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Studies on Effect of Different Levels of Fertigation on Growth and Yield of Ginger Cultivars in Eastern Dry Zone of Karnataka

S. N. Manjunatha, Kavita Kandpal, C. T. Ramachandra, A. Vidya, B. N. Maruthi Prasad and K. Tamil Vendan

Department of Horticulture, College of Agriculture, UAS, GKVK, Bengaluru - 560 065

e-Mail : manjusn.sira@gmail.com

Authors Contribution

S. N. Manjunatha : Conducted the research, data collection, data analysis; Kavita Kandpal, C. T. Ramachandra, A. Vidya, B. N. Maruthi Prasad & K. Tamil Vendan : Guidance, review, supervision & correction.

Corresponding Author :
S. N. Manjunatha
Department of Horticulture, College of Agriculture, UAS, GKVK, Bengaluru

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Abstract

Field experiment was carried out at the Department of Horticulture, UAS, Bangalore, in well-drained red sandy loam soils of the experimental block with a pH of 6.2. The soil was low in organic carbon and available nitrogen, whereas available phosphorus and potassium were in medium range. The experiment consisted of two ginger cultivars (Rio-de-Janeiro and Himachal) and 11 fertigation levels which were replicated thrice in the RCBD. Among the eleven fertigation treatments tried on two ginger cultivars, significant variation was observed for growth and yield parameters. Maximum plant height at 30, 60, 90, 120, 150, 180 and 210 DAS was recorded with 200 per cent RDF (200:100:100 N: P_2O_5: K_2O kg /ha) through fertigation + FYM 30t/ha, Neem cake 2t/ha in both the varieties. Maximum leaf area (1387.52 cm^2 and 2708.02 cm^2) and leaf area index (1.85 and 3.61) at harvest were also recorded in the same treatment for Rio-de- Janeiro and Himachal, respectively. Highest number of primary fingers, secondary fingers per clump, maximum fresh weight and length of mother rhizome, dry matter production at harvest were recorded with the application of 200 per cent RDF + neem cake @ 2 t ha^{-1} which was on par with the 150 per cent RDF along with 30 tons of FYM and 2t of neem cake in both the varieties. Highest growth and yield parameters were recorded in the Himachal variety as compared to Rio-de-Janeiro with respect to the fertigation levels.

Keywords : Ginger, Fertigation, RDF, Neem cake, Bio fertilizers

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Ginger (*Zingiber officinale*) belonging to family Zingiberaceae is the major and widely used spice throughout the world. It occupies a prime position among the spice crops in India. India is a major producer and grower of ginger. It is grown in an area of 1.72 lakh ha accounting to an annual production of 18.43 lakh tonnes with an average productivity of 10.71 t/ha. In India it is grown to a larger extent in Madhya Pradesh (25,402 ha), Karnataka (21,683 ha) and Assam (19,351 ha) with a production of 410950 t, 278000 t and 183160 t, respectively (Anonyomous., 2019). Ginger is extensively prized for its aroma flavour, pungency and medicinal properties since ancient times. Among the major spices grown in the country, ginger occupied an important place, as it is the major GDP earner. Dry ginger, green ginger, oleoresin and essential oils of ginger are the other important value added products and export of these products is increasing year after year. The refreshing aroma and the pungent taste make ginger an essential in the best ingredient of food and several processed products.

Ginger is a long duration crop and needs a balanced and sustained supply of nutrients for higher fresh rhizome yield with a better quality, which can be supplied by both inorganic sources and organic sources. Imbalanced nutrient supply is one of the

major constraints for reduced yield coupled with poor quality. Ginger is a nutrient exhaustive crop and application of organic manures, fertilizers and bio fertilizers are absolutely essential. Ginger rhizomes are mainly N and K exhausting, intermediary in P and Mg removal and the least in Ca removal (Nagarajan and Pillai, 1979). Verma *et al*. (2019) reported an accumulation of macronutrients in the decreasing order *viz*., N, K, Ca, Mg, S and P similarly micronutruints in the order of Fe, Mn, Zn, B, Cu. However, nutrients uptake varies considerably with soil type, varieties or hybrids, climatic conditions, nutrient levels in the soils.

