serious pest of economic importance in stored grains. It causes major damage to stored maize grain thereby reducing its weight, quality and germination. An experiment was conducted in randomized complete block design (RCBD) with 3 replications to screen 32 maize genotypes against maize weevil in no-choice and free-choice conditions at Entomology Division, Khumaltar, Lalitpur (Room temperature: Maximum 24-32°C and Minimum 18-27°C). The findings showed that the maize genotypes had different response to maize weevil damage ranging from susceptible to tolerance. The genotypes Manakamana-3, Lumle White POP Corn and Ganesh-2 showed their tolerance to *S. zeamais* as evidenced by lower number of weevil emerged/attracted, lower amount of grain debris release and lower proportion of bored grains, while the genotype ZM-627 was the most susceptible to weevil damage in both tests. The other remaining genotypes were intermediate types. This information is useful to improve grain protection in storage and varietal improvement/release program.

Keywords: Maize, genotype, storage, *Sitophilus zeamais*, damage, susceptible, tolerance

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INTRODUCTION

Maize is one of the most important food crops in the world with the total production of 1070.5 million t., average yield of 5.96 t/ha, occupying the second position (179.6 million ha) after wheat (220.8 million ha) (Statista, 2016/017). Maize is also the 2nd most important cereal crop in Nepal in terms of area cultivated (891583 ha) and productivity (2.5 t/ha) after rice (1362908 ha and 3.2 t/ha) (MoAD, 2015/016). This crop occupies about 26.9% area of the total cereal cultivated, and contributes to about 25.7% of the total cereal production (AICC, 2016/017). Approximately, 73.5% of maize growing area lies in hilly regions followed by 16% in Terai and 10% in mountain domains (MoAD, 2012/013).

After harvest, maize is stored for household consumption, planting for the next season and for sale. But post harvest losses are high during maize storage in Nepal (Shivakoti & Manandhar, 2000). Ghimire et al. (1996) indicated that the loss in maize grain weight was up to 20% in a typical post harvest storage situation, while KC (1992) reported 15-20% post harvest losses in cereals. According to Sah (1998), weevil caused 51-97% losses in the mid altitude (800-1500 masl) to low altitude (< 800 masl) irrespective of yellow or white maize when stored in a *Kunew* (maize cobs being heaped into a regular shape with no material supports inside the room) for a period of 5 months. In Nepal, maize grain loss due to weevil is high, and affordable alternatives to pesticides are inadequate. Majority of Nepalese farmers are illiterate and resources poor, therefore, they have no proper skills to acquire and handle synthetic pesticides. In such situation, search for effective and resistant/tolerant varieties are worthwhile without any cost to farmers. Insect resistant varieties offer greater advantages in developing countries where farmers can rarely afford to purchase insecticides for crop protection (Mihm, 1997). These varieties provide practical and economic way to minimize field and grain storage losses to improve both quantity and quality of stored grain for planting and human consumption (Simbaras et al., 2013). However, the level of varietal resistance or tolerance to weevil attack is not fully understood in Nepal. Hence, the present study was undertaken to screen different released/pipeline/promising maize genotypes against *Sitophilus zeamais* Motschulsky in storage.

MATERIALS AND METHODS

Maize genotypes selection

Maize genotypes (released/promising/pipelines) were collected from National Maize Research Program (NMRP), Rampur, Chitwan, Regional Agricultural Research Station (RARS), Lumle, and Agriculture Botany Division (ABD), Khumaltar for screening against *S. zeamais* (Table 1).

Weevil inoculum

Weevil culture was maintained in the Laboratory of Entomology Division, Khumaltar, Lalitpur to produce homogenous population (F_2-progeny) for the experiment. The male and female weevils were sexed as per Walker (2008) and Halstead (1963).

