Research Article:

GINGER RHIZOME FLY, *Mimegralla coeruleifrons* (Macquart, 1844), MANAGEMENT BY PLANTING APPROPRIATE SEED RHIZOME SIZE AND SUITABLE VARIETY

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Received date: 27 August 2025, Accepted date: 25 December 2025
DOI: https://doi.org/10.3126/jafu.v6i2.88453

ABSTRACT

A field experiment was conducted at Ginger Research Program (GRP), Salyan during 2019 and 2020 to evaluate ginger varieties (Kapurkot Aduwa-1 and Kapurkot Aduwa-2) for their seed rhizome sizes (20, 40, 60, and 80 g) on yield performance and rhizome fly, *Mimegralla coeruleifrons* (Macquart, 1844), management. The experiment was laid out in a Randomized Complete Block Design (RCBD) with eight treatments and three replications using 3.6 m² plots size at 30 cm × 30 cm crop geometry. Seed rhizomes were planted in late March of 2019 and 2020 and harvested after 9 months in December. Fertilization was done at the rate of 30 ton FYM and 75:50:50 kg NPK per hectare, respectively. Results demonstrated that Kapurkot Aduwa-2 variety with 80 g seed rhizomes produced the mean maximum plant height (81.6 cm), the highest tiller numbers (10.1 per clump) and the highest fresh rhizome yields (32.43 t/ha in 2019 and 28.67 t/ha in 2020). Similarly, larger seed rhizomes (60-80 g) of this variety consistently showed better resistance to rhizome fly and lower pest populations (1.47-3.33 maggots and 1.27-5.3 pupae/rhizome). Larger seed rhizomes (60-80 g) significantly reduced rhizome fly infestation and minimal damage (0.19 t/ha) in Kapurkot Aduwa-2. The study concludes that Kapurkot Aduwa-2 variety with the use of 80 g seed rhizomes provides the maximum yield and effective rhizome fly pest management, representing the most suitable cultivation strategy for ginger production in the mid-hills of Nepal. This method of production can mitigate the use of chemical pesticides to control rhizome flies and could be an avenue for the export of pesticide free ginger from Nepal to international markets.

सारांश

सन् २०१९ र २०२० मा अदुवाबाली अनुसन्धान कार्यक्रम, सल्यानमा अदुवाका प्रजातिहरू (कपुरकोट अदुवा-१ र कपुरकोट अदुवा-२) को बीउ-गानोको आकार (२०, ४०, ६०, र ८० ग्राम) को उत्पादन तथा गानोमा लाग्ने झिंगा (किरा) व्यवस्थापनको मूल्याङ्कन गर्न एक परीक्षण गरिएको थियो। यो परीक्षण ३.६ वर्ग मिटरको प्लटमा आठवटा उपचार बिधि प्रयोग गरी अनियमित पूर्ण ब्लक डिजाइनमा तीन पटक दोहोर्याई ३० से. मी × ३० से. मी. ज्यामितीय रोपण विधि प्रयोग गरी लगाइएको थियो। उक्त परीक्षणमा ३० टन गोबरमल र ७५:५०:५० किलोग्राम नाइट्रोजनःफस्फोरसःपोटास प्रति/हेक्टरका दरले प्रयोग गरिएको थियो। नतिजाहरूले देखाएअनुसार ८० ग्राम बीउ भएको कपुरकोट अदुवा-२ जातमा सबैभन्दा अधिकतम औसत बोटको उचाई (८१.६ से. मी.), र उच्चतम डाँठ संख्या (प्रति झुण्ड १०.१) र धेरै ताजा गानो उत्पादन (२०१९ मा ३२.४३ टन/हेक्टर र २०२० मा २८.६७ टन/हेक्टर) पाइयो । ठूला बीउ भएको (६०-८० ग्राम) त्यहि जातमा निरन्तर राम्रो प्रतिरोध र कम कीराको संख्या (१.४७-३.३३ औसा र १.२७-५.३ प्युपा/गानो) पाइयो। ठूला बीउ गानो भएको केके-२ जातले राइजोम झिंगा प्रकोपलाई उल्लेखनीय रूपमा कम गरेको छ, जसमा कपुरकोट अदुवा-२ मा न्यूनतम क्षति (०.१९ टन/हेक्टर) पाइयो। अध्ययनले यो निष्कर्ष निकालेको छ कि ८० ग्राम बीउ भएको कपुरकोट अदुवा-२ जातले नेपालको मध्य-पहाडी क्षेत्रहरूमा अदुवा उत्पादनको लागि सबैभन्दा उपयुक्त खेती रणनीतिको प्रतिनिधित्व गर्दै उच्चतम उत्पादन र प्रभावकारी गानोको झिंगा कीरा व्यवस्थापन प्रदान गर्दछ। यो उत्पादन प्रविधिले गानोको झिंगा नियन्त्रण गर्न रासायनिक कीटनाशकहरूको प्रयोगलाई कम गर्न सक्छ र नेपालबाट अन्तर्राष्ट्रिय बजारमा कीटनाशक रहित अदुवा निर्यात गर्ने माध्यम बन्न सक्छ।

