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Yield, quality and uptake of nutrients in ginger (*Zingiber officinale* Rosc) as influenced by size of seed rhizome and plant spacing

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ABSTRACT

A field experiment was conducted during 2017=-18 and 2018-19 at the Private Agricultural-cum-Research Farm, Kapsa, Benda-Semaria Road, Rewa (M.P.) to study the influence of size of seed-rhizome and plant spacings on chlorophyll content and nutrients uptake in ginger. The best size of seed rhizome for planting was 50 g which recorded maximum chlorophyll content in leaves and protein contents in rhizome. Thus, 50 g size producing maximum rhizome yield upto 22.27 t ha^{-1} has taken up maximum nutrients (59.7 kg N, 11.8 kg P and 80.1 kg K ha^{-1}) from the soil. Amongst the plant spacing, 30 x 30 cm recorded significantly higher chlorophyll content in leaves and protein contents in rhizome. However closer, 25 x 15 cm spacing producing maximum rhizome yield (22.48 t ha^{-1}) utilized the maximum nutrients (55.5 kg N, 9.4 kg P and 71.1 kg K ha^{-1}) from the soil. The best treatment combination (50 g size with 25 x 15 cm spacing) further encouraged the uptake of these nutrients by ginger rhizomes.

Keywords: Seed-rhizome, plant spacing, chlorophyll content, ginger

INTRODUCTION

Ginger [*Zingiber officinale Rosc.*] is an important commercial tropical underground spice crop used as spice and medicine. Its wide range of utilization in cultural foods drinks and medicinal use makes the crop more valuable. The yield of ginger is low due to many production constraints such as less attention for optimum plant spacings (both ways) and using improper sett size. It is propogated vegetatively from rhizome and the length and weight of pieces used varies from place to place and variety to variety. The ginger yield is influenced by the light intensity, photosynthetic pigments in leaf, chlorophyll content, space available between the plants for nutrients and moisture availability (Tiwari *et al.* 2019). All these factors are governed by the spacial arrangement. These are the inter-connected mechanisms ultimately affecting the withdrawal of nutrients from the soil. The crop removal of nutrients from the soil should be replenished for use by the succeeding crop. As a result of the increasing consumption of ginger in medicines and in food ingredients, it was considered important to assess some of the factors that could boost its production in the Rewa region of Madhya Pradesh. Looking to all these facts, the present research was taken up using ginger as test crop.

MATERIALS AND METHODS

The field experiment was conducted during 2017-18 and 2018-19 at the Private Agricultural-cum-Research Farm, Kapsa, Benda-Semaria Road, Rewa (M.P.). The field soil was silty clay-loam having pH 7.5, electrical conductivity 0.32 dSm^{-1}, organic carbon 8.8 g kg^{-1}, available 238 kg ha^{-1}, available P_2O_5 13.8-14.3 kg ha^{-1} and available K_2O 381 kg ha^{-1}. The rainfall received from June to January was 759.8 and 853.2 mm in 2017-18 and 2018-19, respectively. The experiment was laid out in a randomized block design with factorial concept having treatments four seed rhizome sizes of ginger (20, 30, 40 and 50 g) and five plant spacings (25 x 15, 25 x 25, 30 x 20, 30 x 30 and 40 cm x 20 cm). Thus, twenty treatment combinations were replicated thrice. The land was prepared and brought to fine tilth by ploughing and harrowing for planting of ginger rhizome pieces. These were planted in a raised bed of 1.25 m length, 1.25 m width and 10-12 cm height as per the treatments. A common dose of FYM @ 20 t ha^{-1} along with 75 kg N + 50 kg P_2O_5 + 50 kg K_2O ha^{-1} was applied to all the treatments. The improved high-yielding indigenous variety of ginger cultivar was used. Planting of pre-sprouted seed rhizomes as per the seed rhizome size treatment was done during 1st week of June and harvesting was done during the last week of January. The chlorophyll

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content in leaves was estimated by the acetone extraction method (Witham., 1971). The nutrient contents and their uptake by rhizomes were determined by the Standard procedures.

RESULTS AND DISCUSSION

Yield

The 50 g size of rhizome brought about significantly higher rhizon yield (22.27 t ha^{-1}) followed by 40 g (20.48 t ha^{-1}) and least in 20 g size (13.52 t ha$_{-1}$). The higher yield under large size may be due to increased yield attributes (Datta *et al.* 2017). The closest spacing (25 x 15 cm) produced significantly higher rhizo yield (22.48 t ha^{-1}) and least in under spacing (40 x 20 cm). The highest number of plants under close spacing brought about the maximum ginger yield. Similar results were reported by Mahender *et al.* (2014) and Dutta *et al.* (2017).

Chlorophyll contents in leaves

The data (Table 1) reveal that the best size of seed rhizome was 50 g which recorded maximum chlorophyll content in ginger leaves (1.92, 2.84 and 3.01 mg g^{-1} leaf weight at 50, 100 and 150 days stage, respectively). On the other hand, smallest (20 g) seed size registered significantly lowest chlorophyll content in leaves (1.83, 2.53 and 2.66 mg g^{-1} leaf weight at the respective stages). The enhanced chlorophyll content in leaves due to bigger sized rhizomes planting might be due to the fact that the plants showed vigorous and rapid growth using the increased reserve food material which by one way or another influenced the photosynthetic activity in a positive manner. In fact, the chlorophyll serves as an indicator of photosynthetic activity, growth, development, production as well as biochemical aspects of plant species thus providing valuable information about the physiological status of plants.

