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SCREENING OF GINGER GENOTYPES AGAINST RHIZOME FLY, *Mimegralla sp.* (DIPTERA: MICROPEZIDAE) IN KAPURKOT, SALYAN, NEPAL

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ABSTRACT

An experiment was conducted to evaluate 25 indigenous ginger genotypes against rhizome fly, Mimegralla sp. at the Ginger Research Program, Kapurkot, Salyan, Nepal in 2024/25 and 2025/26. Planting was done at the crop geometry of 30 cm x 30 cm in the plot size of 3 m x 0.6 m (1.8 m2) during the last week of March and each experimental plot was replicated thrice in Randomized Complete Block Design (RCBD). Tiller number, plant height and rhizome fly infected plants scoring were recorded at the full crop growth stages whereas rhizome yields were recorded during harvesting. The rhizome fly infestation was scored by using 1 -5 scoring scale (GRP, 2014), as 1 = not infected, 2 = 0 to 25% infected, 3 = 25 – 50% infected, 4 = 50 – 75% infected and 5 = 75 – 100% infected rhizome. Analysis of variance (ANOVA) was employed to detect significant differences and mean comparisons was done by Duncan's Multiple Range Test (DMRT). Significant difference occurred among the ginger genotypes in terms of growth traits, pest infestation levels, and fresh rhizome yields. Ginger genotypes ZI 9805, ZI 0403 and ZI 0515 produced significantly the highest fresh rhizome yield (27.07-27.56 t/ha, 24.49-27.50 t/ha and 24.39-27.20 t/ha, respectively). Ginger genotypes ZI 9805 was found highly promising for lower rhizome fly infestation (0.0-0.5% rhizome fly infested, 1.0 rhizome fly scoring, 0.13-0.33 maggots/rhizome, 0.07-0.20 pupae/rhizome and 0.40-0.41 t/ha rhizome fly infested ginger) and higher ginger rhizome yield (27.07-27.56 t/ha fresh ginger) followed by fly tolerant genotype ZI 0403 (24.49-27.50 t/ha fresh ginger). The results indicated that utilizing resistant and tolerant genotypes like ZI 9805 and ZI 0403 could be the sustainable strategy to mitigate pest damage and increase production/productivity of ginger in Nepal.

Keywords: *Maggots, pupae, resistant, rhizome fly incidence, rhizome yield and tolerant*

INTRODUCTION

Ginger, *Zingiber officinale* (Roscoe, 1807) is a high-value spice and medicinal crop in Nepal with great export potential (FAO, 2023). However, the average productivity of ginger is very low (12.98 t/ha) in Nepal as compared to its potentiality (30 t/ha) of released Kapurkot Aduwa-1 variety (GRP, 2024; MoALD, 2024). This high yield gap is primarily caused by poor crop management, unavailability of high-quality seed of ginger variety and biotic factors (Gautam,

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2025). In Nepal, ginger production faces various challenges, like crop management practices and variety selection resistance/tolerant to biotic factors. The productivity and quality of ginger are significantly influenced by various crop management practices including variety selection (Kandiannan et al., 2009).

The ginger rhizome fly, *Mimegralla sp.* (Macquart 1844) is the devastating pests that causes significant yield losses and is becoming serious threat in major ginger growing districts of Nepal with the maximum infestation of 31.12% (Gautam & Acharya, 2014; Gautam et al., 2021). In Nepal, some chemical pesticides like chlorpyrifos have been recommended for ginger rhizome fly management but they pose pesticide residue in final products which is the main limiting factor for export of Nepalese ginger to international market, for which organic and quality standard are compulsory (GoN, 2016; Gautam & Ahamad, 2020).