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Table 1. Maize genotypes selected for screening against *S. zeamais* in Khumaltar, Lalitpur, 2015

SN	Selected genotypes	Procured from	Remarks
1.	Rampur hybrid-2	NMRP, Rampur	Hybrid maize
2.	RML 32/17	NMRP, Rampur	Hybrid maize
3.	RML 4/17	NMRP, Rampur	Hybrid maize
4.	RML 86/RML 96	NMRP, Rampur	Hybrid maize
5.	Arun-2	NMRP, Rampur	Early maturing maize
6.	Arun-4	NMRP, Rampur	Early maturing maize
7.	Mankamana-3	NMRP, Rampur	Normal season maize
8.	Across 99 42/Across 99 44	NMRP, Rampur	Pipelines
9.	Across 9 331 RE	NMRP, Rampur	Pipelines
10.	Poshilo Makai-1	NMRP, Rampur	Full season
11.	Poshilo Makai-2 (S99TLYQ-B)	NMRP, Rampur	Full season
12.	Rampur Composite	NMRP, Rampur	Full season
13.	ZM-401	NMRP, Rampur	Pipelines
14.	TLBRS07F16	NMRP, Rampur	Pipelines
15.	BGBYPOP	NMRP, Rampur	Pipelines
16.	ZM-627	NMRP, Rampur	Pipelines
17.	07SADVI	NMRP, Rampur	Pipelines
18.	05SADVI	NMRP, Rampur	Pipelines
19.	P501SRCO/P502SRCO	NMRP, Rampur	Pipelines
20.	RML-95/RML-96	NMRP, Rampur	Pipelines
21.	Mankamana-5	RARS, Lumle	Normal season maize
22.	Mankamana-6	RARS, Lumle	Normal season maize
23.	Lumle White POP Corn	RARS, Lumle	Promising line
24.	Lumle Yellow POP Corn	RARS, Lumle	Promising line
25.	Ganesh-2	RARS, Lumle	Normal season maize
26.	Mankamana-1	NMRP, Rampur	Normal season maize
27.	Khumal Yellow	ABD, Khumaltar	Normal season maize
28.	Deuti	ABD, Khumaltar	Normal season maize
29.	KSYM10	NMRP, Rampur	Pipelines
30.	Mankamana-4	ABD, Khumaltar	Normal season maize
31.	Pop Corn	ABD, Khumaltar	Pipelines
32.	Khumal hybrid-2	ABD, Khumaltar	Hybrid maize

NMRP= National Maize Research Program, Rampur, Chitwan; RARS = Regional Agriculture Research Station; and ABD=Agri Botany Division, NARC, Nepal.

All the maize samples were oven dried at 130^{o}C for 1 hr to make them free from insects. The grain moisture content (GMC) of oven dried maize samples was determined by using a WILE - Moisture Meter and then adjusted to 14% moisture for all the genotypes as per methods explained by Cecilia (1990). The experiment was conducted in free-choice and no-choice tests under the Laboratory condition (room temperature: Maximum 24-32°C and Minimum 18-27°C) at Entomology Division, Khumaltar, Lalitpur from April to September, 2015.

Free-choice test

Thirty two maize genotypes of each 50g grain samples were tested against *S. zeamais*. The experiment was set up in randomized complete block design (RCBD) in polythene bottle of 6cm diameter and 7cm height with 3 replications. Four circular holes were made at the bottom at 4 sides with no lid to allow weevils freely enter into the bottle. These bottles were placed in a circular manner inside a circular wide container (50cm diameter and 18cm height) and 20 days old 800 F_2-progeny of *S. zeamais* (irrespective of sexes) were released in the center. Then the wide container was covered with black muslin cloth. The experiment was set on first week and the first observation was taken for weevil attraction on last week of June, 2015. Subsequent observations were taken on last week of July, 2015 for progeny development and grain damage to each genotype.

No-choice test

For this test also, 50g of maize samples were placed into a polythene bottle of 6cm diameter and 7cm height. Then 20 days old 5 pair of F_2-progeny of *S. zeamais* (male and female) was introduced in each bottle as an inoculum. The mouth of bottles was perforated with black muslin cloth for free air circulation. All the bottles with maize samples along with weevil inoculums were placed inside the wide metal bins (59cm diameter and 33cm height). The experiment was set on RCBD with 3 replications on the second week of July. The observations on number of progeny emerged, the quantity of grain debris released and the number of bored grains were recorded during the last week of August 2015.

