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Research Article

Damage and yield loss estimate in maize varieties owing to stem borer (*Chilo partellus* Swinhoe) infestation and insecticidal control

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ABSTRACT

Stem borer (*Chilo partellus* Swinhoe) is one of the most damaging and yield reducing pest in maize. Field experiments were organized to assess the extent of damage and yield loss due to the infestation of stem borer in maize following two factors randomized complete block design with three replications at National Maize Research Program, Rampur, Chitwan, Nepal, during two consecutive spring seasons of 2020 and 2021. Maize varieties; Rampur Hybrid (RH)-8, RH-10, RH-12 (CAH-1715), RH-14 (RML-86/RML-96), RH-16 (RML-95/RML-96), TX-369, Arun-2, ZM-401, ZM-627 and Rampur Composite were used as a test variety (First factor) whereas pest control conditions (spray and non-spray) was considered as the second factor in the experiments. Thesprayed plots (protected plots) were kept completely free from stem borer infestation by using three application of standard dose of insecticide (spinosad 45% EC @ 0.3 mL/L) at 10 days interval and non spray (unprotected plots) were selected for natural infestation of stem borers. Standard agronomical practices such as time of planting, row spacing, seed rate, irrigation, weeding and fertilizer application and doses were adopted to raise the crop. Among tested varieties Arun-2 was found most susceptible to stem borer attack in both experimental years resulted in higher % dead hearts (6.04%), higher no of exit hole (4.72), higher % foliage damage at before tasseling stage (12.17%) and higher tunnel length (4.62 cm). Quantitative yield loss increased with the increase of the borer's infestation. The yield loss was ranged from 25 to 45% in different maize varieties due to the attack of stem borer. Highest yield loss was quantified for the open pollinated varieties, ZM-401(44.61%) followed by Rampur Composite (41.39%) and Arun-2 (41.22%). Spraying of insecticide enabled the recently introduced maizehybrid RH-14 to produce more yield and to be less vulnerable to stem borer damage.

Keywords: Damage, yield loss, maize, stem borer, infestation

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INTRODUCTION

Maize, *Zea mays* (Linnaeus) (Poaceae) is one of the most prominent cereal crop produced worldwide. It is used as human food, animal feed, fodder, for production of starch, oil, liquor,