Table 1: Total leaf chlorophyll and protein contents in ginger rhizomes as influenced by size of seed-rhizome and plant spacings (Mean of two 2 years)

Treatments	Total chlorophyll content (mg /g leaf weight)			Protein (%)
	50	100	105 DAP	
Size of seed-rhizome (g)				
20	1.83	2.53	2.66	1.51
30	1.84	2.60	2.75	1.55
40	1.89	2.72	2.87	1.65
50	1.92	2.84	3.01	1.70
CD (P=0.05)	0.008	0.008	0.009	0.02
Plant spacings (cm)				
25 x 15	1.70	2.34	2.43	1.53
25 x 25	1.85	2.47	2.70	1.60
30 x 20	1.89	2.81	2.92	1.59
30 x 30	1.96	2.92	3.07	1.66
40 x 20	1.94	2.88	2.99	1.63
CD (P=0.05)	0.009	0.010	0.010	0.02

The widest plant spacing (30 x 30 cm) encouraged the chlorophyll formation in leaves upto the maximum extent. (1.96, 2.92 and 3.07 mg g^{-1} leaf weight at 50, 100 and 150 days stages, respectively). Whereas the closest plant spacing (25 x 15 cm) brought about the decreased chlorophyll formation in leaves (1.70,2.34 and 2.43 mg g^{-1} leaf weight at 50, 100 and 150 days stages, respectively). The beneficial effect of wider spacing between plants might be due to better availability of plant nutrients, moisture and particularly light. In this connection, Sheikh *et al.* (2017) reported that the amount of chlorophyll varies with change in season as growing conditions like temperature, precipitation and sunlight also change. It has been observed that maximum amount of chlorophyll is recorded in summer season followed by spring season and least amount is registered in autumn season because of low temperature and short-day conditions in this season. The water and CO_2 in the presence of sunlight give rise to the chlorophyll formation in leaves.

Protein

The increase in the seed size of planting upto 50 g increased the protein content in rhizome significantly (1.7%), whereas the significantly lowest protein content (1.5%) was obtained from the smallest 20 g seed size. The higher protein content in ginger due to planting of bigger sized rhizomes may be due to the fact that the reproductive parts of ginger acted as a sink for photosynthates and larger seed size diverted comparatively more NPK nutrients from the vegetative parts towards the reproductive organs (sink). These results agree with those of Mahender *et al.* (2015). The widest plant spacing (30 x 30 cm) brought about significantly higher protein content in rhizome (1.66%) as compared to the remaining plant spacing. However, the second best spacing was 40 x 20 cm where the protein content was 1.63%. The plant spacing 25 x 25 and 30 x 20 cm resulted in equal protein content. The significantly lowest protein content (1.53%) was noted under the closest plant spacing (25 x 15 cm). The overall improvement in protein concentration and crop growth under the influence of widest spacing between plants could be due to more absorption and translocation of plant nutrients and thereby stimulation of root-shoot growth, increased metabolic activities and chlorophyll content in leaves. These results agree with those of Mohamed*et al.* (2014).

Table 2: Effect of size of seed rhizome and plant spacing on yield and uptake of nutrients in ginger rhizome (Mean of two 2 years)

Treatments	Nutrients uptake (kg ha^{-1})			Rhizome yield (t ha^{-1})
	N	N	N	
Size of seed-rhizome (g)				
20	32.79	5.78	43.90	13.52
30	38.04	7.17	51.81	15.36
40	53.57	10.11	71.01	20.48
50	59.79	11.84	80.13	22.27
CD (P=0.05)	0.50	0.66	0.35	0.20
Plant spacings (cm)				
25 x 15	55.50	9.41	71.10	22.48
25 x 25	45.70	8.01	58.84	17.70
30 x 20	48.90	9.14	65.26	18.95
30 x 30	40.08	8.51	55.35	14.85
40 x 20	40.07	8.54	58.00	15.56
CD (P=0.05)	0.56	0.73	0.39	0.22

Uptake of nutrients

The ginger rhizome planted with biggest 50 g seed size resulted in significantly higher N-uptake (59.7 kg ha^{-1}), followed by 40 g size (53.5 kg ha^{-1}), 30 g size (38.0 kg ha^{-1}) and then 20 g seed size (32.7 kg ha^{-1}). The highest P-uptake (11.8 kg ha^{-1}) and K- (uptake 80.1 kg ha^{-1}) was recorded under the largest seed size. The higher uptake of N, P and K nutrients by ginger rhizomes under the planting of largest seeds of rhizomes may be ascribed to increased ginger yield and N, P and K contents in ginger (Woelore *et al.* 2016).The narrowest plant spacing (25 x 15 cm) recorded significantly higher N-uptake (55.5 kg ha^{-1}). This was followed by 30 x 20 cm spacing (48.9 kg ha^{-1}) and then 25 x 25 cm (45.7 kg ha^{-1}). The wider spacing (30 x 30 cm and 40 x 20 cm) recorded the almost equal amounts of N-uptake (40.7 to 4.08 kg ha^{-1}). The P and K uptake was also found significantly highest (9.4 and 71.1 kg ha^{-1}, respectively) under the closest spacing. However, the second best spacing was 30 x 20 cm giving 65.2 kg ha^{-1} uptake value. The increased uptake of N, P and K due to closer plant spacing was as a result of similar increases in N, P and K contents in the ginger as well as increased ginger yield. The positive influence of wider spacings on plant growth, yield attributes and yield as well as nutrients uptake was eventual as a result of higher plant densities and increased number and size of leaves per plant or photosynthetic surface area. This means increased photosynthates and their effective translocation towards the developing reproductive organs. Thus, the closer spacing 25 x 15 cm and 30 x 20 cm brought about enhanced NPK uptake upto the maximum extent. These results are in conformity with those of Mohamed *et al.* (2014).

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