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EFFECT OF ORGANIC AMENDMENTS ON POSTHARVEST QUALITY AND SHELF LIFE OF GINGER (*ZINGIBER OFFICINALE* ROSC.)

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ABSTRACT

A field study was conducted during two consecutive years 2020-2022 at Horticultural Research Station (HRS), Mondouri, BCKV, Nadia, West Bengal to study the effect of organic amendments on quality and storage of ginger. The variety Gorubathan was selected for this study. The aim was to evaluate the response of organic amendments like neem cake and FYM on ginger quality and storage. The experiment was laid out in randomized block design. T1 (15 t ha^{-1} FYM+1 t ha^{-1} neem cake) T2 (15 t ha^{-1} FYM+ 2 t ha^{-1} neem cake) T3 (15 t ha^{-1} FYM+ 3 t ha^{-1} neem cake), T4 (23 t ha^{-1} FYM) and Control (15 t ha^{-1} FYM) are the treatment details.

Plots treated with 15 t ha^{-1} FYM+ 3 t ha^{-1} neem cake (T3) produced the highest oleoresin content among the other treatment combinations, with values of 5.67%, 5.92%, and 6.54%, at 210, 240, and 270 DAP respectively. In the Control treatment (FYM@15t ha^{-1}), the highest weight loss was recorded at 5, 10, and 15 days after storage, with percentages of 12.44%, 31.09%, and 44.80%. The treatment T3 showed the highest essential oil content of 0.35%, 0.32%, and 0.28% at 5, 10, and 15 days after storage. As the duration of storage days increased, the essential oil content gradually decreased.

Considering all the parameters it may be concluded the most effective organic treatment combination is FYM@15t ha^{-1}+neem cake@ 3tha^{-1} (T3) for obtaining maximum profit from ginger and may be recommended.
***Keywords*:** Essential oil, oleoresin, Farm Yard Manure (FYM), ginger, neem cake.

Introduction

Ginger is a perennial herb characterized by its tuberous or rhizomatous roots and is part of the Zingiberaceae family. This plant is extensively grown across India, Bangladesh, Taiwan, Jamaica, and Nigeria. It thrives in warm climates (Schauenberg and Paris, 1977). Known for its widespread use, particularly in Asia, ginger is rich in bioactive compounds and offers health benefits. It ranks among India's top five spices, playing a crucial role in the economy. Cultivated for its fragrant rhizomes, ginger has been primarily utilized as both a spice and a medicinal herb for over 2000 years (Bartley and Jacobs, 2000). Besides being a key ingredient in many world cuisines and food processing industry, ginger possesses anti-carcinogenic, antioxidant and anti-inflammatory properties (An *et al.* (2016); Shukla and Singh (2007); Stoilova *et al.* (2007)).

The characteristic flavour and pungency of ginger are attributed to its essential oil and oleoresin contents Huang *et al.* (2012).

Various forms of ginger are available commercially, including green ginger, dry ginger, ginger powder, ginger oil, ginger oleoresin, and preserved ginger. It is also widely incorporated into recipes like gingerbread, cookies, crackers, cakes, ginger ale, and ginger beer (Asumugha *et al.*, 2006; Jakes, 2007). To boost crop production, developing suitable production technology is essential, as relying solely on a variety's yield potential is inadequate (Yadav *et al.*, 2014). Utilizing different organic sources such as farmyard manure, vermicompost, and neem cake leads to high-quality and high-yield turmeric rhizomes (Sarma *et al*., 2015).

Organic manures have been utilized throughout history due to their capacity to rejuvenate soil fertility and provide essential nutrients like N, P, K, Ca, and Mg, while also stabilizing soil pH (Sanchez and Miller, 1986). The enhancement of soil chemical properties, which are crucial for crop growth and yield, has also been linked to the use of organic manures (Adetunji, 1990). However, organic manures come with certain drawbacks, such as limited availability, challenges in transportation and handling, slow nutrient release, a high C: N ratio, and occasionally, heavy metal contamination (Ayeni *et al*., 2010). As the focus gradually shifts towards organic farming to sustain soil productivity and reduce reliance on synthetic fertilizers, which have contributed to climate change, these issues become increasingly relevant.

Ginger thrives with the application of manure, yielding high returns per unit area, but it depletes a significant amount of nutrients, leading to reduced soil fertility. Due to the rising costs of fertilizers, their limited availability, and the growing concern over residual effects, it has become crucial to lessen reliance on chemical fertilizers. Biofertilizers have emerged as cost-effective agricultural inputs that offer substantial returns when conditions are favorable (Rana and Korla, 2010).