Grains bored data were transformed into arcsine. Then data were analyzed using R package for analysis of variance and Duncan Multiple Range Test (DMRT) was used for significant mean separation at 5% level.

RESULTS AND DISCUSSION

The study showed that maize genotypes varied to response to maize weevil attack ranging from susceptible to tolerance, indicating the genotype resistance mechanisms.

Effect of genotypes on number of *S. zeamais* progeny emergence

In no-choice test, there were variations, and the significant differences were observed at <1% level among the 32 genotypes for weevil progeny emergence (Table 2). It ranged from 67.3 to 300.3 mean adult emergence, which was low in Manakamana-3 followed by Lumle White POP Corn, Ganesh-2 and Rampur Composite indicating their tolerance to *S. zeamais*. Similarly, the mean number of weevil was high in RML 32/RML-17 followed by Poshilo Makai-2 (S99TLYQ-B), Poshilo Makai-1, Pop Corn and RML 86/RML 96 showing their susceptibility to *S. zeamais*. The remaining tested genotypes were intermediate types.

In free-choice test also, significant differences were observed at <1% level among the tested genotypes (Table 2). It ranged from 136.7 to 220.7 mean weevil emergence. The mean number of progeny emergence was low in Ganesh-2 followed by RML-95/RML-96, Lumle Yellow POP Corn, Manakamana-1, Lumle White POP Corn, Manakamana-6 and Manakamana-3 indicating their tolerance to *S. zeamais*. Similarly, the mean number of progeny emergence was high in ZM-627, Across 9 331 RE, Arun-4, TLBRS07F16, 05SADVI, RML 32/17 and P501SRCO/ P502SRCO showing their susceptibility to the *S. zeamais*. The rest of the genotypes were intermediate types.

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Table 2. Mean number of *S. zeamais* progeny emergence in selected maize genotypes at Khumaltar, Lalitpur, 2015

SN	Selected genotypes	Mean number of weevil emergence ⁰	
		No-choice test	Free-choice test
1.	Rampur hybrid-2	143.7±16.7 g-j	195.7±17.0 a-h
2.	RML 32/17	300.3±30.2 a	210.7±0.3 a-d
3.	RML 4/17	170.3±19.9 b-j	187.3±21.4 a-i
4.	RML 86/RML 96	216.7±24.5 b-e	208.7±29.7 a-f
5.	Arun-2	190.3±10.7 b-i	190.3±30.7 a-i
6.	Arun-4	196.7±35.5 b-h	219.1±22.7 ab
7.	Mankamana-3	67.3±11.9 k	158.7±26.8 e-j
8.	Across 99 42/Across 99 44	191.0±1.0 b-i	163.7±6.4 c-j
9.	Across 9 331 RE	202.3±23.3 b-g	220.3±23.1 ab
10.	Poshilo Makai-1	234.0±20.2 abc	177.0±11.0 a-j
11.	Poshilo Makai-2 (S99TLYQ-B)	242.0±1.7 ab	178.7±18.0 a-j
12.	Rampur Composite	128.0±21.9 h-k	160.3±10.8 d-j
13.	ZM-401	159.0±16.6 d-j	201.3±13.6 a-g
14.	TLBRS07F16	214.0±21.2 b-f	212.7±10.5 abc
15.	BGBYPOP	188.3±20.2 b-i	168.3±12.7 b-j
16.	ZM-627	207.0±35.6 b-g	220.7±12.2 a
17.	07SADVI	166.7±27.9 c-i	209.7±27.2 a-e
18.	05SADVI	149.7±18.9 f-j	214.3±24.8 abc
19.	P501SRCO/P502SRCO	192.7±6.7 b-h	210.0±11.5 a-d
20.	RML-95/RML-96	155±17.1 f-j	141.7±19.1 ij
21.	Mankamana-5	176.7±19.6 b-j	173.7±17.1 a-j
22.	Mankamana-6	153.0±6.1 f-j	156.3±19.9 f-j
23.	Lumle White POP Corn	118.3±37.6 jk	153.3±15.6 g-j
24.	Lumle Yellow POP Corn	189.7±11.1 b-i	146.7±11.4 hij
25.	Ganesh-2	121.0±18.6 ijk	136.7±10.3 j
26.	Mankamana-1	176.7±14.2 b-j	151.0±11.1 g-j
27.	Khumal Yellow	171.7±21.0 b-j	193.7±1 a-h
28.	Deuti	156.7±2.3 e-i	170.0±5.1 a-j
29.	KSYM10	155.3±10.2 f-j	195.7±15.0 a-g
30.	Mankamana-4	163.3±9.0 c-j	163.7±2.6 c-j
31.	Pop Corn	224.7±38.0 bcd	172.3±9.9 a-j
32.	Khumal hybrid-2	156.3±16.3 f-j	185.0±9.50 a-i
	F Value	4.22	2.75
	Probability	$5.65e^{-07}$	0.000352
	CV	20.31%	2.86%
	DMRT	***	***