Fertigation is a method of fertilizer application in which fertilizers are supplied along with water by drip system. In this system fertilizer solution is distributed evenly in water and directly supplied to the active root zone through drippers which results in higher nutrient use efficiency. As water and fertilizers are supplied evenly to the ginger crop there is possibility of getting 25-50 per cent higher yield (TNAU Agritech portal, 2016). Fertilizer use efficiency through fertigation varied between 80-90 per cent, which helps to save on an average of 25 per cent of applied nutrients.

Till today farmers are practicing conventional method of nutrients applications in ginger cultivation getting average yield coupled with poor quality of rhizomes. This warrants the use of alternative nutrients application method. Nutrients application through fertigation offers a viable option as this enhances the Nutrient use efficiency in turn increased yield. This present study focus on the standardization of fertigation level for increasing the nutrient use efficiency increased yield of ginger cultivars.

Material and Methods

Field experiments were carried out to evaluate the performance of ginger cultivars and to study the effect of different fertigation levels on growth and yield of ginger cultivars by increasing the nutrient use efficiency in Southern dry zone of Karnataka during the *kharif* season of 2021 at the Department of Horticulture, GKVK, University of Agricultural Sciences, Bangalore.

The experiment was carried out on the red sandy loam soil in the Horticulture experimental block, Gandhi Krishi Vignana Kendra, University of Agricultural Sciences, Bangalore. It is situated in the Southern dry zone of Karnataka with the mean annual rainfall of 800-900mm which is fairly distributed from May to November. The soils of the experimental block are well drained red sandy loam, with a neutral pH of 6.4. The soil is low in organic carbon (0.35%), low in available nitrogen (201.14 kg ha^{-1}), medium in available phosphorus (34.0 kg ha^{-1}) and medium in available potassium (152 kg ha^{-1}).

The field experiment was laid out in a randomized complete block design with three replications. Eleven fertigation levels were tried on two ginger cultivars namely Rio-de-Janeiro and Himachal. Ginger cultivars were grown in the net plot size of 10.0 m × 1.0 m with a spacing of 45 cm between the rows and 30 cm between the plants. The treatment details are described below.

Treatment **Details**

T_1 RDF (100:50:50 N: P_2O_5: K_2O kg /ha normal fertilizers) + FYM 30 t/ha, Neem cake 2t/ha

T_2 200 % RDF (200:100:100 N: P_2O_5: K_2O kg /ha) Fertigation + FYM 30t/ha, Neem cake 2t/ha

T_3 150 % RDF (150:75:75 N: P_2O_5: K_2O kg/ha) Fertigation + FYM 30t/ha, Neem cake 2t/ha

T_4 100 % RDF (100:50:50 N: P_2O_5: K_2O kg/ha) Fertigation + FYM 30t/ha, Neem cake 2t/ha

T_5 75 % RDF (75:37.5:37.5 N: P_2O_5: K_2O kg/ha) Fertigation + FYM 30t/ha, Neem cake 2t/ha

T_6 50 % RDF (50:25:25 N: P_2O_5: K_2O kg/ha) NF soil application + 50% Fertigation (50:25:25 NPK kg/ha) WSP + FYM 30 t/ha, Neem cake 2t/ha

T_7 100 % RDF (100:50:50 N: P_2O_5: K_2O kg/ha NF) + Azotobacter + PSB + AMF + KMB + FYM 30t/ha, Neem cake 2t/ha

T_8 75 % RDF (75:37.5:37.5 N: P_2O_5: K_2O kg/ha WSF) + Azotobacter + PSB + AMF + KMB + FYM 30t/ha, Neem cake 2t/ha

T_9 50 % RDF (50:25:25 N: P_2O_5: K_2O kg/ha WSF) + Azotobacter + PSB +AMF + KMB + FYM 30 t/ha, Neem cake 2t/ha