Materials and Methods

Fieldwork was conducted at HRS, Mondouri, BCKV, Nadia, WB, from early March to early December over two consecutive years (2020–2022). Laboratory works were carried out according to the schedule in the Departmental lab of Plantation, Spices, Medicinal and Aromatic Crops, within the faculty of Horticulture, BCKV. The soil in the experimental plot was characterized by a pH of 6.5, a well-drained clay loam texture, good water retention capacity, and moderate fertility.

Repeated ploughing was done to a depth of 30 cm to make the soil friable and pulverized for making raised beds of 15 cm. properly sprouted well-developed healthy and disease-free ginger rhizomes were selected as planting material. The seed rhizomes were soaked in Trichoderma solution (@4g l^{-1}) as a seed treatment for six hours. Then, during the first fortnight of March (2020 and 2021), treated seed rhizomes were planted in the raised beds at a depth of 3–4 cm with a spacing of 25 x 20 cm. After planting, the soil was immediately drenched with a solution of Trichoderma viride @4g $l\text{-}^{1}$. Since ginger is primarily susceptible to rhizome rot disease, regular soil drenching was carried out until harvest at monthly intervals to check soil-borne pathogen attack.

There were altogether five treatment combinations in randomized block design with six replications namely T_1 (FYM@15 t ha^{-1} + neem cake@1t ha^{-1}), T_2 (FYM @15 t ha^{-1}+ neem cake@2 t ha^{-1}), T_3 (FYM@15 t ha^{-1} + neem cake@3 t ha^{-1}), T_4 (FYM@23 (15+8) t ha^{-1}) and control T_5 (FYM@15tha^{-1}). Generally, FYM @ 15 t ha^{-1} was applied in three splits to all plots: half as a basal dose at the end of the land preparation, and the remaining half in two equal splits at 30 and 60 DAP. Neem cake @ 1, 2, and 3 t ha^{-1} was applied in two split doses at intervals of 30 and 60 days in accordance with the treatment. Additionally, two halves of FYM @ 8 t ha^{-1} were added as T4 and thoroughly mixed into the soil. In order to promote uniform rhizome germination and control weed growth, the crop was mulched with paddy straw as soon as it was sown.

After applying the first split dosage of manure, earthing up was done to cover up the exposed young rhizomes. At 45 and 90 DAP, green manuring dhaincha plants were later used to mulch each bed. Three to five days after planting, the crop received its first irrigation. Additional irrigation was provided in accordance with the crop's requirements based on rainfall and soil moisture levels.

Hand weeding was done twice at the initial stage after sowing at an interval of 30days. Destructive sampling of the crop was started from the 7^{th} month of planting *i.e.,* from the first fortnight of October in each year at monthly intervals to check the oleoresin content at different stages of maturity. Matured rhizomes were harvested during first fortnight of December, cleaned after removing the adhering soil, roots and other foreign matters then dried in partial shade and kept in the laboratory conditions for postharvest studies.

Oleoresin in ginger was extracted in a Soxhlet's apparatus by using solvent acetone (Anon., 1984). Ginger rhizomes harvested at 210 days stage was dried in a hot air oven at 50°C and powdered finely in a mixer grinder. 2-5 g. of ginger powder was weighed and packed in filter paper and placed in Soxhlet's apparatus. 200ml of acetone was taken in the round bottom flask of the apparatus and heated in a mantle. The temperature was maintained at the boiling point of the solvent (around 50°C). After complete extraction (4-5 hours) the solvent was evaporated to dryness. The quantity of oleoresin on dry weight basis was calculated using the formula –

$$\text{Oleoresin (\%)} = \frac{\text{Weight of Oleoresin}}{\text{Weight of Sample}} \times 100$$

After harvesting ginger rhizomes were kept under shade in the laboratory and the weight loss g^{-1} during storage was taken in every 5 days interval to record the storage capability of rhizomes along with oil content and weight loss.

Clevenger apparatus has been used to determine the percentage of essential oils present in the ginger. 50g of peeled and finely sliced material was taken in a sample flask and water is added. Generally, the ratio of the material to water is 1:3. The flask with the Clevenger apparatus is connected and the tap was opened for running the flow of water in a condenser. Heating was done on a controlled heating mantle. Oil with water vapors comes into the graduated distillate receiving tube and excess water goes back into the flask. Continue heating was done for two and half hours, then the assembly was cooled and water is removed from the distillate receiving tube, oil is taken into the evaporator for removing the traces of water and the flask is cooled in a desiccator after that the content of the oil is recorded.