Values are means of three replications; ⁰ Means followed by the same letters within each column are not significantly different at 5% level by DMRT.

In both tests, the maize genotypes Manakamana-3**,** Lumle White POP Corn and Ganesh-2 were tolerant to *S. zeamais* attack and the genotype RML 32/17 was susceptible one.

Effect of maize genotypes on grain debris release by *S. zeamais*

In no-choice test, the maize genotypes were statistically significant at 1% level for grain debris release (Table 3). It ranged from 0.2g to 0.7g mean grain debris, which was low in Manakamana-3 followed by Rampur Composite and Ganesh-2 indicating their tolerance to *S. zeamais*. Similarly, the mean amount of grain debris release was high in Poshilo Makai-1 followed by

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Poshilo Makai-2 (S99TLYQ-B, P501SRCO/P502SRCO and ZM-627 showing their susceptibility to *S. zeamais*. The remaining tested genotypes were intermediate types.

Under free-choice test, the maize genotypes were statistically significant at 1% level for grain debris release at 20 days, which ranged from 0.02 to 0.09g (Table 3).

Table 3. Effect of maize genotypes on amount of grain debris release by *S. zeamais* in storage at Khumaltar, Lalitpur, 2015

SN	Selected genotypes	Mean amount of grain debris (g)		
		No-choice test at 50 days	Free-choice at 20 days	Free-choice at 50 days
1.	Rampur hybrid-2	0.37±0.10 b-e	0.04±0.01 g-m	0.48±0.06 c-h
2.	RML 32/17	0.53±0.09 a-d	0.05±0.00 c-l	0.44±0.05 e-h
3.	RML 4/17	0.42±0.11 b-e	0.08±0.01 abc	0.69±0.12 ab
4.	RML 86/RML 96	0.40±0.06 b-e	0.06±0.02 a-h	0.37±0.11 f-k
5.	Arun-2	0.46±0.04 a-d	0.05±0.01 c-k	0.39±0.11 e-j
6.	Arun-4	0.46±0.06 a-d	0.08±0.01 a-d	0.41±0.06 e-j
7.	Mankamana-3	0.21±0.03 e	0.04±0.01 h-m	0.34±0.05 h-k
8.	Across 99 42/Across 99 44	0.53±0.01 a-d	0.07±0.01 a-g	0.50±0.07 c-f
9.	Across 9 331 RE	0.53±0.09 a-d	0.09±0.01 ab	0.59±0.13 bcd
10.	Poshilo Makai-1	0.66±0.01 a	0.04±0.01 f-m	0.45±0.06 d-h
11.	Poshilo Makai-2 (S99TLYQ-B)	0.58±0.05 ab	0.05±0.01 c-l	0.45±0.10 d-h
12.	Rampur Composite	0.30±0.08 de	0.03±0.01 j-m	0.29±0.07 jk
13.	ZM-401	0.42±0.08 b-e	0.04±0.01 g-m	0.60±0.08 bc
14.	TLBRS07F16	0.52±0.08 a-d	0.06±0.01 a-h	0.74±0.08 a
15.	BGBYPOP	0.48±0.05 a-d	0.04±0.01 g-m	0.45±0.03 d-h
16.	ZM-627	0.55±0.08 abc	0.06±0.01 b-i	0.53±0.10 cde
17.	07SADVI	0.35±0.09 b-e	0.07±0.01 a-e	0.43±0.06 e-i
18.	05SADVI	0.38±0.02 b-e	0.09±0.01 a	0.52±0.07 cde