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dextrose and dyes etc (Khera & Dhillon, 1982). In Nepal, Maize was cultivated on an area of 979,776 hectares with a production and productivity of 2,997,733 tonnes and 3.06 metric tonnes per hectare, respectively during 2020-21 (MoALD, 2022). New agricultural technology has enabled Nepal to raise its production of maize by 37.55%, from 2,179,414 mt in 2011–12 to 2,997,733 mt at present. However, Nepal's average maize crop yield, 3.06 mt/ha per hectare, is extremely low when compared to the global average of 5.8 t/ha per hectare in 2021 (FAO, 2021). Being a C4 plant, maize has a higher yield potential than other cereals. However, the onslaught of biotic stresses like disease and insect pests infesting this crop at various crop growth stages, from sowing to maturity, seriously limits the full manifestation of maize's yield potential over different seasons (Subedi, 2015). Sarup *et al*. (1987) listed 130 insect species attacking maize crop at its different growth stages. However, according to Mathur (1992) there are more than 250 numbers of insect and mite pestsinfesting maize crop. Further, Siddiqui & Marwaha (1994) reported that only a dozen pests, which cause harm to maize crops in varied degrees from sowing to harvest, are very destructive and call for control efforts. Amongst the pest complex of maize, *Chilo partellus* (Swinhoe), is major importance during different seasons in Nepal (Neupane *et al*., 2016). *C. partellus* is the most abundant and has been identified as the world's most devastating pest of maize at its early growth stage (Sharma & Sharma, 1987; Polaszek & Khan, 1998; Duale & Nwanze, 1999). The maize crop is most susceptible to the infestation of the maize stem borer when it is 10 to 12 days old and has no antibiosis (Sekhon & Sajjan, 1985). The adult femalesof *C. partellus* lay eggs in batches parallel to the long axis of the underside of leaves. The first 2 three larval instars feed initially by scrapping in the leaf whorls of growing plants, producing characteristic ‘window-paning’ and ‘pin-holes’ like symptoms. The period from egg hatching to the completion of third instar larval stage of *C. partellus* i.e. the time when the larva feed externally, lasts for about 10 days and chemical control is effective when restricted in this period (Reyes, 1987). Afterwards, the grown up larvae bore inside the central shoot resulting in production of ‘deadhearts’ under severe infestation conditions and causes complete loss of the plant. The strategies for management of *C. partellus* include chemical, biological, cultural and transgenic maize. However, the insecticides, being an easy, quick and reliable method of control, are widely used for the management of this insect. Several insecticides and chemicals have been identified to provide successful control of this pest. However, the damage assessment studies do not support the preventive spraying against this insect as this may result in unnecessary applications of insecticides which are ecologically and economically unacceptable (Berg *et al*., 1990). It has been reported by different workers that *C. partellus* caused 4-97% maize yield losses in different countries all over the world (Reddy & Walker, 1990). The losses caused by *C. partellus* in maize were reported to be 25 to 40 per cent in yield in different agro climatic zones of Nepal (NMRP, 2016). Sharma & Gautam (2010) have reported 27 to 30 % maize grain yield losses due to *C. partellus* in Nepal. However, the information on the losses caused by *C. partellus* in maizehas not been updated since last decade especially after the recommendation of hybrid maize varieties for cultivation in Nepal. These hybrids are moderately susceptible to the damage of *C. partellus* (NMRP, 2019). In addition, it has been noted that despite commendable control efforts, crop losses due to insect pests remain extremely high. This is likely due to the lack of accurate data on crop losses and accepted methods for assessing crop loss. In light of the aforementioned information, an evaluation of the degree of yield loss and damage resulting from the stem borer infestation in maize was undertaken.

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MATERIALS AND METHODS

Field experiments were carried out following two factors randomized complete block design with three replications at National Maize Research Program, Rampur, Chitwan, Nepal, during two consecutive spring seasons of 2020 and 2021. The geographical location of NMRP, Rampur, Chitwan is in 27°40' N latitude, 84^0 9' 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. Maize varieties; Rampur Hybrid (RH)-8, RH-10, RH-12 (CAH-1715), RH- 14 (RML-86/RML-96), RH-16 (RML-95/RML-96), TX-369, Arun-2, ZM-401, ZM-627 and Rampur Composite was used as a test variety (First factor) whereas different pest control conditions (spray and non-spray) was considered as the second factor in the experiments. The sprayed plots (protected plots) were kept completely free from stem borer infestation by using three application of standard dose of insecticide (spinosad 45% EC@0.3 mL/L) at 10 days interval and non spray (unprotected plots) were selected for natural infestation of stem borers. The plot size was four rows of five meter long with the spacing of 60 cm for row to row 60 and 20 cm for plant to plant. The source of all released and promising maizegenotypes were maize breeding program of NMRP, Rampur. The recommended dose of fertilizer for full season open pollinated 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. Other standard agronomical practices were adopted as recommended to raise the crop. Observation were taken on foliage damaged percent at before tasseling stage, tunnel length per plant (cm), dead heart (%), grain yield (kg/ha) and thousand grain weight (g). The meteorological data was recorded from the weather station reside at National Maize Research Program, Rampur, Chitwan. The maize grain yield was recorded from the inner 4 rows in each treatment plot and it was adjusted at 15% moisture level and then converted to kilogram per hectare. The percent decreased over unprotected plots form insect damage parameters were calculated.The losses in maize grain yield during both the years were determined by following formula given below:

$$\text{Loss in maize grain yield (\%)} = \frac{\text{Grain yield in protected plots} - \text{Grain yield in unprotected plots}}{\text{Grain yield in protected plots}} \times 100$$

All data were analyzed statistically using Microsoft Excel 2014 and GENSTAT-18th edition computer package program.