At every 5 days interval, oil extraction was done from ginger rhizomes which were kept in storage. For each treatment 50g of ginger was taken for extracting essential oil. Ginger rhizomes were peeled, cut into small slices and crushed. The steam distillation method for essential oil extraction is done through the Clevenger apparatus.

The sample was taken in a round bottom flask along with distilled water which was boiled at 60-70^{o}C for about 2-3 hours by a heating mantle. After that, the extracted oil was collected, measured and recorded by the following formula –

$$\text{Essential Oil (\%)} = \frac{\text{Weight of oil}}{\text{Weight of sample}} \times 100$$

The data collected were subjected to statistical analysis of variance following Panse and Sukhatme (1967). Fisher and Snedecor's 'F' test at probability level of 0.05 was used to verify the significance of different sources of variation. For the determination of critical difference (C.D.) at 5% level of significance, Fisher and Yates (1979) tables were consulted.

Results and Discussions

Quality Parameters:

Oleoresin content

It was evident that the oleoresin content varied significantly among the treatments at different stages of harvesting (210, 240 and 270 DAP). An increasing trend in oleoresin content was observed with the maturity of the plants irrespective of any treatment and it was found maximum at 270 DAP. Highest oleoresin content of 6.54 % was recorded in T3 (15t ha^{-1} FYM+ 3 t h^{-1}neem cake) at 270 DAP, followed by T_2 (6.08%) whereas, lowest oleoresin content of 4.97 % was recorded at 270 DAP, in control plots (15t ha^{-1} FYM) indicates a clear picture that neem cake in combination with FYM@ 15t of /ha can yield highest % of Oleoresin at proper stage of maturity (270DAP) and for obtaining maximum oleoresin from ginger rhizomes harvesting should be done at proper stage of maturity.

Physiological loss in weight during storage:

The fresh rhizome weight, was recorded maximum in T_3 (FYM@ 15t ha^{-1} + neem cake@ 3 t ha^{-1}) at harvest followed by T_2 (FYM@ 15t ha^{-1} + neem cake@ 2 t ha^{-1}). Physiological weight loss during storage of ginger was comparatively higher in control plots than in other treatments. The trends of the results showed that the application of FYM along with a higher quantity of neem cake has influenced the quality of rhizomes during storage also. The highest percentage of weight loss was recorded in T5 at all the stages of storage *i.e.* at 5, 10 and 15 days as 12.44%, 31.09% and 44.80% respectively, while the lowest weight loss was recorded under T3 in all stages.

Oil content

The effect of organic amendments on essential oil content is clearly indicated significant differences in essential oil content (%) also due to the effect of organic amendments. Here a common relation was observed in essential oil content and days of storage. It was observed that irrespective of any treatment during storage up to 5 days this essential oil % has been increased and after that a gradual decreasing trend was observed here. At 5 days of storage highest essential oil content of 0.35% was recorded in the treatment T3 which gradually decreased @0.32% and 0.28% at 10 and 15 days of storage followed by treatmentT_2 (0.33%,0.30% and 0.25%) respectively. The least was recorded in control (0.21, 0.18% and 0.15%) at 5,10 and 15 days interval during storage, respectively. This observation clearly indicates that to get maximum oil % from the stored rhizomes extraction should be done within 5 days of storage otherwise oil % will be reduced gradually.

Discussion

From the present study, it was observed that organic amendments had a consistent effect on all the quality and storage of ginger. Sadanandan and Iyer (1986) observed a reduction in rhizome rot and an increase in the yield of ginger when neem cake was applied @ 2 t ha^{-1}. It also added organic carbon and potash to the soil. The highest essential oil content 0.30% was recorded in T3 at harvest whereas, it was recorded @0.35%, 0.32% and 0.28% at 5, 10 and 15 days after storage. The content of oleoresin in ginger was influenced significantly by the different treatments and also it is affected by the time of harvesting. The current study indicated that most of the quality parameters except moisture content were significantly affected by the harvesting stage which is very supportive to the reports of many reviewers (Girma and Digafie, 2008; Purseglove 1981). Namboothiry (2001) reported that there was an increase in curcumin and oleoresin content in turmeric under organic manure application. Sejali *et al*. (2011) and Mahmoodi *et al.* (2014) reported that the drying of plant material caused either an increase or a decrease in the essential oil yield. In the experiments, the essential oil yield was increased with increasing drying time from 1-2 days, however, the yield decreased with further increasing drying time to 4 days.

This suggests that a longer drying time will not be appropriate for efficient extraction of ginger essential oil, since a part of volatile compounds in essential oil will disappear from the material during the drying process. During the drying of raw material, heat sensitive active ingredients in the plant materials will be lost. Thus, proper control of the drying process is important in minimizing the loss of volatile compounds of the plant parts.