Keywords: Cultivation strategy, eco-friendly production, infected yield, maggots, mid-hill regions

INTRODUCTION

Ginger (*Zingiber officinale* Roscoe) is one of the most important spice crops globally, valued for its culinary, medicinal, and economic significance (Parthasarathy et al., 2008). Mid-hills of Nepal have potential to trap the benefits of this cash/commercial/industrial/exportable commodity (GRP, 2024). This spice crop is high price fetching exportable commodity providing job opportunities, income generation and fostering agro-based industrial development. About 40% of the ginger is exported annually (GRP, 2018) mainly to India. This crop not only plays an important role in the agrarian and industrial development of the country but also contributes a significant amount to the national exchequer of the country's export and import substitution, as well. It has been traditionally grown since long back in remote areas by the middle class or marginal farmers. In Nepal, ginger is grown in an area of 23,829 ha with an annual production of 3,09,533 mt (MoALD, 2024). Ilam, Salyan, Palpa, Sindhuli, Morang, Doti and Kaski are the major ginger growing districts which cover more than 40% of the total ginger cultivated area and production of the country (MoALD, 2024). Nepal ranks fourth position in terms of total ginger production in the world after India, Nigeria and China (FAO, 2023).

GRP, 2024 reported that, the national average productivity of ginger (12.98 mt/ha) is quite low as compared to the production potentiality of both the released varieties (30.00 mt/ha of Kapurkot Aduwa-1 and 32.75 mt/ha of Kapurkot Aduwa-2 variety). The plant growth, productivity and quality of ginger are significantly influenced by various agronomic factors, including variety selection and seed rhizome size (Kandiannan et al., 2009).

In Nepal, ginger cultivation faces significant challenges including variety selection, optimum rhizome size for planting, insect and pest management. Among different pests, ginger rhizome fly is the most important that causes substantial yield losses (Maharjan et al., 2011). Ginger rhizome fly, *Mimegralla coeruleifrons* (Macquart, 1844), is an oligophagous dipteran pest species of family Zingiberaceae, mainly affecting the ginger crop (Ghorpade et al., 2008). In India, it causes significant yield losses through larval feeding and subsequent damage to the rhizomes (Sasikumar et.al., 1996). It is reported that ginger rhizome fly reduces about 20-31 percent of ginger rhizome yield (Sharma et.al., 1998; Gautam & Acharya, 2014).

Rhizome flies can be effectively controlled by using chemical pesticides (Gautam & Ahamad, 2020; Sinha & Ray, 2024). However, use of pesticides often causes health hazards due to their residue presence in the rhizome and not accepted for export in the international market. Most of the importing countries require certification for pest free and pesticide residue free products. Moreover, the use of pesticides causes environmental pollution. Considering these facts, there is an urgent need to find out the alternative safe technology for production of pesticide free high yielding ginger variety with appropriate seed rhizome size. There is a need to find production technology of ginger without using hazardous chemical pesticides (Sinha & Ray, 2024). It is reported that the size of seed rhizomes and choice of variety are critical factors determining crop establishment, disease resistance, and yield performance (Singh et al., 2013). Islam et.al. 2017 also reported that the larger seed rhizomes lead to higher overall yields and potentially lower down rhizome flies damage. The interaction between variety and seed rhizome size on pest incidence is essential for developing integrated management strategies to optimize both yield and quality. This study evaluated the performance of two ginger varieties namely Kapurkot Aduwa-1 (KK-1) and Kapurkot Aduwa-2 (KK-2) and used their different seed rhizome sizes to determine for the management of ginger rhizome fly.