A significant research gap exists in the Nepalese context regarding the development and identification of pest-resistant genotypes. In the past, most of the studies were focused on chemical management rather than systematic screening of indigenous landraces. There is a lack of systematic, multi-year screening of indigenous landraces and germplasm to identify genotypic resistance or tolerance against the *Mimegralla* species. Studies conducted in India (specifically Kerala and Karnataka) have identified that certain cultivars, such as 'Rio-de-Janeiro' and 'Humnabad local,' exhibit lower infestation rates, suggesting that varietal selection is a viable and sustainable management strategy (IISR, 2018). However, the performance of Nepalese indigenous genotypes under local climatic conditions at various altitudes remain largely undocumented. To address this gap, the current study was carried out to evaluate 25 indigenous ginger genotypes at the Ginger Research Program in Kapurkot, Salyan during 2024/025 and 2025/026. The objective of this varietal screening was to identify promising genotypes with field resistance to the rhizome fly and high-yield potential, thereby providing a pesticide-free solution for sustainable ginger production while enhancing Nepal's export competitiveness in the global market.

MATERIALS AND METHODS

Two years field experiments were conducted at Ginger Research Program, Kapurkot (870 masl, 27^{0}58'25" N latitude and 83^{0}25'30" E longitude), Salyan during 2024/025 and 2025/026 to screen the promising ginger genotypes against ginger rhizome fly. Total 25 indigenous ginger genotypes [ZI 9304, ZI 9805, ZI 0403, ZI 0515, ZI 1007, ZI 1010, ZI 1025, ZI 1026, ZI 1302, ZI 1303, ZI 1609, ZI 1616, ZI 1620, ZI 1904, ZI 1905, ZI 1906, ZI 2201, ZI 2401, ZI 2402, ZI 2403, ZI 2404, ZI 2405, ZI 2406, including standard check Kapurkot Aduwa-1 (KK-1) and Kapurkot Aduwa-2 (KK-2)] collected from Ginger Research Program, Kapurkot, Salyan were used in this study. The temperature during the germination period ranged from minimum 12.90^{0}C in February to maximum 30.03^{0}C in June with cumulative rainfall 74.00 mm and average relative humidity 62.25%. Similarly, during the full crop growth stages from July to September the temperature ranged from minimum 19.63^{0}C in September to maximum 26.97^{0}C in July with cumulative rainfall 1744.30 mm and average relative humidity 73.70%.

Planting of 60 g seed rhizome size was done at the spacing of 30 cm x 30 cm in the plot size of 3 m x 0.6 m (1.8 m^2) during the last week of March, and each experimental plot was replicated thrice in Randomized Complete Block Design (RCBD). Recommended doses of manure and fertilizers were applied @ 30 t FYM and 75: 50: 50 kg NPK per hectare, respectively. Full dose of FYM, phosphorus and half dose of potash was applied as a basal dose in furrow before planting of rhizome. The half dose of nitrogen was applied through side dressing one months after germination. The remaining half dose of potash and nitrogen was applied after two months of germination. Immediately after planting 10-15 cm thick dry leaves mulching was done with wooden sticks over the mulch to protect from wind. Manual weeding and hoeing were done two times first at one month and second at two months after ginger germination. No irrigation was used during the ginger growing period. Data on yield attributing traits, such as tiller number, plant height and rhizome fly infected plants scoring were recorded at the full growth stages of crop during the last week of September. Infected rhizome yield and fresh rhizome yield were recorded. The rhizome fly infestation was scored by using 1 -5 scoring scale (GRP, 2014), as 1 = not infested, 2 = 0 to 25% infested, 3 = 25 – 50% infested, 4 = 50 – 75% infested and 5 = 75 – 100% infested rhizome. The plants were harvested during the last week of November when the leaves were dry and pseudo stem fallen down. Data on maggot and pupal number per infected rhizome and various categories of rhizome yield were recorded. Data were entered in Microsoft Excel and analyzed using Statistical Tool for Agricultural Research (STAR) version 2.0.1 (IRRI, 2017). Analysis of variance (ANOVA) was employed to detect significant differences among ginger rhizome seed sizes and varietal traits, and mean comparisons by Duncan's Multiple Range Test (DMRT), and Least Significant Differences (LSD) for all significant traits (Gomez & Gomez, 1984).