T_{10} 50 % RDF (50:25:25 N: P_2O_5: K_2O kg/ha WSF) + Ginger Special 25 % Foliar spray at 60, 90, 120 DAP + Azotobacter + PSB + AMF + KMB + FYM 30 t/ha, Neem cake 2t/ha

T_{11} 100% RDF (100:50:50 N: P_2O_5: K_2O kg/ha WSF) + Azotobactor + PSB + AMF + KMB + FYM + Neem cake

The land was prepared and brought to a fine tilth by ploughing followed by harrowing. Ridges and furrows were formed after leveling the plots. The seed material was procured from ZARS, Chamarajnagara. Healthy and disease free, uniform sized fingers of cultivars with well-developed buds were selected for planting. The fingers were planted in the furrows by adopting a proper spacing between rows and plants. After the preparation of land and plots, farm yard manure was applied at 30 tonnes per hectare as a basal dose. The fertilizers in the form of urea (46% N), single super phosphate (16% P_2O_5) and muriate of potash (60% K_2O) were applied. Nitrogenous fertilizer was applied in two splits, phosphatic and potassic fertilizers were applied as a basal application. The fertilizers were applied in the rows and mixed in the soil. Each plot, the required quantity of fertilizers was calculated as per the treatments. Weed management and plant protection measures were taken whenever is required to get the optimum growth and yield.

The crop was harvested as per maturity standards as indicated by the drying up of the leaves, pseudostem and drooping of the plants. One day before digging of the rhizomes, light irrigation was provided. Rhizomes were removed by digging and were separated.

Observations on vegetative growth parameters were recorded from five randomly selected and marked plants from each treatment at 30, 60, 90, 120, 150, 180 and 210 days after planting (DAP). The leaf area (Y) was calculated by an equation y = 0.6995 lb-0.768. This is an accurate method for determining leaf area in ginger and expressed as leaf area per plant in cm^2. The dry weight (g) was recorded by drying the fresh plants parts at 70 ^oC till consistent weights were obtained. The average value was expressed as dry matter per plants in grams. Fresh rhizomes from each plot were weighed and recorded as kg per plot. The gross plot yield was computed and expressed as fresh yield in tonnes per hectare. The number of primary fingers arising from the mother rhizomes (plant material) in each of the labeled plants was counted and mean was worked out. Length of primary fingers was measured by using a non-stretchable string and expressed in centimeter. The number of secondary fingers arising from the primary fingers was counted in all the labeled plants and average was worked out. The length of secondary fingers was measured by using a non-stretchable string from the selected five fingers and expressed in centimeter.

The experimental data was subjected to standard analysis of FRCBD. The level of significance @ 5 per cent employed in F test and critical differences (CD) were calculated where ever F test was significant.

Results and Discussion

Plant Height (cm)

The data pertaining to effect of different fertigation levels on plant height recorded at different stages of crop growth (30, 60, 90, 120, 150, 180 and 210 days) for different cultivars during 2021 are presented in the Table 1.

Plant height differed significantly among the cultivars at all the stages of crop growth and also among the fertigation levels.

Application of 200 per cent RDF (200:100:100 kg N: P_2O_5 : K_2O/ha) through fertigation + FYM 30t/ha, Neem cake 2t/ha (T_2) to Himachal cultivar recorded highest plant height of 19.40, 19.92, 35.90, 39.12, 39.90 and 41.50 cm at 60, 90, 120, 150, 180 and 210 days after planting, respectively as compared to