RESEARCH METHODS

An experiment was conducted at Ginger Research Program (altitude 1480 masl, $28^o14"$ N latitude and $32^o24"$E longitude), Kapurkot, Salyan from the months of March to December 2019 and 2020 to study the effect of seed rhizome size i.e., 20 g, 40 g, 60 g and 80 g for rhizome fly infestation in Kapurkot Aduwa- 1 and Kapurkot Aduwa- 2 varieties of ginger. In total there were eight treatment combinations. The experiment was laid out in RCBD and replicated thrice. Planting was done at a spacing of 30 cm x 30 cm in 3.6 m^2 plot size during the last week of March. The experiment was conducted under rain fed conditions in sandy loam soil. The recommended dose of manure and fertilizers were applied @ 30 ton 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 month after germination. The remaining half dose of potash and nitrogen was applied after two months of ginger germination. Immediately after planting 10-15 cm thick mulching was done with dry leaves.

Weeding was done twice, first at one month and second at 2 months after germination through hoeing and hand weeding. The rhizomes were harvested during the first week of December (after leaves and pseudo stems became dry and fallen down). The temperature during the growing period ranges from 7.6 ^{0}C in March to maximum 27.8^{0}C in June and cumulative rainfall was 1721.3 mm in 2019 and 2299.0 mm in 2020, respectively. The data were recorded on tiller number, plant height and rhizome fly infestation, rhizome fly maggot, rhizome fly pupae and different categories of harvested ginger rhizome. The rhizome fly infestation was scored by using 1 -5 scoring scale (GRP, 2014), as 1 = no infected, 2 = 0 to 25 % infected, 3 = 25 – 50 % infected, 4 = 50 – 75% infected and 5 = 75 – 100 % rhizome infected. Data were compiled in Microsoft Excel and analyzed using GenStat software, version 18 (VSN International, 2015). Analysis of variance (ANOVA) was employed to detect significant differences among ginger rhizome seed sizes and varietal traits. Mean comparisons were conducted using Duncan's Multiple Range Test (DMRT), and least significant differences (LSD) were calculated for all significant traits.

RESULTS AND DISCUSSION

Effect of seed rhizome size and varieties on ginger growth and rhizome fly incidence

The effect of rhizome size on growth and rhizome fly incidence in two varieties of ginger is presented in Table 1. All the growth parameters including plant height, tiller number and rhizome fly incidence were influenced by the size of seed rhizome. Interaction of seed rhizome size and variety on ginger yield attributes reveals significant effects between seed rhizome size and ginger variety (KK-1 vs KK-2) across multiple yield-attributing parameters. The KK-1 variety showed optimal plant height (92.1 cm in 2019) with 80 g seed rhizomes, but performance was inconsistent across years. The KK-2 variety demonstrated more consistent performance, with progressive height increases from 20 g to 80 g seed rhizomes (72.9 cm to 84.3 cm in 2019; 68.9 cm to 78.9 cm in 2020). Both varieties showed positive relation between seed rhizome size and tiller number: KK-1 tiller count increased from 5.6 to 8.3 per clump (2019) with larger seed rhizomes. KK-2 superior tillering response, reaching 9.5 tillers per clump with 80 g seed rhizomes, indicating better multiplication potential and minimal rhizome fly infestation.

The interaction effects showed variety-specific responses: KK-2 variety with larger seed rhizomes (60-80 g) consistently showed better resistance (1.0 scale in 1-5 scoring scale) and lower pest populations (1.47-3.33 maggots/rhizome and 1.27-5.03 pupae/rhizome). The KK-1 variety maintained higher pest susceptibility regardless of seed size, with larvae counts remaining elevated even with larger seed rhizomes. The interaction suggests that KK-2 variety with 80g seed rhizomes provides the optimal combination for yield-related traits, offering superior tillering capacity, consistent plant development, and enhanced pest resistance compared to KK-1 variety across all seed rhizome sizes tested under mid-hill conditions.