RESULTS

Expression of ginger genotypes in relation to yield traits and rhizome fly incidence

Evaluation of 25 ginger genotypes screening against ginger rhizome fly at the Ginger Research Program in Kapurkot is shown in Figure 1. The effect of 25 indigenous ginger genotypes during 2024/025 and 2025/026 revealed significant different yield attributing traits and rhizome fly incidence (Table 1). Statistically significant differences were observed among all evaluated parameters, including germination percentage, tiller number, plant height, and rhizome fly infestation, which were significantly influenced by the genotype in both years. Among tested genotypes, 100% ginger germination percentage was found in ZI 2403 during 2024/025 and in ZI 9805 during 2025/026. The tiller number was found consistently the highest in ZI 1303 genotype in both years (14.93 and 14.53 during 2024/25 and 2025/26, respectively). The genotypes ZI 9805 (71.67–72.00 cm) and KK-2 (68.00–71.00 cm) were the tallest, whereas ZI 1906 (55.33–56.00 cm) and ZI 1025 (56.33–57.67 cm) were the dwarf genotypes. The rhizome flies infested plant percentage significantly differed from 0.00 – 5.00% in ZI 9805 to 16.15 – 21.46% in ZI 0515 genotypes. The genotypes ZI 9805 was found highly promising with minimum (0.00 – 5.00%) infested plants and the low infestation score (1.00).

Figure 1: Screening of ginger genotypes against rhizome fly at Kapurkot, Salyan during 2024/25 and 2025/26

Table 1: Yield attributing traits and rhizome fly incidence of ginger genotypes at Kapurkot, Salyan during 2024/25 and 2025/26

Genotypes	Germination (%)		Tiller (No./plant)		Plant height (cm)		Rhizome fly infested plant (%)		Rhizome fly scoring (1-5 scale)	
	2024/25	2025/26	2024/25	2025/26	2024/25	2025/26	2024/25	2025/26	2024/25	2025/26
ZI 9304	93.33^{a-d}	96.67^{ab}	13.27^{a-c}	14.13^{a-d}	66.33^{a-e}	69.00^{a-c}	7.05^{c-h}	5.19^{f}	1.33^{de}	1.33^{cd}
ZI 9805	95.00^{a-c}	100.00^{a}	13.33^{ab}	14.33^{a-c}	72.00^{a}	71.67^{a}	0.00^{h}	5.00^{f}	1.00^{e}	1.00^{d}
ZI 0403	90.00^{a-e}	96.67^{ab}	13.00^{a-e}	14.07^{a-e}	66.67^{a-d}	69.33^{a-c}	14.69^{a-c}	15.53^{a-c}	2.00^{b-d}	1.67^{b-d}
ZI 0515	86.67^{b-g}	93.33^{ab}	13.10^{a-d}	14.00^{a-e}	64.67^{b-g}	67.00^{a-d}	21.46^{a}	16.15^{ab}	1.33^{de}	2.00^{a-c}
ZI 1007	88.33^{b-f}	90.00^{b-d}	11.60^{b-i}	11.80^{a-f}	60.33^{e-j}	62.67^{d-g}	3.98^{f-h}	7.35^{d-f}	1.33^{de}	1.33^{cd}
ZI 1010	96.67^{ab}	95.00^{ab}	10.67^{g-i}	11.60^{b-f}	58.33^{h-j}	58.33^{f-h}	7.04^{c-h}	8.63^{d-f}	1.33^{de}	1.33^{cd}
ZI 1025	88.33^{b-f}	90.00^{b-d}	12.27^{b-h}	12.60^{a-f}	56.33j	57.67^{gh}	15.07^{ab}	18.46^{a}	2.33^{bc}	2.00^{a-c}
ZI 1026	91.67^{a-d}	91.67^{a-c}	11.20^{d-i}	11.47^{d-f}	58.33^{h-j}	58.00^{gh}	7.15^{b-h}	10.92^{b-f}	1.33^{de}	1.33^{cd}
ZI 1302	85.00^{c-g}	90.00^{b-d}	10.93^{f-i}	11.00f	57.00^{ij}	59.67^{e-h}	6.02^{d-h}	7.42^{d-f}	1.67^{c-e}	2.00^{a-c}
ZI 1303	88.33^{b-f}	95.00^{ab}	14.93^{a}	14.53^{a}	69.33^{ab}	70.33^{ab}	9.48^{b-g}	8.79^{d-f}	1.00^{e}	1.33^{cd}
ZI 1609	85.00^{c-g}	90.00^{b-d}	10.40^{hi}	10.87^{f}	57.33^{ij}	58.00^{gh}	13.75^{a-d}	11.34^{b-f}	2.67^{ab}	2.33^{ab}
ZI 1616	85.00^{c-g}	90.00^{b-d}	11.73^{b-i}	12.20^{a-f}	65.00^{b-g}	64.00^{c-f}	5.56^{e-h}	11.03^{b-f}	1.00^{e}	1.00^{d}
ZI 1620	80.00^{e-g}	83.33^{cd}	13.07^{a-d}	12.93^{a-f}	67.67^{a-c}	69.33^{a-c}	10.31^{b-g}	12.04^{a-e}	1.33^{de}	1.67^{b-d}
ZI 1904	78.33^{fg}	81.67^{d}	12.73^{b-f}	12.80^{a-f}	68.00^{a-c}	68.67^{a-c}	6.25^{d-h}	10.05^{b-f}	2.00^{b-d}	2.00^{a-c}
ZI 1905	76.67^{g}	83.33^{cd}	11.00^{e-i}	11.07^{f}	59.67^{f-j}	60.33^{e-h}	8.61^{b-g}	10.05^{b-f}	1.00^{e}	1.33^{cd}
ZI 1906	91.67^{ad}	96.67^{ab}	11.93^{b-h}	12.27^{a-f}	55.33^{j}	56.00^{h}	10.85^{b-g}	13.70^{a-d}	2.33^{bc}	2.00^{a-c}