19.	P501SRCO/P502SRCO	0.58±0.06 ab	0.07±0.00 a-f	0.57±0.05 bcd
20.	RML-95/RML-96	0.37±0.06 b-e	0.05±0.00 d-l	0.30±0.02 ijk
21.	Mankamana-5	0.42±0.02 b-e	0.03±0.00 j-m	0.34±0.07 g-k
22.	Mankamana-6	0.41±0.08 b-e	0.03±0.00 j-m	0.29±0.05 jk
23.	Lumle White POP Corn	0.41±0.05 b-e	0.04±0.00 h-m	0.35±0.04 g-k
24.	Lumle Yellow POP Corn	0.47±0.02 a-d	0.03±0.00 klm	0.26±0.04 jk
25.	Ganesh-2	0.32±0.09 cde	0.02±0.00 m	0.24±0.03 k
26.	Mankamana-1	0.50±0.11 a-d	0.02±0.00 lm	0.28±0.06 jk
27.	Khumal Yellow	0.45±0.09 a-e	0.06±0.03 b-j	0.48±0.03 c-g
28.	Deuti	0.51±0.07 a-d	0.03±0.00 klm	0.39±0.03 e-j
29.	KSYM10	0.41±0.08 b-e	0.05±0.00 e-l	0.39±0.05 e-j
30.	Mankamana-4	0.47±0.04 a-d	0.03±0.00 i-m	0.49±0.11 c-g
31.	Pop Corn	0.54±0.17 a-d	0.02±0.00 lm	0.28±0.04 jk
32.	Khumal hybrid-2	0.37±0.04 b-e	0.03±0.01 lm	0.30±0.04 ijk
	F- value	1.609	5.242	8.229
	P-value	0.0547	$1.55e^{-}08$	$1.50e^{-}12$
	CV	28.38%	31.37%	17.67%
	DMRT	**	***	***

Values are means of three replications; [0] Means followed by the same letters within each column are not significantly different at 5% level by DMRT.

The amount of grain debris release was low in Ganesh-2 followed by Pop Corn, Mankamana-1, Khumal hybrid-2, Lumle Yellow POP Corn, Deuti, Mankamana-5, Mankamana-6, Rampur Composite, Manakamana-4, Lumle White POP Corn and Mankamana-3 showing their tolerance to *S. zeamais*. Similarly, the amount of grain debris release was high in 05SADVI followed by Across 9 331 RE, RML 4/17, Arun-4, 07SADVI, P501SRCO/P502SRCO and Across 99 42/Across 99 44 indicating their susceptibility to *S. zeamais*. The remaining genotypes were intermediate types.

In similar test at 50 days, statistically significant differences were observed at 1% level for all tested genotypes (Table 3). It ranged from 0.2g to 0.7g mean grain debris which was low in Ganesh-2, Lumle Yellow POP Corn, Pop Corn, Manakamana-1, ManaKamana-6, Rampur Composite, Khumal Hybrid-2, RML-95/RML-96 and Manakama-3 indicating their tolerance to *S. zeamais*. Similarly, mean grain debris release was high in TLBRS07F16, RML 4/17, ZM-401, Across 9 331 RE, P501SRCO/P502SRCO, ZM-627 and 05SADVI showing their susceptibility to *S. zeamais*. The remaining tested genotypes were intermediate types. In both tests, the genotypes Manakamana-3**,** Lumle White POP Corn**,** Khumal Hybrid-2**,** and Ganesh -2 showed their tolerance to *S. zeamais* and the genotypes RML 32/17, BGBYPOP and ZM-627 showed their susceptibility to *S. zeamais*.