TABLE 1

Effect of fertigation levels on plant height of different cultivars of ginger

Treatments/ Fertigation levels	Plant height (cm) of the ginger verities													
	Rio – de – Janeiro (Days after planting)							Himachal (Days after planting)						
	30 DAP	60 DAP	90 DAP	120 DAP	150 DAP	180 DAP	210 DAP	30 DAP	60 DAP	90 DAP	120 DAP	150 DAP	180 DAP	210 DAP
T_1	6.48	12.23	16.00	26.13	28.10	29.93	30.03	6.86	14.33	16.95	28.30	31.04	34.00	38.04
T_2	6.84	15.16	18.40	33.66	37.03	39.46	40.24	6.96	19.40	19.92	35.90	39.12	39.90	41.50
T_3	6.40	14.33	17.66	32.43	36.86	38.90	39.94	6.83	18.40	18.90	34.86	38.90	39.12	40.84
T_4	6.48	12.34	17.24	30.26	35.33	37.12	38.25	6.74	14.34	18.36	33.12	37.56	38.73	39.66
T_5	6.72	12.29	16.22	31.12	33.34	36.48	38.10	7.10	15.12	17.84	32.22	36.90	37.90	39.12
T_6	6.46	13.10	17.21	29.83	34.10	37.50	39.05	6.89	16.03	18.03	31.50	37.04	38.84	39.04
T_7	6.54	13.50	17.90	30.34	33.12	36.84	38.45	6.98	16.26	18.56	31.64	37.12	38.56	39.26
T_8	6.90	13.26	16.94	31.25	34.20	36.56	39.24	7.04	17.03	18.12	31.08	36.50	37.64	38.93
T_9	6.60	12.90	17.10	30.16	33.46	37.22	38.15	7.20	16.10	18.04	32.43	37.15	39.03	39.88
T_{10}	6.46	13.35	17.30	31.45	34.15	37.58	39.26	6.88	16.90	18.12	33.03	37.24	38.87	39.00
T_{11}	6.74	13.45	17.94	30.24	33.90	37.25	39.50	6.95	17.10	18.90	33.12	38.04	39.08	39.34
F test	*	*	*	*	*	*	*	*	*	*	*	*	*	*
SEm+	0.072	0.465	0.271	0.283	0.432	0.323	0.346	0.015	0.171	0.016	0.241	0.104	0.301	0.309
CD @ 5%	0.212	1.374	0.801	0.837	1.276	0.953	1.021	0.046	0.507	0.048	0.712	0.308	0.890	0.912

Rio-de-Janeiro cultivar (15.16, 18.40, 33.66, 37.03, 39.46 and 40.24 cm at 60, 90, 120, 150, 180 and 210 days after planting, respectively), which is on par with the application of 150 per cent RDF (150:75:75 N: P_2O_5: K_2O kg/ha) through fertigation + FYM 30t/ ha, Neem cake 2t/ha (T_3) with respect to the plant height of both the cultivars. Among the two cultivars tested, Himachal cultivar performed very well for the fertigation levels when compared to Rio-de-Janeiro cultivar. Among the fertigation levels tried on the cultivars, application of 200 per cent RDF (200 : 100 : 100 kg N : P_2O_5 : K_2O/ha) through fertigation + FYM 30t/ha, Neem cake 2t/ha (T_2) is performed well among the different fertigation levels tested in both the cultivars. The lowest plant height at 60, 90, 120, 150, 180 and 210 days after planting was recorded with the application of RDF (100:50:50 N: P_2O_5: K_2O kg /ha normal fertilizers) + FYM 30 t/ha, Neem cake 2t/ha (T_1) to the Himachal (12.23, 16.00, 26.13, 28.10, 29.93 and 30.03 cm, respectively) and Rio-de-Janeiro cultivar (14.33, 16.95, 28.30, 31.04, 34.00 and 38.04 cm, respectively). The results are in confirmation with the findings of Mathew and Sreekala (2019), who analyzed the nutrients effect on growth as well as yield in transplanted ginger (Soumya *et al.,* 2009).

Leaf Area Per Plant

It is evident from Table 2 that leaf area per plant differed significantly at 180 days after planting in both the cultivars with different fertigation levels.