RESULTS AND DISCUSSION

During spring season of 2020, the mean foliage damaged percentage before tasseling stage, exit hole, tunnel length (cm), dead heart (%), grain yield (kg/ha) and thousand grain weight (g) were differed significantly with maize varieties (Table 1). The higher mean foliage damaged percentage before tasseling stage (6.10%), higher numbers of exit hole (5.75), higher tunnel length (5.38 cm), higher dead heart (5.27%) with lower grain yield (3312 kg/ha) and lower thousand grain weight (335 g) was recorded in full season variety Arun-2. Recently released

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hybrid Rampur Hybrid-14 (RML-86/RML-96) was found resistant with stem borer infestation with lower mean foliage damaged percentage before tasseling stage (3.66%), lower numbers of exit hole (2.75), lower tunnel length (2.85 cm), lower dead heart (2.03%) with higher grain yield (9452 kg/ha) and higher thousand grain weight (417 g) than other tested varieties (Table 1).

All the recorded insect damaged parameters, yield and yield attributing traits were significantly differed with the different pest control conditions i.e. in sprayed and non sprayed condition (Table 1). The higher mean foliage damaged percentage before tasseling stage (7.92%), higher numbers of exit hole (6.33), higher tunnel length (6.81 cm), higher dead heart (5.01%) with lower grain yield (5629 kg/ha) and lower thousand grain weight (356 g) was recorded in non sprayed plots (Table 1). While insecticide sprayed plots had recorded significantly lower mean foliage damaged percentage before tasseling stage (2.25%), lower numbers of exit hole (2.28), lower tunnel length (1.36 cm), lower dead heart (1.74%) with higher grain yield (7407 kg/ha) and higher thousand grain weight (410 g). The overall mean foliage damaged percentage before tasseling stage, exit hole, tunnel length (cm) and thousand grain weight (g) were differed significantly with different tested maize varieties and different pest control conditions, irrespective of each other, during 2020. The overall mean grain yield (kg/ha) and dead heart (%) were found statistically at par. The lower mean foliage damaged percentage before tasseling stage (1.00%), lower numbers of exit hole (1.83) and lower tunnel length (0.52 cm) withhigher thousand grain weight (463 g) was recorded in variety RH-14 with insecticide sprayed plots (Table 1).

Table 1: Effect of insecticidal (spinosad @ 0.3 mL/L of water) spray and non-spray in different maize varieties infested with stem borer (*Chilo partellus* Swinhoe) at NMRP, Rampur during spring 2020

Treatments	FDP BTs (%)	Exit hole	TL /PL (cm)	DH %	GY (kg/ha)	TGW (g)
Variety (V)						
RH-8	5.36†	4.25	4.10	3.64	5992	379
RH-10	4.58	4.00	3.51	2.93	8342	396
RH-12 (CAH-1715)	3.96	3.25	3.43	2.54	8521	411
RH-14 (RML-86/RML-96)	3.66	2.75	2.85	2.03	9452	417
RH-16 (RML-95/RML-96)	4.38	3.75	3.43	2.65	8406	402
TX-369	5.07	4.02	4.05	3.26	7399	393
Arun-2	6.10	5.75	5.38	5.27	3312	335
ZM-401	6.06	5.39	5.03	3.98	3864	353
ZM-627	5.91	5.08	4.78	3.81	4859	367
Rampur Composite (RC)	5.76	4.83	4.28	3.64	5030	375
P-value	0.05	<.001	<.001	<.001	<.001	<.001
LSD (0.05)	1.83	0.79	0.67	1.09	568	23.75
Pest control condition (PCC)						
Non spray (NS)	7.92	6.33	6.81	5.01	5629	356
Spray (S)	2.25	2.28	1.36	1.74	7407	410
P-value	<.001	<.001	<.001	<.001	<.001	<.001
LSD (0.05)	0.82	0.35	0.30	0.49	254.00	10.62
V× PCC						
RH-8× NS	6.77	5.67	5.62	5.45	5038	366
RH-8× S	2.40	2.33	1.25	1.83	6946	391
RH-10× NS	8.13	4.33	8.52	4.51	7475	352
RH-10× S	2.00	2.17	1.03	1.35	9209	440