Genotypes	Germination (%)		Tiller (No./plant)		Plant height (cm)		Rhizome fly infested plant (%)		Rhizome fly scoring (1-5 scale)	
	2024/25	2025/26	2024/25	2025/26	2024/25	2025/26	2024/25	2025/26	2024/25	2025/26
ZI 2201	86.67^{b-g}	90.00^{b-d}	10.73^{f-i}	11.27^{ef}	59.00^{g-j}	60.00^{e-h}	13.75^{a-d}	12.84^{a-e}	2.33^{bc}	2.00^{a-c}
ZI 2401	85.00^{c-g}	91.67^{a-c}	13.40^{ab}	10.40f	64.33^{b-h}	65.33^{b-e}	11.90^{b-f}	10.92^{b-f}	1.67^{c-e}	1.33^{cd}
ZI 2402	90.00^{a-e}	91.67^{a-c}	12.20^{b-h}	13.13^{a-f}	67.67^{a-c}	67.67^{a-d}	9.62^{b-g}	9.34^{c-f}	1.33^{de}	1.33^{cd}
ZI 2403	100.00^{a}	96.67^{ab}	11.27^{c-i}	11.53^{c-f}	62.67^{c-i}	62.33^{d-g}	3.33^{g-h}	6.93^{ef}	1.00^{e}	1.33^{cd}
ZI 2404	83.33^{d-g}	91.67^{a-c}	10.73^{f-i}	10.40^{f}	61.00^{d-j}	62.00^{d-g}	12.50^{b-e}	9.16^{c-f}	2.67^{ab}	1.67^{b-d}
ZI 2405	93.33^{a-d}	91.67^{a-c}	10.27^{hi}	11.07^{f}	60.33^{e-j}	60.00^{e-h}	3.52^{gh}	9.11^{c-f}	1.33^{de}	1.33^{cd}
ZI 2406	90.00^{a-e}	91.67^{a-c}	9.73^{i}	10.47^{f}	60.67^{d-j}	62.67^{d-g}	5.57^{e-h}	9.06^{c-f}	1.33^{de}	1.33^{cd}
KK-1	90.00^{a-e}	96.67^{ab}	12.47^{b-g}	14.40^{ab}	65.33^{b-f}	67.67^{a-d}	11.23^{b-g}	10.35^{b-f}	3.33^{a}	2.67^{a}
KK-2	85.00^{c-g}	98.33^{ab}	13.60^{ab}	14.07^{a-e}	68.00^{a-c}	71.00^{ab}	7.87^{b-h}	6.84^{ef}	1.67^{c-e}	1.33^{cd}
Mean	88.13	92.13	11.98	12.34	62.85	63.95	9.06	10.25	1.67	1.60
CV (%)	8.03	6.49	10.50	13.99	6.05	5.61	53.78	38.55	32.19	32.84
P-Value	*	*	**	*	**	**	**	*	**	*
LSD(0.05))	11.61	9.81	2.07	2.83	6.24	5.89	8.00	6.48	0.88	0.86