Effects of maize genotypes on grain damage by *S. zeamais*

In no-choice test, statistically significant differences were observed at 1% level among 32 genotypes for proportion of bored grains (Table 4). It ranged from 39.1 to 92.4%. The mean percent of holes was low in Manakamana-3 followed by Lumle White POP Corn and Khumal Hybrid-2 showing their tolerance to *S. zeamais*. Similarly, mean percent of bored grains was high in Poshilo Makai-1 followed by RML 32/17, RML 86/RML 96, BGBYPOP, Poshilo Makai-2 (S99TLYQ-B) and ZM-627 showing their susceptibility to *S. zeamais*. The remaining tested genotypes were intermediate types.

In free-choice test as well, statistically significant difference was observed among the tested genotypes. Mean percent grains bored was low in Pop Corn followed by Lumle Yellow POP Corn, Manakamana-3, Ganesh-2, Khumal Hybrid-2 and Lumle White POP Corn indicating their tolerance to *S. zeamais*. Similarly, mean proportion of holed grains was high in Across 99 42/ Across 99 44, 05SADVI, ZM-401, BGBYPOP, ZM-627, RML 4/17, TLBRS07F16, Across 9 331 RE, RML 32/17 and P501SRCO/P502SRCO indicating their susceptibility to *S. zeamais*. In both test, Manakamana-3, Ganesh-2, Khumal Hybrid-2, Lumle White POP showed their tolerance and the genotypes BGBYPOP, ZM-627 and RML 32/17 showed their susceptibility.

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Table 4. Effect of maize genotypes on grain damage by *S. zeamais* in storage at Khumaltar, Lalitpur, 2015

SN	Selected genotypes	Mean bored grains (%)±SE	
		No-choice test	Free-choice test
1.	Rampur hybrid-2	77.35±9.28 b-f	89.58±2.29 c-h
2.	RML 32/17	91.16±0.13 ab	94.62±0.94 a-e
3.	RML 4/17	75.47±8.95 b-f	94.58±2.29 a-d
4.	RML 86/RML 96	84.54±4.32 a-d	82.83±4.77 g-j
5.	Arun-2	86.48±2.31 a-d	82.29±3.87 f-j
6.	Arun-4	83.31±7.31 a-d	86.85±1.90 e-j
7.	Mankamana-3	39.06±7.02 g	71.01±6.43 kl
8.	Across 99 42/Across 99 44	86.28±0.41 a-d	98.13±1.18 a
9.	Across 9 331 RE	87.37±1.19 a-d	94.68±1.33 a-d
10.	Poshilo Makai-1	92.39±0.58 a	90.13±2.31 b-h
11.	Poshilo Makai-2 (S99TLYQ-B)	90.46±1.18 abc	87.65±2.05 d-i
12.	Rampur Composite	73.12±7.59 def	82.94±1.71 g-k
13.	ZM-401	78.56±7.07 a-f	96.12±0.44 ab
14.	TLBRS07F16	88.01±2.15 a-d	94.79±1.40 a-d
15.	BGBYPOP	90.36±4.06 ab	96.01±0.31 abc
16.	ZM-627	89.75±2.78 abc	94.42±2.43 abc
17.	07SADVI	75.62±6.15 c-f	93.36±2.02 a-f
18.	05SADVI	77.71±9.15 a-f	97.41±1.14 a
19.	P501SRCO/P502SRCO	87.17±2.28 a-d	94.50±0.40 a-e
20.	RML-95/RML-96	72.73±6.46 def	83.13±1.71 g-j
21.	Mankamana-5	87.59±3.59 a-d	83.58±3.80 g-j
22.	Mankamana-6	83.70±3.41 a-e	82.63±6.67 g-j
23.	Lumle White POP Corn	60.65±11.85 fg	78.75±4.20 i-l
24.	Lumle Yellow POP Corn	78.33±1.85 b-f	69.24±0.64 lm
25.	Ganesh-2	75.48±5.55 c-f	76.97±2.57 jkl
26.	Mankamana-1	83.68±2.88 a-e	80.12±7.39 h-k
27.	Khumal Yellow	82.32±1.31 a-e	94.42±0.57 a-e
28.	Deuti	88.74±2.37 a-d	90.63±1.61 b-g
29.	KSYM10	80.05±2.10 a-f	91.07±2.82 b-g
30.	Mankamana-4	85.68±1.57 a-d	90.30±2.98 b-g
31.	Pop Corn	77.84±3.46 b-f	58.63±4.93 m
32.	Khumal hybrid-2	64.29± 11.41 ef	77.27±9.13 i-l
	F-value	3.466	11.52
	P- value	$1.32^{e-0}5$	$5.90e^{-}16$
	CV	10.37%	5.65%
	DMRT	***	***