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RH-12 × NS	9.60	8.67	6.32	4.13	7345	377
RH-12 × S	1.12	2.11	0.70	1.16	9697	457
RH-14 × NS	11.21	3.67	5.18	4.09	8589	360
RH-14 × S	1.00	1.83	0.52	1.00	10315	463
RH-16 × NS	6.16	5.33	9.12	2.86	7327	356
RH-16 × S	1.16	2.17	0.95	1.19	9486	448
TX-369× NS	9.99	8.00	7.38	5.00	6680	382
TX-369× S	2.13	2.17	1.18	1.53	8117	405
Arun-2 × NS	8.45	7.00	5.55	7.79	2398	314
Arun-2 × S	3.36	2.67	2.55	2.74	4227	355
ZM-401 × NS	4.72	9.00	6.28	4.87	3061	355
ZM-401 × S	3.20	2.50	1.92	2.41	4666	379
ZM-627× NS	8.42	6.00	5.12	5.68	4231	368
ZM-627× S	3.09	2.50	1.75	2.28	5488	381
RC × NS	5.73	5.67	9.05	5.76	4142	317
RC× S	3.02	2.37	1.72	1.86	5918	389
P-value	<.001	<.001	<.001	0.242	0.75	<.001
LSD (0.05)	2.58	1.12	0.95	1.54	803.30	33.58
CV,%	30.7	15.7	14.1	27.7	7.5	5.3

†means of three replications, FDPBTs-foliage damaged percent at before tasseling stage, TL/PL tunnel length per plant, DH%-dead heart percentage, GY-grain yield, TGW-thousand grain weight, kg/ha-kilogram perhectare, g-gram, cm-centimeter

Similar trend was recorded in the experiment conducted during subsequent year. During spring season of 2021, maize varieties differed significantly with the mean foliage damaged percentage before tasseling stage, exit hole, dead heart(%), grain yield (kg/ha) and thousand grain weight (g) (Table 2). The tunnel length (cm) was found statistically at par. The higher mean foliage damaged percentage before tasseling stage (18.23%), higher numbers of exit hole (3.68), higher dead heart (6.80%) with lower grain yield (2750 kg/ha) and lower thousand grain weight (345 g) was recorded in full season variety Arun-2. The lower mean foliage damaged percentage before tasseling stage (8.41%), lower numbers of exit hole (2.68), lower tunnel length (2.21cm), lower dead heart (4.35%) with higher grain yield (7739 kg/ha) and higher thousand grain weight (393g) was recorded in RH-14 (Table 2).

Different pest control conditions (spray and no-spray) had found significant effect on insect damaged parameters, yield and yield attributing traits during 2021 (Table 2). The higher mean foliage damaged percentage before tasseling stage (21.13%), higher numbers of exit hole (4.33), higher tunnel length (5.47 cm), higher dead heart (7.76%) with lower grain yield (3906 kg/ha) and lower thousand grain weight (353 g) was recorded in non sprayed plots (Table 2). While insecticide sprayed plots had recorded significantly lower mean foliage damaged percentage before tasseling stage (7.37%), lower numbers of exit hole (1.86), lower tunnel length (0.72 cm), lower dead heart (2.95%) with higher grain yield (6392 kg/ha) and higher thousand grain weight (387 g).

The interaction effect of different pest control conditions in tested maize varieties was differed significantly with insect damaged parameters foliage damaged percentage before tasseling stage, exit hole and dead heart % only, irrespective of each other, during 2021. The tunnel length (cm), grain yield (kg/ha) and thousand grain weight (g) were insignificant. The lower mean foliage damaged percentage before tasseling stage (3.17%), lower numbers of exit hole (1.37) and lower dead heart (1.50%) was recorded in variety RH-14 with insecticide sprayed plots (Table 2).