Himachal cultivar recorded maximum leaf area (2708.02 cm^2) as compared to the Rio-de-Janeiro cultivar (1387.52 cm^2) with 200 per cent RDF (200:100:100 kg N: P_2O_5: K_2O /ha) Fertigation + FYM 30t/ha, Neem cake 2t/ha (T_2) among the different fertigation levels applied to cultivars and minimum leaf area was recorded in Rio-de-Janeiro (731.80 cm^2) as compared to Himachal cultivar (898.28 cm^2) with the application of RDF (100:50:50 N: P_2O_5: K_2O kg / ha normal fertilizers) + FYM 30 t/ha, Neem cake 2t/ha (T_1) among the different fertigation levels.

TABLE 2

Effect of fertigation levels on leaf area and leaf area index (LAI) of different cultivars of ginger at 180 days after planting

Treatments	Leaf Area Index (LAI)			
	Rio – de - Janeiro		Himachal	
	Leaf area (cm^2)	Leaf area Index	Leaf area (cm^2)	Leaf area Index
T_1	731.80	0.97	898.28	1.19
T_2	1387.52	1.85	2708.02	3.61
T_3	1277.00	1.70	2286.75	3.05
T_4	1266.48	1.69	1845.04	2.46
T_5	1215.81	1.62	1678.86	2.34
T_6	1015.36	1.35	1642.04	2.19
T_7	1164.28	1.53	1136.75	1.52
T_8	1212.46	1.62	1331.72	1.78
T_9	1185.93	1.58	1407.70	1.88
T_{10}	1256.34	1.64	1487.99	1.99
T_{11}	1290.25	1.75	1442.36	1.92
F test	*	*	*	*
SEM+	74.09	0.099	204.49	0.273
CD @ 5%	218.27	0.293	603.25	0.807

Leaf Area Index

The data pertaining to the leaf area index is presented in the Table 2. The leaf area index per plant for different cultivars differed significantly when observed at 180 DAP with the different fertigation levels.

During *kharif* 2021, Himachal cultivar recorded highest leaf area index (3.61) as compared to Rio-de-Janeiro cultivar (1.85) with 200 per cent RDF (200:100:100 kg N: P_2O_5: K_2O /ha) Fertigation + FYM 30t/ha, Neem cake 2t/ha (T_2) which was on par with 150 per cent RDF (150:75:75 N: P_2O_5: K_2O kg/ha) Fertigation + FYM 30t/ha, Neem cake 2t/ha (T_3) as compared to different fertigation levels. Lowest leaf area index was recorded with RDF (100:50:50 N: P_2O_5: K_2O kg /ha normal fertilizers) + FYM 30 t/ha, Neem cake 2t/ha (T_1) in both the ginger cultivars. Mathew and Sreekala (2019) analyzed the nutrients effect on growth as well as yield in transplanted ginger. The results of the study indicated that ginger transplants intercropped in coconut garden, with mulching @ 30 t ha^{-1} (half at transplanting and remained at 2 MAT) along with 150:100:100 kg NPK ha^{-1} apart from basal application of 30 t ha^{-1} of farm yard manure resulted in better growth and higher yield.

Number of Primary Fingers

The production of primary fingers per plant differed significantly among the cultivars and fertigation levels (Table 3). Higher number of primary fingers per plant were produced by Himachal cultivar (4.96) compared to Rio-de-Janeiro cultivar (3.56) with 200 per cent RDF (200:100:100 kg N: P_2O_5: K_2O /ha) Fertigation + FYM 30t/ha, Neem cake 2t/ha (T_2) which is on par with 150 per cent RDF (150:75:75 N: P_2O_5: K_2O kg/ha) Fertigation + FYM 30t/ha, Neem cake 2t/ha (T_3) as compared to other fertigation levels. Lower number of primary fingers were found in Rio-de-Janeiro cultivar (2.20) with the application of RDF

TABLE 3

Effect of fertigation levels on number of primary and secondary fingers per clump of different cultivars of ginger