Table 1. Effect of seed rhizome size on growth and rhizome fly incidence in two varieties of ginger at GRP, Salyan during 2019 and 2020

Treatments	Plant height (cm)		Tiller number/ clump		Rhizome fly scoring (1-5 scoring scale)		Maggot number/ rhizome		Pupae number/ rhizome	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
20 gm seed rhizome of KK-1 ginger variety	68^{e}	68.1^{c}	5.6^{b}	6.8^{c}	3^{a}	2.667^{a}	9.6^{a}	7.77^{a}	8.4^{a}	6.5^{a}
40 gm seed rhizome of KK-1 ginger variety	70.9^{de}	68.6^{c}	6.3^{b}	8.3^{abc}	2^{a}	2.667^{a}	8.37^{a}	6.97^{ab}	7.07^{ab}	5.9^{ab}
60 gm seed rhizome of KK-1 ginger variety	89.3^{ab}	73.7^{abc}	8^{a}	8.9^{abc}	1.667^{abc}	1.667^{bc}	5.07^{bc}	5.77^{ab}	4.5^{c}	4.4^{abc}
80 gm seed rhizome of KK-1 ginger variety	92.1^{a}	67.7^{c}	8.3^{a}	9.3^{ab}	1.333^{bc}	1.333^{bc}	4.37^{c}	2.4^{cd}	3.93^{c}	2.4^{cd}
20 gm seed rhizome of KK-2 ginger variety	72.9^{de}	68.9^{c}	5.8^{b}	7.4^{bc}	1.667^{abc}	2^{ab}	7.37^{ab}	5^{bc}	5.47^{bc}	4.1^{bc}
40 gm seed rhizome of KK-2 ginger variety	74.4^{de}	71^{bc}	6.2^{b}	8.5^{abc}	2^{ab}	1.667^{bc}	7.07^{ab}	4.87^{bc}	5.1^{c}	4.07^{bc}
60 gm seed rhizome of KK-2 ginger variety	77.4^{cd}	76.5^{ab}	8.4^{a}	9^{abc}	1^{c}	1^{c}	3.33^{c}	1.57^{d}	5.03^{c}	2.4^{cd}
80 gm seed rhizome of KK-2 ginger variety	84.3^{bc}	78.9^{a}	9.5^{a}	10.7^{a}	1^{c}	1^{c}	3.27^{c}	1.47^{d}	4.33^{c}	1.27^{d}
Mean	78.7	71.7	7.3	8.6	1.708	1.75	6.05	4.47	5.48	3.88
CV (%)	5.4	5.3	11.6	14.6	20.7	26.1	22.6	32.5	19.5	32.7
F-test	**	*	**	*	**	**	**	**	**	**
LSD (0.05)	7.29	6.55	1.46	2.18	0.612	0.79	2.364	2.52	1.847	2.193

Note: KK-1= Kapurkot Aduwa–1, KK-2= Kapurkot Aduwa – 2, *=Significant, **=highly significant

Effect of seed rhizome size and varieties on yield

Effect of ginger varieties and seed rhizome size on different categories of ginger rhizome yield is presented in Table 2. The results reveal that seed rhizome size and varietal variation significantly influenced total ginger yield, as well as rhizome health components such as fly infestation, rotting, and marketable fresh weight. The larger seed rhizomes (80g) consistently produced the highest fresh yields for both varieties, with around 32+ t/ha in 2019 and 25-28 t/ha in 2020, while KK-2 variety slightly outperformed KK-1, particularly with larger seed sizes. Smaller seed rhizomes (20g) showed higher rates of fly infestation and rot, suggesting greater vulnerability to stress. The infected rhizome yield was lowest (0.19 and 0.51 t/ha) and the fresh rhizome yield was highest (32.43 and 28.67 t/ha) in KK-2 variety with larger seed rhizomes (80g), while the infected rhizome yield was highest (2.36 and 2.63 t/ha) and fresh rhizome yield was lowest (21.03 and 18.82 t/ha) in KK-1 variety with smaller seed rhizomes (20 g) respectively in the year 2019 and 2020. Higher fresh yields in 2019 than 2020 was possibly due to environmental conditions. The absolute yields varied between 2019 and 2020 (Table 2), likely influenced by differences in cumulative rainfall (1721.3 mm in 2019 and 2299.0 mm in 2020) and temperature profiles (temperature of the growing period ranges from 7.6 ^{0}C in March to 27.8^{0}C in June during 2019 and 9.9 ^{0}C in March to 23.8 ^{0}C in October during 2020).