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Table 2: Effect of pest control condition in different maize varieties infested with stem borer (*Chilo partellus* Swinhoe) at NMRP, Rampur during spring 2021

Treatments	FDP BTs (%)	Exit hole	TL /PL (cm)	DH %	GY (kg/ha)	TGW (g)
Variety (V)						
RH-8	15.00[†]	3.07	3.37	5.05	3964	363
RH-10	13.28	2.9	2.73	4.92	6695	376
RH-12 (CAH-1715)	9.81	2.83	2.42	4.6	7563	393
RH-14 (RML-86/RML-96)	8.41	2.68	2.21	4.35	7739	393
RH-16 (RML-95/RML-96)	11.37	2.87	2.49	4.88	6712	381
TX-369	13.83	3.05	3.12	5.02	5842	373
Arun-2	18.23	3.68	3.86	6.8	2750	345
ZM-401	18.2	3.41	3.65	6.77	3017	351
ZM-627	17.94	3.18	3.6	5.58	3573	360
Rampur Composite (RC)	16.42	3.27	3.5	5.57	3630	362
P-value	<.001	0.04	0.7	<.001	<.001	0.01
LSD (0.05)	2.76	0.58	2	0.54	837.8	27.18
Pest control condition (PCC)						
Non spray (NS)	21.13	4.33	5.47	7.76	3906	353
Spray (S)	7.37	1.86	0.72	2.95	6392	387
P-value	<.001	<.001	<.001	<.001	<.001	<.001
LSD (0.05)	1.23	0.26	2.83	0.24	374.7	12.15
V× PCC						
RH-8× NS	11.35	4.67	6.27	5.43	2855	364
RH-8× S	8.28	1.87	0.72	3.27	5073	381
RH-10× NS	10.7	3.87	3.72	8.7	5294	365
RH-10× S	6.13	1.8	0.7	2.47	8095	387
RH-12 × NS	31.49	3.77	4.31	9.17	6204	382
RH-12 × S	4.92	1.6	0.67	1.97	8922	405
RH-14 × NS	24.5	5.0	4.25	8.33	6020	371
RH-14 × S	3.17	1.37	0.58	1.5	9458	416
RH-16 × NS	20.66	4.0	6.61	7.7	5069	364
RH-16 × S	5.9	1.8	0.69	2.33	8355	399
TX-369× NS	26.3	3.87	7.02	7.33	4640	303
TX-369× S	6.54	1.87	0.7	2.77	7045	387
Arun-2 × NS	25.15	3.93	5.41	5.4	2091	352
Arun-2 × S	11.3	2.2	0.83	4.37	3410	369
ZM-401 × NS	19.28	5.27	4.67	9.57	1844	349
ZM-401 × S	10.73	2.1	0.78	3.97	4190	374
ZM-627× NS	14.27	4.07	6.42	10.1	2824	327
ZM-627× S	8.46	2.03	0.77	3.5	4437	375
RC × NS	27.57	4.87	6.01	5.83	2216	349
RC× S	8.3	1.95	0.74	3.37	4930	376
P-value	<.001	0.03	0.73	<.001	0.28	0.33
LSD (0.05)	3.9	0.81	0.9	0.76	1184.	38.44
CV,%	16.6	15.9	55.3	8.6	13.9	6.3

[†]means of three replications, FDPBTs- foliage damaged percent at before tasseling stage, TL/PL tunnel length per plant, DH%-dead heart percentage, GY-grain yield, TGW-thousand grain weight, kg/ha-kilogram perhectare, g-gram, cm-centimeter