*Note: ZI=Zingiber indigenous, KK-1=Kapurkot Aduwa–1, KK-2=Kapurkot Aduwa – 2, *=Significant, **=highly significant, CV=Coefficient of variation, LSD=Least significant different*

Reactions of ginger genotypes on rhizome fly incidence and rhizome yield

The maggots and pupae population as well as different categories of harvested ginger rhizome showed highly significant variation among the genotypes (Table 2). The consistently minimum maggots (0.07 – 0.33 maggots/rhizome) and pupae (0.07 – 0.33 pupae/rhizome) numbers were found in ZI 2403 and ZI 9805. The highest number of maggots was found in ZI 0515 (8.40 - 9.27) and ZI 0403 (6.40 - 7.60). Similarly, the pupae count was found the highest in ZI 0403 (3.73 and 4.60) and ZI 0515 (3.27 and 4.00). Mother rhizome yield was found significantly higher in ZI 1302 (4.56 t/ha) followed by ZI 1302 (4.19 t/ha). The lowest rhizome fly infested yield (0.25 -0.57 t/ha) was found in genotypes ZI 2403, ZI 9304, ZI 9805, ZI 2405 and ZI 2402. The released ginger variety KK-1 and genotypes ZI 1025, ZI 0515, ZI 2401ZI 1616, ZI 1010 and ZI 1906 were found more prune (rhizome fly infested yield of 1.47 – 2.18 t/ha during 2024/25 and 1.50 – 2.03 t/ha in 2025/26) to ginger rhizome fly. Fresh rhizome yield was significantly affected by the genotype where ZI 9805, ZI 0403, ZI 0515, ZI 1904, ZI 2402 and KK-2 were found superior with the yield potential of 23.44 -27.56 t/ha in both the experimental years. During 2024/25, the highest fresh yield (27.56 t/ha) was recorded in genotype ZI 9805 followed by ZI 2402 (24.93 t/ha) and KK-2 (24.80 t/ha) whereas ZI 0403 produced the highest fresh yield (27.50 t/ha) in the 2025/26. Ginger genotype 9805 was found highly promising as it was more tolerant to rhizome fly and had higher yield.

Among the screened genotypes, seven promising genotypes are shown in Figure 2. A notable observation was the yield performance of ZI 0403, which resulted in the highest fresh yield (27.50 t/ha) despite having a moderate infection score (1.67-2.00). This genotype is more tolerant and maintains high productivity even under low pest pressure.

Figure 2: Fresh rhizome yield of promising ginger genotypes at Kapurkot, Salyan during 2024/25 and 2025/26

Table 2: Rhizome fly infestation and fresh yield of ginger genotypes at Kapurkot, Salyan during 2024/25 and 2025/26