Values are means of three replications; SE= Standard error; [0] Means followed by the same letters within each column are not significantly different at 5% level by DMRT.

Effect of maize genotypes on *S. zeamais* preference

In free-choice test, there was a statistically significant difference at 1% level for the mean number of weevils attracted on tested genotypes at 20 days (Table 5). The mean number of weevils attracted to the different genotypes ranged 13.3 to 37.7. The preference was high in P501SRCO/P502SRCO followed by Arun-4, Poshilo Makai-1, Rampur Hybrid-2, Arun-2, RML 86/RML 96 and Pop Corn. Similarly, the preference was low in RML-95/RML-96, Deuti, BGBYPOP, RML 4/17, Manakamana-4, Khumal yellow, Khumal hybrid-2, Across 99 42/Across 99 44, Manakamana-3. The remaining tested genotypes were intermediate types.

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Table 5. Preference of *S. zeamais* at 20 days on selected maize genotypes in Khumaltar, Lalitpur, 2015

SN	Selected genotypes	*S. zeamais* adults attracted (No)±SE
1.	Rampur hybrid-2	33.0±5.13 abc
2.	RML 32/17	20.3±4.91 b-f
3.	RML 4/17	15.7±4.37 ef
4.	RML 86/RML 96	30.0±1.15 abc
5.	Arun-2	30.7±4.06 abc
6.	Arun-4	34.7±7.75 ab
7.	Mankamana-3	18.3±1.20 c-f
8.	Across 99 42/Across 99 44	17.7±2.03 c-f
9.	Across 9 331 RE	25.0±4.93 a-f
10.	Poshilo Makai-1	33.3±3.48 abc
11.	Poshilo Makai-2 (S99TLYQ-B)	28.3±3.18 a-d
12.	Rampur Composite	33.0±5.21 b-f
13.	ZM-401	19.3±3.18 a-f
14.	TLBRS07F16	28.0±5.51 a-e
15.	BGBYPOP	15.7±5.04 f
16.	ZM-627	28.0±2.08 a-d
17.	07SADVI	26.0±3.21 a-e
18.	05SADVI	21.7±2.40 a-f
19.	P501SRCO/P502SRCO	37.7±0.02 a
20.	RML-95/RML-96	13.3±3.28 f
21.	Mankamana-5	20.3±1.20 a-f
22.	Mankamana-6	22.3±2.73 a-f
23.	Lumle White POP Corn	21.3±4.37 a-f
24.	Lumle Yellow POP Corn	18.7±2.03 b-f
25.	Ganesh-2	19.0±2.08 b-f
26.	Mankamana-1	23.3±3.53 a-f
27.	Khumal Yellow	17.7±3.18 c-f
28.	Deuti	13.7±4.18 f
29.	KSYM10	21.7±5.90 a-f
30.	Mankamana-4	15.0±2.65 def
31.	Pop Corn	30.0±3.79 abc
32.	Khumal hybrid-2	17.3±1.76 c-f
	F-value	2.37
	F-test	0.00194
	CV	10.92%
	DMRT	***

Values are means of three replications; SE= Standard error; [0] Means followed by the same letters within each column are not significantly different at 5% level by DMRT.