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The two years combined mean performance of different tested maize varieties with respect to insect damage parameters, grain yield and percentage yield loss due to stem borer infestation showed that the foliage damaged percentage before tasseling stage was ranged from (6.04-12.17%) with the mean average of 9.67%, exit hole (2.72-4.72) with the average of 3.70, tunnel length (2.53-4.62 cm) with the average of 3.59cm, dead heart (3.19-6.04%) with the average of 4.37%, grain yield in protected plots (3819-9887 kg/ha) with the average of 6899.50 kg/ha, grain yield in un-protected plots (2245-7305 kg/ha) with the average of 4767.50 kg/ha and yield loss (25.34 to 44.61%) with the average of 32.59% (Table 3). The lower mean foliage damaged percentage before tasseling stage (6.04%), lower numbers of exit hole (2.72), lower tunnel length (2.53 cm), lower dead heart (3.19%) with higher grain yield (9887 kg/ha) in protected plots and 7305 kg/ha in unprotected plots with the yield loss of 26.12% were recorded in hybrid variety RH-14. Full season open pollinated variety Arun-2 was found relatively more susceptible with stem borer infestation with higher mean foliage damaged percentage before tasseling stage (12.17%), higher numbers of exit hole (4.72), higher tunnel length (4.62 cm), higher dead heart (6.04%) with lower grain yield (3819 kg/ha) in protected plots and 2245 kg/ha in unprotected plots with the yield loss of 41.22% (Table 3).The higher yield loss (44.61%) was recorded in full season OP variety ZM-401 while lower yield loss (25.34%) was recorded in commercial maize hybrid TX-369 (Table 3).

Table 3: Combined mean performance of different tested maize varieties with respect to insect damage parameters, grain yield and percentage yield loss due to stem borer infestation during spring season of 2020 and 2021

Varieties	FDP BTS%	Exit hole	TL/PL (cm)	DH %	Protected GY (kg/ha)	Unprotected GY (kg/ha)	Yield loss %
RH-8	10.18	3.66	3.74	4.35	6010	3947	34.33
RH-10	8.93	3.45	3.12	3.93	8652	6385	26.21
RH-12	6.89	3.04	2.93	3.57	9310	6775	27.23
RH-14	6.04	2.72	2.53	3.19	9887	7305	26.12
RH-16	7.88	3.31	2.96	3.77	8921	6198	30.52
TX-369	9.45	3.54	3.59	4.14	7581	5660	25.34
Arun-2	12.17	4.72	4.62	6.04	3819	2245	41.22
ZM-401	12.13	4.4	4.34	5.38	4428	2453	44.61
ZM-627	11.93	4.13	4.19	4.7	4963	3528	28.92
RC	11.09	4.05	3.89	4.61	5424	3179	41.39
Grand mean	9.67	3.70	3.59	4.37	6899.50	4767.50	32.59
Min	6.04	2.72	2.53	3.19	3819	2245	25.34
Max	12.17	4.72	4.62	6.04	9887	7305	44.61

FDPBTs- foliage damaged percent at before tasseling stage, TL/PL tunnel length per plant, DH%-dead heart percentage, GY-grain yield, TGW-thousand grain weight, kg/ha-kilogram per hectare, g-gram, cm-centimeter

The combined mean of two years (2020 and 2021) showed that the higher percent decreased over unprotected plots with respect to foliage damaged percentage before tasseling stage (88.30 %), exit hole (70.59 %), tunnel length (89.60%) and dead heart (79.87 %) was recorded in recently released maize hybrid RH-14 (Table 4).

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Table 4: Combined mean of extent of damage due to stem borer infestation on maize varieties in protected and unprotected plots during spring season of 2020 and 2021