Treatments	Number of primary and secondary fingers per clump			
	Rio – de - Janeiro		Himachal	
	Primary fingers	Secondary fingers	Primary fingers	Secondary fingers
T_1	2.20	1.76	2.40	2.00
T_2	3.56	2.93	4.96	3.80
T_3	3.50	2.90	4.73	3.46
T_4	3.16	2.93	3.80	3.26
T_5	2.86	2.36	3.66	2.73
T_6	3.20	2.60	3.53	2.93
T_7	3.13	2.60	4.53	2.33
T_8	3.26	2.00	3.40	3.33
T_9	2.94	2.40	3.66	2.00
T_{10}	3.10	2.58	3.93	3.20
T_{11}	3.36	2.53	4.20	2.23
F test	*	*	*	*
SEM+	0.153	0.132	0.289	0.203
CD @ 5%	0.453	0.390	0.853	0.600

only among the different fertigation levels as compared to Himachal cultivar (2.40). Among the cultivars, Himachal cultivar recorded higher number of primary tillers as compared to Rio-de-Janeiro cultivar (Viswanatha *et al.,* 2000).

Number of Secondary Fingers

The observations on the production of secondary fingers per plant differed significantly among the cultivars and fertigation levels (Table 3).

The number of secondary fingers varied from 2.00 to 3.80 in Himachal and 1.76 to 2.93 in Rio-de-Janeiro. Himachal produced higher number of secondary fingers with the application of fertigation levels, maximum number (3.80) was recorded in 200 per cent RDF (200:100:100 kg N: P_2O_5: K_2O /ha) Fertigation + FYM 30t/ha, Neem cake 2t/ha (T_2) and lowest was recorded in RDF (100:50:50 N: P_2O_5: K_2O kg /ha normal fertilizers) + FYM 30 t/ha, Neem cake 2t/ha (T_1) (2.00) which was on par with 50 per cent RDF (50:25:25 N: P_2O_5: K_2O kg/ha WSF) + *Azotobacter* + PSB +AMF + KMB + FYM 30 t/ha, Neem cake 2t/ha (T_9) (2.00) as compared to Rio-de-Janeiro.

Similarly, cultivar Rio-de-Janeiro recorded maximum number of secondary fingers (2.93) in T_2 and lowest number (1.93) of secondary fingers was produced with RDF (100:50:50 N: P_2O_5: K_2O kg /ha normal fertilizers) + FYM 30 t/ha, Neem cake 2t/ha (T_1).

Wight of Mother Rhizomes

It was observed that the weight of mother rhizomes per plant differed significantly among the cultivars with different fertigation levels (Table 4).

Himachal cultivar recorded highest weight of mother rhizome per plant (51.33 g) as compared to Rio-de-Janeiro (39.66 g) in the treatment T_2 which was on par with T_3 among the different fertigation levels. Lowest weight of mother rhizomes was found in the Rio-de-Janeiro (22.33 g) and Himachal (26.00 g) with the application of RDF (100:50:50 N: P_2O_5: K_2O kg /

TABLE 4

Effect of fertigation levels on fresh weight of mother rhizome, primary and secondary fingers per clump of different cultivars of ginger

Treatments	Fresh weight of mother rhizome, primary and secondary fingers per clump (g)					
	Rio – de - Janeiro			Himachal		
	MR	PF	SF	MR	PF	SF
T_1	22.33	57.00	21.33	26.00	61.00	24.33
T_2	39.66	83.00	31.33	51.33	124.66	44.33
T_3	32.00	71.33	25.33	47.33	119.33	39.66
T_4	26.00	57.00	21.33	33.33	114.00	29.00
T_5	29.33	106.66	26.00	35.00	92.00	31.66
T_6	31.00	105.33	37.33	38.00	101.66	30.00
T_7	31.66	84.33	27.33	38.66	115.33	34.00
T_8	29.00	67.00	21.66	41.66	106.33	33.00
T_9	29.66	66.00	23.66	36.00	113.33	41.33
T_{10}	31.25	73.00	24.34	42.33	123.33	37.66
T_{11}	32.54	68.00	24.34	43.00	91.00	34.00
F test	*	*	*	*	*	*
SEM+	1.587	5.261	0.542	0.859	1.793	0.682
CD @ 5%	4.682	15.519	1.600	2.533	5.291	2.013

ha normal fertilizers) + FYM 30 t/ha, Neem cake 2t/ha (T_1).