Usually vigorously growing plant from large seed rhizome produce healthy rhizome while, poorly grown plants from small seed rhizome produce small weak rhizomes that are weak and more prone to infestation.

The study conclusively demonstrates that seed rhizome size significantly impacts ginger yield and quality. Larger seed rhizomes (80g) of both KK-1 and KK-2 varieties produced the highest fresh rhizome yields while exhibiting greater resistance to pest infestation and rot. The KK-2 variety showed marginally superior performance, particularly with larger seed sizes. Based on these findings, farmers should prioritize using 80g seed rhizomes for optimal ginger production, with KK-2 variety being the preferred choice for maximizing both yield and quality.

The infected rhizomes by ginger rhizome fly and rotten rhizome was recorded significantly higher in the year 2020 in all the treatments. It could be due to high rainfall and humidity from June to August. The lower fresh rhizome yield in all treatment in 2020 could be due to higher rotten and ginger rhizome fly infected yield in second years. It has been reported that warm and humid weather with high soil moisture condition is ideal for ginger rhizome fly and *Pythium* fungus that causes soft rot. (Gautam & Mainali 2016) It has been noticed that the rain fall during June, July and August in 2020 was very high exceeding 400 mm per month. (GRP, 2020). It seems that uniformly distributed annual rain fall about 1600-1800 could be better than higher rainfall concentrating within a short period of time**.**

Table 2. Effect of seed rhizome size on different categories of rhizome yield in two varieties of ginger at GRP, Salyan during 2019 and 2020

Treatments	Rhizome Yield (t/ha)							
	Mother		Ginger rhizome fly infected		Rotten		Fresh	
	2019	2020	2019	2020	2019	2020	2019	2020
20 gm seed rhizome of KK-1 ginger variety	1.27^{f}	1.37^{e}	2.36^{a}	2.63^{a}	3.3^{a}	4.1^{a}	21.03^{c}	18.82^{d}
40 gm seed rhizome of KK-1 ginger variety	2.68^{de}	2.15^{cd}	1.35^{a}	2.22^{a}	2.8^{a}	3.4^{a}	22.64^{bc}	21.23^{cd}
60 gm seed rhizome of KK-1 ginger variety	4.66^{b}	4^{b}	0.75^{a}	1.3^{bc}	0.9^{ab}	1.8^{b}	29.47^{ab}	23.51^{bc}
80 gm seed rhizome of KK-1 ginger variety	5.95^{a}	4.97^{a}	0.34^{b}	1.3^{bc}	0.5^{b}	1.3^{b}	32.27^{a}	25.85^{ab}
20 gm seed rhizome of KK-2 ginger variety	1.97^{ef}	1.61^{de}	1.36^{a}	1.51^{b}	1.1^{a}	2^{b}	23.71^{bc}	21.26^{cd}
40 gm seed rhizome of KK-2 ginger variety	3.42^{cd}	2.75^{c}	1.22^{a}	1.23^{bc}	1^{a}	2^{b}	22.54^{bc}	21.26^{cd}
60 gm seed rhizome of KK-2 ginger variety	4.61^{b}	4.03^{b}	0.35^{b}	0.74^{cd}	0.7^{ab}	1.1^{b}	27.45^{abc}	24.81^{b}
80 gm seed rhizome of KK-2 ginger variety	6.55^{a}	4.93^{a}	0.19^{b}	0.51^{d}	0.4^{b}	0.9^{b}	32.43^{a}	28.67^{a}
Mean	3.89	3.23	0.99	1.43	1.3	2.1	26.44	23.17
CV (%)	18.3	11	20.6	23.1	21.4	34	13.9	7.8
F-test	**	**	**	**	**	**	**	**
LSD (0.05)	1.233	0.615	0.353	0.574	0.5	1.22	6.37	3.142

Note: KK-1= Kapurkot Aduwa – 1, KK-2= Kapurkot Aduwa – 2, *=significant, **=highly significant