Varieties	Protected Plot (Sprayed)				Unprotected Plot (Non-Sprayed)				% decreased over unprotected plot			
	FDP BTs (%)	Exit hole	TL/PL (cm)	DH %	FDP BTs (%)	Exit hole	TL/PL (cm)	DH %	FDP BTs (%)	Exit hole	TL/PL (cm)	DH %
RH-8	5.34	2.10	0.99	2.55	9.06	5.17	5.95	5.44	41.06	59.38	83.36	53.13
RH-10	4.07	1.99	0.87	1.91	9.42	4.10	6.12	6.61	56.79	51.46	85.78	71.10
RH-12	3.02	1.86	0.69	1.57	20.55	6.22	5.32	6.65	85.30	70.10	87.03	76.39
RH-14	2.09	1.60	0.55	1.25	17.86	5.44	5.29	6.21	88.30	70.59	89.60	79.87
RH-16	3.53	1.99	0.82	1.76	13.41	4.67	7.87	5.28	73.68	57.39	89.58	66.67
TX-369	4.34	2.02	0.94	2.15	18.15	5.94	7.20	6.17	76.09	65.99	86.94	65.15
Arun-2	7.33	2.44	1.69	3.56	16.80	5.47	5.48	6.60	56.37	55.39	69.16	46.06
ZM-401	6.97	2.30	1.35	3.19	12.00	7.14	5.48	7.22	41.92	67.79	75.36	55.82
ZM-627	5.78	2.27	1.26	2.89	11.35	5.04	5.77	7.89	49.07	54.96	78.16	63.37
RC	5.66	2.16	1.23	2.62	16.65	5.27	7.53	5.80	66.01	59.01	83.67	54.83

FDPBTs- foliage damaged percent at before tasseling stage, TL/PL tunnel length per plant, DH%-dead heart percentage, GY-grain yield, TGW-thousand grain weight, kg/ha-kilogram per hectare, g-gram, cm-centimeter

Weather data

During the experimental period of 2020, the maximum temperature ranged from 31.82 to 36.31°C with the average of 33.23 °C, minimum temperature (15.13-23.45 °C) with the average of 19.83 °C, total rainfall during crop period (1585.3 mm) and relative humidity (75- 87.9%) with the average of 82.82%. Similar weather trend was observed during the experimental period of 2021. The maximum temperature ranged from 31.59 to 35.42 °C with the average of 32.97 °C, minimum temperature (14.12-25.16 °C) with the average of 20.43°C, total rainfall during crop period (2002.2 mm) and relative humidity (77-89%) with the average of 84% was recorded in 2021 (Figure 1).

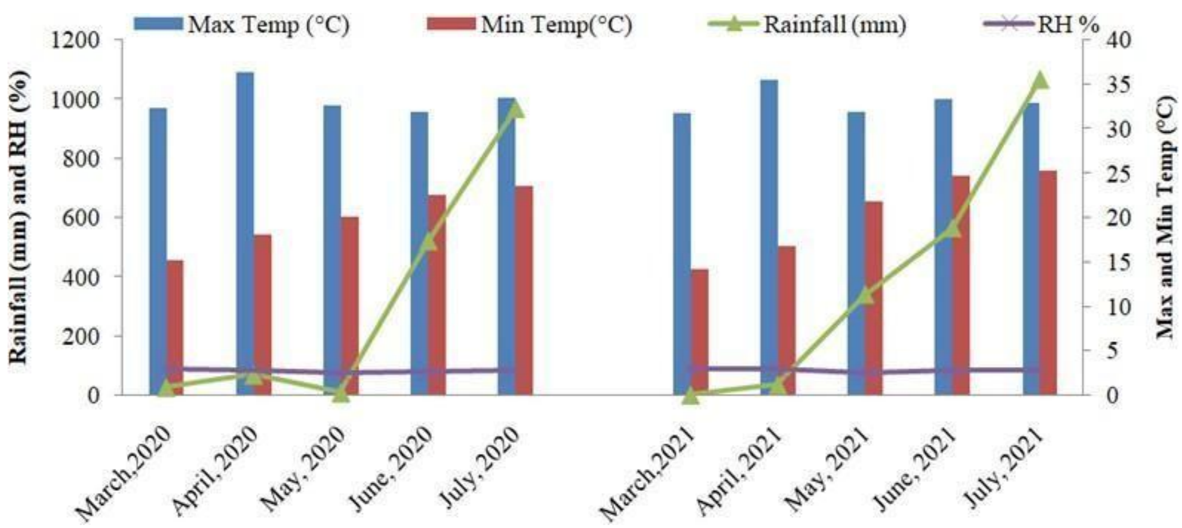

Figure 1: Meteorological data during experimental period (2020-2021) at Rampur,Chitwan, Nepal