Genotypes	Maggots (No/ rhizome)		Pupae (No/ rhizome)		Rhizome yield (t/ha)					
					Mother		Rhizome fly infested		Fresh rhizome	
	2024/25	2025/26	2024/25	2025/26	2024/25	2025/26	2024/25	2025/26	2024/25	2025/26
ZI 9304	0.27^{i-k}	0.22^{f}	0.13^{hi}	0.27^{jk}	2.11^{h-l}	2.20^{h-k}	0.35^{lm}	0.43^{j-l}	22.99^{a-c}	25.39^{a-c}
ZI 9805	0.13^{jk}	0.33^{f}	0.07^{i}	0.20^{k}	2.55^{e-j}	2.60^{f-j}	0.41^{k-m}	0.40^{kl}	27.56^{a}	27.07^{ab}
ZI 0403	6.40^{c}	7.60^{b}	3.73^{a}	4.60^{a}	2.89^{b-h}	2.70^{f-i}	1.84^{b}	1.73^{ab}	24.49^{ab}	27.50^{a}
ZI 0515	8.40^{a}	9.27^{a}	3.27^{b}	4.00^{b}	4.04^{ab}	4.17^{a-c}	1.93^{ab}	1.86^{ab}	24.39^{ab}	27.20^{ab}
ZI 1007	0.47^{g-j}	0.54^{f}	0.27^{g-i}	0.27^{jk}	3.04^{d-g}	3.21^{d-g}	1.20^{de}	1.19^{d-f}	14.85^{e-i}	16.37^{f-j}
ZI 1010	0.67^{f-h}	1.07^{f}	0.47^{fg}	0.80^{f-h}	4.49^{a}	4.56^{a}	1.61^{bc}	1.55^{b-d}	16.67^{d-g}	17.13^{e-j}
ZI 1025	7.13^{b}	5.68^{c}	3.07^{b}	3.27^{c}	1.11^{m}	1.19^{l}	2.18^{a}	2.03^{a}	10.51^{g-j}	12.02^{i-l}
ZI 1026	0.33^{h-k}	0.60^{f}	0.47^{fg}	0.67^{g-j}	3.19^{c-f}	3.31^{c-f}	1.04^{e-h}	1.17^{d-g}	13.41^{f-j}	14.06^{g-k}
ZI 1302	0.33^{h-k}	0.73^{f}	0.33^{f-i}	0.40^{h-k}	3.89^{a-c}	4.19^{ab}	0.75^{h-j}	0.89^{f-i}	10.48^{h-j}	10.87^{j-l}
ZI 1303	0.53^{f-i}	0.93^{f}	0.40^{f-h}	0.67^{g-j}	3.59^{b-d}	3.92^{a-d}	0.55^{i-m}	0.66^{i-l}	21.66^{a-d}	20.05^{c-g}
ZI 1609	2.47^{e}	3.13^{d}	1.60^{d}	2.13^{d}	1.43^{lm}	1.85^{i-l}	1.17^{d-f}	0.87^{f-i}	9.73^{ij}	7.58^{l}
ZI 1616	0.40^{g-k}	0.93^{f}	0.60^{f}	0.73^{f-i}	1.68^{k-m}	1.85^{i-l}	1.84^{b}	1.70^{a-c}	14.43^{e-j}	14.74^{g-k}
ZI 1620	0.33^{h-k}	0.53^{f}	0.47^{fg}	0.20^{k}	1.90^{i-m}	1.93^{i-l}	0.62^{i-l}	0.72^{i-l}	20.18^{b-e}	21.11^{b-f}