Larger seed rhizomes (60-80 g) resulted in better resistance against rhizome fly in both varieties. This improved resistance pattern is consistent with findings by Raghaven & Nair (2019), who attributed enhanced pest resistance in larger seed rhizomes to improved plant vigor and secondary metabolite production. The KK-1 variety achieving the highest plant height performed the best. These findings align with previous research by Sharma et al. (2018), who reported that larger seed rhizomes typically produce taller plants due to increased nutrient reserves and vigor. The tiller number per clump consistently increased with larger seed rhizome sizes, producing the highest tiller counts, vigorous growth and higher yield. This improved resistance pattern is consistent with findings by Raghavan and Nair (2019), who attributed enhanced pest resistance in larger seed rhizomes to improved plant vigor and secondary metabolite production. The pest load data further supported this trend, where both larvae and pupae numbers per rhizome decreased substantially with increasing seed rhizome size, similar to observations made by Singh et al. (2021) in both KK-2 and KK-1 variety. The most striking finding was the positive relation between seed rhizome size and fresh rhizome yield across both varieties. The 80 g seed rhizomes consistently produced the highest fresh yields, due to greater nutrient reserves and more vigorous initial growth. It has been similarly demonstrated that rhizome weight directly correlates with the number of shoots per plant and subsequent yield potential in ginger cultivation (Patel et al. 2020: Patel & Kumar 2020).

Both KK-1 and KK-2 varieties showed similar yield patterns, however KK-2 exhibited slightly better performance in the larger seed rhizome categories. This varietal difference aligns with the work of Sharma & Thakur (2021), who noted that improved varieties like KK-2 exhibit better adaptability to local conditions and stress tolerance. The yield potentiality of KK-1 and KK-2 was reported 30.00 and 32.75 mt/ha, respectively (GRP, 2018) this finding also produced the significantly similar yield when using 60- 80 g rhizomes in both varieties.

An inverse relationship was observed between seed rhizome size and both ginger rhizomes fly infection and rhizome rot incidence. Smaller seed rhizomes showed higher infection rates. This finding corroborates the research by Kumar et al. (2017), who reported that plants from smaller seed rhizomes are more susceptible to pest attacks due to weaker plant vigor and reduced defensive compounds. The reduced disease incidence in larger seed rhizomes could be attributed to faster canopy establishment and better root development, creating less favorable conditions for pest colonization.

The ginger production requires a warm and humid climate with an optimal temperature range of 21–32°C, annual rainfall 1500-2000 mm and high relative humidity typically above 60%. 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 the similar environmental condition during rhizome growing period for satisfactory rhizome yield and rhizome fly management.

The superior vigor of plants from larger rhizomes potentially enhanced their resilience to the environmental fluctuations, allowing for faster canopy establishment and better root development (Nair & Abraham, 2019). Additionally, the higher initial vigor from larger rhizomes may enhance the plant's natural resistance mechanisms against pathogens (Verma et al., 2018) which may be associated with rhizome fly. The use of small seed rhizomes causes poor plant growth and weakens plant vigor and may be infected by the pests. So, the use of large seed rhizomes free from infection of pests could be the best alternative options to control the rhizome fly infections. Additionally, it has been noticed that heavy rainfall during June, July and August favors the infestation of rhizome fly and rot. Proper drainage management is essential to prevent water logging conditions and excess soil moisture. The use of chemical pesticides to control ginger rhizomes increases the cost of production, environmental pollution and health hazard to the users as well the products are not salable in the international markets. Pesticide residue free ginger rhizome production is possible by selecting suitable variety and planting appropriate size of seed rhizome and the product can be exported to the foreign market.

CONCLUSION

The study revealed that seed rhizome size significantly influenced ginger rhizome fly infestation in two varieties of ginger. In both the varieties bigger the size of rhizome lesser was the fly infestation. Seed rhizome size between 60-80 gm produced healthy, vigorous plants with more numbers of tillers, less infected by ginger rhizome fly and produced more yield. Among two varieties Kapurkot Aduwa-2 was found superior compared to Kapurkot Aduwa-1 for yield and rhizome fly resistance because of its vigorous growth. Heavy rainfall during June, July and August favors the infestation of rhizome fly. Proper drainage should be ensured to avoid high soil moisture conditions during the rainy season. From the environmental point of view, these findings are very important for the production of chemical pesticide free ginger rhizomes and to promote ginger export.

ACKNOWLEDGEMENTS

The author gives thanks to Ginger Research Program (GRP), Kapurkot Salyan for providing necessary facilities for conducting this experiment. The author is grateful to Prof. Dr. Durga Mani Gautam and Mr. Shyam Prasad Poudel for helping in preparing this manuscript.

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