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The potential yield of any crop variety is affected by biotic (diseases, insects, and weeds) and a-biotic (temperature, moisture, wind, etc.) restrictions when cultivated in the field, which affects the quantity and/or quality of the produce and causes crop losses. The measurement of a pest's influence on crop yield is known as crop loss assessment. The prevalence of the pest population and its feeding habits are known to be the main contributing factors to crop losses. Plants can sustain different types of damage from insect activity, which may or may not diminish their output. However, yield loss is more of an economic notion based on the advantages of adopting plant protection over neglecting the crop. For IPM practitioners and policy makers on a wider scale, a crop loss assessment approach is essential to offer this crucial input at the farm level. The present study revealed that quantitative yield loss increased with the increase of the stem borer's infestation in maize varieties. The yield loss was ranged from 25 to 45% with the mean average of 33% in different maize varieties. The highest yield loss was quantified for the open pollinated varieties while spraying of insecticide enabled the recently introduced maize hybrids to produce more yield and to be lessvulnerable to stem borer damage. The finding is in line with the Reddy & Walker (1990) whoreported that the maize stem borer, *C. partellus* caused 4-97% yield losses on different cultivars of maize in different countries all over the world. Sharma & Gautam (2010) reported that *C. partellus* caused 28% yield losses in unprotected maize crop as compared to protected one in Nepal. Chatterji *et al*. (1969) reported that the yield losses caused by *C. partellus* on different cultivars were found to range from 24.30 to 36.30% in chemically unprotected Kharif maize in different agro climatic regions of India. Singh *et al*. (1971) reported that *C. partellus* caused 11.38 and 14.73% maize grain yield losses in early and late sown unprotected crop of maize in New Delhi, respectively. Sarup *et al*. (1977) reported that maize yield losses ranged from 57.36-95.04 per cent due to artificial infestation of maize plants at its 7 different ages (10, 13, 15, 17, 20, 25 and 30 day old) with variable number of *C. partellus* eggs (5, 10, 15, 20 and 25 eggs per plant). Further, Singh (1977) reported that yield losses due to different injury grades of *C. partellus* ranged from 6.56-95.59 and 4.45- 96.64 % on CM 202 × CM 111 variety and Vijay composite of maize, respectively in Punjab. Ganguli *et al*. (1997) reported that the avoidable losses caused by C. partellus were 0.00 and 81.20 % on chemically protected and unprotected crop of Kharif maize, respectively in West Bengal. The differences in reported estimated losses caused by *C. partellus* by different workers might be due to different crop varieties, pest infestation levels, localities and prevailing weather conditions. The one factor impacting borer damage that has the greatest influence on grain yield is controversial. Grain yield reduction in maize, caused by *C.partellus* has been reported to be due to a number of factors, such as leaf damage, dead heart, stunting of growth, stem tunnelling and stalk breakage (Neupane *et al*., 2016). The difference in grain yield between entries with *C. partellus* infestations and their uninfested and unprotected counterparts served as the benchmark for the yield loss reported here.

CONCLUSION

The quantitative yield loss increased with the increase of the stem borer's infestation in maize varieties. The yield loss was ranged from 25 to 45% with the mean average of 33% in different maize varieties. The highest yield loss was quantified for the open pollinated varieties while spraying of insecticide enabled the recently introduced maize hybrids to producemore yield and to be less vulnerable to stem borer damage. So to minimize the losses caused by *C. partellus* to maize, it is proposed that the recently released hybrid maize Rampur Hybrid- 14 (RML-86/RML-96) should be promoted in farmers’ field with timely pest control measuresagainst this pest.

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Authors' Contributions

S. Neupane designed and performed the experiment, recorded and analyzed data and wrote the manuscript. S. Subedi edited the manuscript. R. Shrestha helped in overall management in field level while S. Pandey helped for making final shape of the manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript.

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