ZI 1904	0.33^{h-k}	0.87^{f}	0.27^{g-i}	0.47^{g-k}	2.64^{e-i}	2.89^{e-h}	0.73^{h-k}	0.73^{h-l}	23.44^{a-c}	24.61^{a-d}
ZI 1905	0.33^{h-k}	0.67^{f}	0.33^{f-i}	0.47^{g-k}	1.67^{k-m}	1.74^{j-l}	0.77^{g-j}	0.80^{f-j}	13.27^{f-j}	14.74^{g-k}
ZI 1906	2.40^{e}	2.87^{de}	0.60^{f}	1.13^{ef}	1.78^{j-m}	1.83^{i-l}	1.47^{c-d}	1.50^{b-e}	13.20^{f-j}	14.27^{g-k}
ZI 2201	0.87^{f}	1.40^{ef}	1.00^{e}	0.87^{fg}	1.73^{k-m}	1.69^{kl}	1.36^{c-e}	1.31^{c-e}	11.97^{f-j}	12.91^{h-l}
ZI 2401	0.73^{fg}	1.07^{f}	0.27^{g-i}	0.60^{g-k}	2.43^{f-k}	2.57^{f-j}	1.85^{ab}	1.70^{a-c}	16.50^{d-h}	17.30^{e-i}
ZI 2402	0.27^{i-k}	0.60^{f}	0.40^{f-h}	0.47^{g-k}	1.98^{i-l}	2.21^{h-k}	0.51^{j-m}	0.56^{i-l}	24.93^{ab}	25.99^{a-c}
ZI 2403	0.07^{k}	0.33^{f}	0.07^{i}	0.33^{i-k}	4.00^{ab}	4.14^{a-c}	0.26^{m}	0.36^{l}	17.56^{c-f}	18.83^{d-h}
ZI 2404	0.47^{g-j}	0.87^{f}	0.40^{f-h}	0.47^{g-k}	3.32^{b-e}	3.61^{b-e}	1.06^{e-h}	1.16^{d-g}	10.09^{ij}	11.57^{i-l}
ZI 2405	0.53^{f-i}	0.73^{f}	0.27^{g-i}	0.60^{g-k}	1.84^{i-m}	1.90^{i-l}	0.41^{k-m}	0.57^{i-l}	8.51^{j}	9.48^{kl}
ZI 2406	4.33^{d}	5.07^{c}	2.53^{c}	3.00^{c}	2.27^{g-k}	2.35^{g-k}	1.10^{e-g}	1.13^{e-h}	9.09^{ij}	9.10^{kl}
KK-1	2.27^{e}	2.73^{de}	0.93^{e}	1.47^{e}	3.13^{c-f}	3.19^{d-g}	1.93^{ab}	1.98^{a}	22.27^{a-d}	23.18^{a-e}
KK-2	0.33^{h-k}	0.40^{f}	0.33^{f-i}	0.33^{i-k}	2.79^{d-h}	3.18^{d-g}	0.85^{f-i}	0.78^{g-k}	24.80^{ab}	25.59^{a-c}
Mean	1.63	1.97	0.891	1.14	2.62	2.76	1.11	1.11	17.08	17.95
CV (%)	14.12	47.06	21.41	24.22	18.63	19.26	18.44	22.00	22.09	21.53
P-Value	**	**	**	**	**	**	**	**	**	**
LSD (0.05)	0.38	1.52	0.31	0.45	0.80	0.87	0.34	0.40	6.19	6.34