Weight of Primary and Secondary Fingers

The weight of primary fingers per plant varied significantly in both the cultivars with application of different fertigation levels (Table 4). Among the different fertigation levels applied, Himachal cultivar responded very well as compared to Rio-de-Janeiro. Application of 200 per cent RDF (200:100:100 kg N: P_2O_5: K_2O /ha) Fertigation + FYM 30t/ha, Neem cake 2t/ha (T_2) resulted in higher weight of primary fingers in Himachal (124.66 g) and Rio-de-Janeiro (83.00 g). Lowest primary finger weight was recorded in Rio-de-Janeiro (57.00 g) and Himachal (61.00 g) with the application of RDF (100:50:50 N: P_2O_5: K_2O kg /ha normal fertilizers) + FYM 30 t/ha, Neem cake 2t/ha (T_1).

Similar trend was observed in weight of secondary fingers. Among the cultivars, Himachal recorded higher weight of secondary fingers as compared to Rio-de-Janeiro. The maximum weight was recorded with the application of 200 per cent RDF (200:100:100 kg N: P_2O_5: K_2O /ha) Fertigation + FYM 30t/ha, Neem cake 2t/ha (T_2) in Himachal (44.33 g) and Rio-de-Janeiro (31.33 g). This treatment was on par with the 150 per cent RDF (150:75:75 N: P_2O_5: K_2O kg/ha) Fertigation + FYM 30t/ha, Neem cake 2t/ha (T_3) in both the ginger cultivars. The lowest weight of secondary fingers was recorded with 100 per cent RDF (T_1) in Rio-de-Janeiro (21.33 g) and Himachal (24.33 g). The similar results were reported by Sharath Pal *et al*. (2014) and Yadgirwar *et al*. (2017).

Length of Mother Rhizomes

Significant variation in the length of mother rhizome was observed in Himachal and Rio-de-Janeiro cultivars of ginger with different fertigation levels (Table 5). The length of mother rhizome ranged from 2.54 to 4.51cm in Himachal cultivar and 2.42 to 3.65 cm in Rio-de-Janeiro cultivar with different fertigation levels and maximum length of mother

TABLE 5

Effect of fertigation levels on length of mother rhizome, primary and secondary fingers per clump of different cultivars of ginger

Treatments	Length of mother rhizome, primary and secondary fingers per clump (cm)					
	Rio – de - Janeiro			Himachal		
	MR	PF	SF	MR	PF	SF
T_1	2.42	3.23	3.96	2.54	3.34	4.10
T_2	3.65	3.67	3.93	4.41	3.75	4.30
T_3	3.36	3.60	3.85	4.28	3.46	4.15
T_4	2.86	3.35	3.78	3.22	3.75	4.21
T_5	2.86	3.16	3.54	3.54	3.57	3.96
T_6	2.97	3.02	3.77	3.25	3.43	4.22
T_7	3.13	3.31	4.13	3.32	3.19	4.91
T_8	2.94	3.43	3.86	3.09	3.05	3.87
T_9	3.24	3.15	3.89	2.98	3.46	3.91
T_{10}	3.05	3.58	4.12	2.98	3.28	3.68
T_{11}	3.18	3.11	4.76	3.80	3.80	4.06
F test	*	*	*	*	*	*
SEM+	0.138	0.049	0.137	0.211	0.058	0.138
CD @ 5%	0.410	0.147	0.407	0.623	0.173	0.418

rhizome was observed with the application of 200 per cent RDF (200:100:100 kg N: P_2O_5: K_2O /ha) Fertigation + FYM 30t/ha, Neem cake 2t/ha (T_2) followed by 150 per cent RDF (150:75:75 N: P_2O_5: K_2O kg/ha) Fertigation + FYM 30t/ha, Neem cake 2t/ha (T_3) and least length of mother rhizome was observed in 100 per cent application to both the cultivars.