Conclusion

Considering the above-mentioned data, it was found that FYM @ 15 t ha^{-1}+neem cake @ 3 t ha^{-1} improved the oleoresin and essential oil content and reduced the postharvest weight loss of ginger during storage whereas control showed the highest weight loss. Thus, T3 was the most effective treatment for enhancing both quality and storability of ginger.

Table 1: Influence of different organic amendments on oleoresin content, weight loss during storage and oil content of ginger:

Treatments	Oleoresin content (%)			Physiological loss in weight during Storage							Oil content (%)			
	Days after planting			Days							Days after harvest			
	210	240	270	Fresh wt. kg $3m^{-2}$	5 (kg)	5 (%)	10 (kg)	10 (%)	15 (kg)	15 (%)	0	5	10	15
T1	5.09	5.25	5.51	3.36	3.08	8.29	2.65	13.96	2.19	35.09	0.25	0.30	0.25	0.20
T2	5.30	5.63	6.08	4.03	3.78	6.20	3.34	17.12	2.91	27.79	0.28	0.33	0.30	0.25
T3	5.67	5.92	6.54	4.53	4.22	7.13	3.98	12.43	3.46	23.90	0.30	0.35	0.32	0.28
T4	4.94	5.20	5.38	3.28	2.94	10.32	2.46	24.96	1.92	41.43	0.22	0.27	0.20	0.15
T5	4.27	4.61	4.97	2.62	2.30	12.44	1.81	31.09	1.45	44.80	0.15	0.21	0.18	0.15
S.Em(±)	0.14	0.12	0.10	0.03	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.033	0.03	0.02
LSD(0.05)	0.41	0.34	0.30	0.08	0.04	0.04	0.06	0.06	0.05	0.05	0.09	0.09	0.10	0.07

T1-15t ha^{-1} FYM+ 1t ha^{-1} neem cake, T2- 15t ha^{-1} FYM + 2 t ha^{-1} neem cake, T3-15t ha^{-1} FYM + 3 t ha^{-1} neem cake, T4 - 23t ha^{-1} FYM, T5-15t ha^{-1} FYM.

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Appendices

Details of soil at the experiment site

The soil of the experiment at the field was Gangetic Alluvial sandy clay loam texture, well-drained, good water holding capacity with moderate soil fertility status.

Appendices 1 : Physico-chemical properties of the soil at the experiment site.

Properties	Particulars	Value	Methods used
Physical Properties	Sand	54.25%	International pipette (Piper, 1996)
	Silt	30.20%	
	Clay	14.30%	
	pH	5.74	pH meter, (Jackson, 1996)
	Organic carbon (%)	0.85	(Walkey and Black, 1967)
Chemical Properties	N (kg/ha) (A)	207	Modified Kjeldhal's (Jackson, 1973)
	P_2O_5(kg/ha) (A)	380.1	Modified Olsen (Jackson, 1973)
	K_2O (kg/ha) (A)	526.6	Flame photometer (Jackson, 1973)
	S (mg/ha) (A)	60.18	
	Zn (mg/ha) (A)	1.66	
	Ca (mg/ha) (A)	949.55	
	B (mg/ha) (A)	0.44	

Climatic condition

The climatic condition of the experimental site is sub-tropical sub humid. The details of metrological parameters during the experimental period of (March,2021- March, 2022) have been presented below.

Appendices 2 : Meteorological parameters during the cropping period of experimentation March 2021 to March 2022

Month	Temperature (^{0}C)		Total rainfall (mm)	Relative humidity (%)		Sun shine hours
	Max.	Min.		Max.	Min.	
Mar-21	35.98	20.78	0.00	86.54	33.14	6.92
Apr -21	37.01	24.63	0.86	84.23	41.16	8.26
May -21	34.24	24.73	11.37	89.57	66.04	6.61
Jun -21	32.67	25.85	11.94	93.53	77.69	3.77
Jul -21	32.60	26.28	8.18	94.48	79.42	3.63
Aug -21	32.88	26.39	7.36	94.93	77.35	3.94
Sep -21	31.76	25.61	8.51	93.90	77.68	4.34
Oct -21	31.29	23.32	5.66	93.24	69.40	6.03
Nov -21	28.40	17.61	20.7	90.06	57.03	6.67
Dec -21	24.48	14.11	14.0	91.79	62.6	4.92
Jan -22	23.65	12.39	25.8	92.26	60.38	5.15
Feb -22	26.70	13.10	0.98	90.76	49.95	7.44
Mar-22	34.30	20.98	0.00	90.54	45.29	8.21

(Source: AICRP, Agrometeorology, BCKV Mohanpur)