*Note: ZI=Zingiber indigenous, KK-1=Kapurkot Aduwa–1, KK-2=Kapurkot Aduwa – 2, **=highly significant, CV=Coefficient of variation, LSD=Least significant different*

DISCUSSION

Evaluation of 25 ginger genotypes at the Ginger Research Program in Kapurkot revealed significant genetic variability in growth, yield, and resistance to the rhizome fly (*Mimegralla* sp.). There was great variation in plant height (53.33 – 72.00 cm) and tiller number (9.53 – 14.93 per clump) that can be a broad genetic base among indigenous Nepalese ginger germplasm. It has been reported that genotypes with higher vigor expressed through increased plant height and tillering consistently demonstrated superior photosynthetic capacity and subsequent rhizome bulking (Anargha et al., 2021; Karthikeyan et al., 2018). For instance, good growth performance and tolerant to ginger fly of ZI 9805 and ZI 1303 in this study aligns with previous findings (Gautam, 2025) that high-vigor of Kapurkot Aduwa-2 (KK-2) variety established a strong canopy, influenced their ability to withstand biotic stress.

The screening for rhizome fly revealed ZI 9805 as a highly promising genotype, exhibiting the least infestation (score 1.00). This resistance profile is exceptional. Management research conducted at Salyan confirmed that the chemical and organic drenching can mitigate fly damage (Gautam & Mainali, 2016). The low infestation levels in ZI 9805 and ZI 2403 suggest possession of potential antibiosis or antixenosis resistance mechanisms, which are critical to rhizome fly damage as the precursor to devastating rhizome rot complexes (Gautam & Acharya, 2014). The selection of resistant varieties remains the most sustainable strategy.

A notable observation was the yield performance of ZI 0403, which also resulted in the highest fresh yield (27.50 t/ha) in 2025/26 despite having infestation score (1.67-2.00). This genotype is more tolerant and maintains high productivity even under-pest pressure. Further, among the tested ginger genotypes, ZI 0515 (24.39-27.20 t/ha), ZI 2402 (24.93 - 25.99 t/ha), ZI 9304 (22.99-25.93) and ZI 1904 (23.44-24.61 t/ha) were found better performing whereas in coordinated varietal trial significantly the highest total rhizome yield was recorded in genotype ZI 1303 (24.9 t/ha) followed by ZI 1007 (21.4 t/ha) with higher fresh rhizome yield (GRP, 2021). Singh et al. (2013) emphasized that certain ginger genotypes possessed physiological resilience to compensate the rhizome tissue loss. Conversely, ZI 2405 and ZI 2406 genotypes proved susceptible land races with low vigor and yield. Usually, there exists positive correlation between tiller number and yield. In this study ZI 1303 recorded the highest tillers and maintained competitive yields.

The warm and humid climate with 21–32°C temperature, 1500-2000 mm annual rainfall and above 60% relative humidity are ideal for ginger production. High temperatures can induce heat stress in ginger plants, resulting in wilting, reduced photosynthesis, and damage to plant tissues. Rising temperatures also create favorable conditions for pests and diseases, affecting ginger plants. Conversely prolonged exposure to cold conditions can cause stunted growth and diminished productivity (Kumar et al., 2025). Our findings also reveal similar environmental conditions during rhizome growing period for satisfactory rhizome fly management and rhizome yield.

The identification of ZI 9805 as a resistant, high-yielding genotype and ZI 0403 as a tolerant, high-yielding genotype provides a valuable foundation for ginger breeding programs in Nepal. These genotypes offer a viable alternative to susceptible local varieties, potentially reducing 20–31% yield loss typically attributed to rhizome fly infestation in the mid-hills (Gautam, 2025). Future research should focus on the mechanisms of host plant resistance and biochemical markers associated with the resistance in ZI 9805 to facilitate the development of fly-resistant cultivars for commercial ginger cultivation.

CONCLUSION

The field study conducted at Kapurkot, Salyan, from 2024 to 2026 identifies specific ginger genotypes that can significantly improve rhizome production and productivity. Among the 25 tested genotypes, ZI 9805 stands out as the most promising genotype as it is highly resistance to the rhizome fly, recording no pest maggots or pupae during the two-year evaluation. Productivity was also higher in genotypes ZI 0403, ZI 0515, ZI 2402, ZI 9304 and ZI 1904. While ZI 0403 showed some signs of infestation, it demonstrated a unique tolerance by maintaining high yields despite the pest pressure. Additionally, ZI 1303 was noted for its good growth vigor, consistently producing the highest number of tillers per plant.

Adopting these improved varieties is essential because low-yielding genotypes, such as ZI 2405 and ZI 2406, currently limit the agricultural potential in the ginger growing regions. Utilizing resistant and tolerant genotypes, like ZI 9805 and ZI 0403 offers a sustainable, pesticide-free strategy to mitigate yield losses, which range 20 - 31% in the mid-hills regions. Reducing reliance on chemical treatments, like chloropyrifos, which farmers were using in the past and banned in Nepal align Nepalese ginger with strict international organic standards, which is vital for enhancing export competitiveness. Therefore, future research should focus on mechanisms of resistance and identifying the specific biochemical markers that give ZI 9805 its natural resistance to support the development of resilient cultivars for commercial use.

DECLARATION

The authors declare no conflict of interests.

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