Length of Primary and Secondary Fingers

Length of primary and secondary fingers showed the significant variation among the cultivars and fertigation levels (Table 5). Maximum length of primary fingers was observed in Himachal (3.75 cm) and Rio-de-Janeiro (3.67cm) with the application of 200 per cent RDF (200:100:100 kg N: P_2O_5: K_2O /ha) Fertigation + FYM 30t/ha, Neem cake 2t/ha (T_2) followed by 150 per cent RDF (150:75:75 N: P_2O_5: K_2O kg/ha) Fertigation + FYM 30t/ha, Neem cake 2t/ha (T_3). The minimum length was observed with T_1 with 100 per cent RDF in both the cultivars. Similar trend was observed with the length of secondary fingers in Himachal and Rio-de-Janeiro. Application of 200 per cent RDF (200:100:100 kg N: P_2O_5: K_2O /ha) Fertigation + FYM 30t/ha, Neem cake 2t/ha (T_2) resulted in maximum length of secondary fingers and 100 per cent RDF recorded minimum length in both the cultivars. The similar results were quoted by Sharath Pal *et al*. (2014).

Dry Matter Production per Hectare (t/ha)

The dry matter production per hectare varied significantly among the cultivars and different fertigation levels (Table 6).

Himachal cultivar recorded higher dry matter production (68.25 g/plant and 9.10 t/ ha) and Rio-de-Janeiro recorded the dry matter production of 34.31 g/ plant and 4.57 t/ha with the application of 200 per cent RDF (200:100:100 kg N: P_2O_5: K_2O /ha) Fertigation + FYM 30t/ha, Neem cake 2t/ha (T_2) followed by 150 per cent RDF (150:75:75 N: P_2O_5: K_2O kg/ha) Fertigation + FYM 30t/ha, Neem cake 2t/ha (T_3). The least dry matter production was

TABLE 6

Effect of fertigation levels on total dry matter production of different cultivars of ginger

Treatments	Total dry matter production			
	Rio – de - Janeiro		Himachal	
	g/ plant	t/ha	g/ plant	t/ha
T_1	22.86	3.04	26.06	3.47
T_2	34.31	4.57	68.25	9.10
T_3	28.17	3.75	47.99	6.36
T_4	26.32	3.50	37.71	5.02
T_5	23.03	3.06	31.42	4.18
T_6	28.15	3.75	46.08	6.40
T_7	27.19	3.62	44.00	5.86
T_8	19.69	2.62	34.28	4.57
T_9	26.20	3.49	32.85	4.42
T_{10}	28.20	3.86	40.31	5.36
T_{11}	29.12	4.10	53.31	7.10
F test	*	*	*	*
SEM+	1.065	0.172	4.767	0.636
CD @ 5%	3.143	0.510	14.063	1.877

recorded with the RDF (100:50:50 N: P_2O_5: K_2O kg / ha normal fertilizers) + FYM 30 t/ha, Neem cake 2t/ha (T_1) in both the cultivars. Himachal cultivar of ginger responded very well for the application of fertigation levels as compared to Rio-de-Janeiro. Variations could be attributed to the difference in genetic makeup and response to inputs by these genotypes. The results are in conformity with the findings of Sudha *et al*. (2020).

The Himachal ginger cultivar performed well for the application of different fertigation levels as compared to the Rio-de-Janeiro cultivar with respect to the plant height, leaf area, leaf area index, number of primary fingers, secondary fingers, fresh weight of mother rhizomes, primary fingers, secondary fingers and length of mother rhizomes, primary fingers, secondary fingers and total dry matter production with different fertigation levels. Application of 200 per cent RDF (200:100:100 kg N: P_2O_5: K_2O /ha) Fertigation + FYM 30t/ha, Neem cake 2t/ha resulted in higher plant growth and yield attributes as compared to different fertigation levels in both the ginger cultivars.

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