This study focused to the number of progeny emergence, amount of grain debris release, proportion of bored grains, number of *S. zeamais* attracted as important indicators of a genotype's susceptibility to weevil attack. Abebe et al. (2009) reported that an increasing number of F_1-progeny resulted in an increasing grain damageg and grain weight loss. They found the numbers of F_1-progeny, percent grain damage and grain weight loss positively related with the susceptibility index. Resistance in stored maize to insect attack has been attributed to physical factors, such as grain hardness, pericap surface texture, and nutritional factors, such as amylose, lipid and protein content (Dobie, 1974; Tepping et al., 1988) or non-nutritional factors, especially phenolic compounds (Serratos et al., 1987). The role phenolics play in resistance formation in these surface tissues may be both related to structural components and antibiosis factors (Arnason et al., 1993). For weevils, grain hardiness has been reported as the main resistance parameter (Bamaiyi et al., 2007). The difference in the number of weevil emerged showed that there existed variations in susceptibility to maize weevil attack among the genotypes. The genotypes which recorded the higher number of weevil progeny emergence indicated the higher susceptibility to maize weevil attack and this might have been due to lack of resistance mechanisms. The low weevil emergence in genotypes can be attributed to high mortality of parent weevils. These parent weevils might have died before laying eggs thus few progeny emerged. The low weevil emergence in the genotypes may possibly be attributed to absence of essential nutrients and unbalanced proportion of nutrients leading to the death of weevil larvae. The significant variation for number of weevils emerged among the varieties could be due to antibiosis effects in the genotypes leading to retarded development of weevil progeny and sometimes death of weevils before laying eggs. The lower amount of grain debris release could be due to resistance mechanisms in or on the grain which prevented weevil attack. Thus, greater amount of debris released indicates more susceptibility to weevil attack than other experimental genotypes. Simbaras et al. (2013) reported that resistance mechanisms could be in the form of deterrents which could be biochemical or morphological or a combination of both. Biochemical compounds in the form of phenolic amides, such as defeuroyl and dicoumaroyl may be antibiosis factors to the weevil. These phenolic compounds have been detected by fluorescence imaging technique, which clearly shows the phenolic barrier to insects in the outer tissues. It has also been reported that antibiotic effects increased restlessness of insects, which reduced feeding and could explain how grain debris were low among tolerance genotypes. He also noted that variation in maize genotypes was due to antibiosis. Less amount of grain debris release could be attributed to antixenosis mechanisms like a smooth pericarp, which could deter weevils from oviposition and feeding and also prevents mandibles from gripping maize kernels. The great variation observed in the germplasms evaluated forms a genetic resource base for further improvement to raise the levels of resistance to weevils while conserving the preferred traits. This variation on response to *S. zeamais* attack gives an evidence of genetic diversity existence hence a rich genetic resource base for breeding insect resistance. Present findings offer good opportunity to exploit the variability for reducing post harvest insect pest loss, varietal improvement and release through genetic improvement.

CONCLUSIONS

The findings showed that the maize genotypes had different response to *S. zeamais* attack from susceptible to tolerance level. The genotypes Manakamana-3, Lumle White POP Corn and Ganesh-2 showed their tolerance to *S. zeamais* as evidenced by less number of weevil emerged/attracted, low amount of grain debris release and low proportion of bored grains in both free-choice and no-choice tests. The genotypes ZM-627 was the most susceptible one to *S. zeamais*. The remaining tested genotypes were intermediate types. Hence, there is ample opportunity to explore and utilize such genotypes in post harvest insect pest management, maize breeding programs and varietal improvement/release.

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AUTHOR CONTRIBUTIONS

R. B. P. conceived and designed the experiments, collected data, analyzed the data and wrote the paper, and R. B. T. revised the article for final approval of the version to be published.

CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest.

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