Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(6): 2004-2007
Received: 16-09-2020
Accepted: 18-10-2020

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Effect of different media and nutrients on growth and yield of ginger (*Zingiber officinale* Rosc.) in soilless culture under protected structure

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Abstract
An experiment was carried out at College of Horticulture Mudigere, to evaluate the effect of media and nutrient levels on growth, yield and quality of ginger in soilless culture under protected structure. The experiment was laid out in a factorial completely randomized design with two factors. Factor one being different growth media and factor two was nutrient levels. Results showed that media, nutrient levels and interactions had a significant effect on growth and yield of ginger. The highest plant height, number of leaves, number of tillers, leaf area, Leaf Area Index, fresh rhizome yield per plant and dry recovery percentage were recorded in treatment with M_3 (cocopeat + sand-75:25) and N_4 (140% RDF + 140% secondary and micronutrients).

Keywords: ginger, soilless, protected structure, media, nutrient level, cocopeat

Introduction
Ginger (*Zingiber officinale* Rosc., Family: Zingiberaceae) is one of the oldest known spices valued for its aroma and pungency. Ginger is used both in fresh and dried form. It is utilized widely as spice, for pickles, candies and as a medicinal herb for the treatment of gastrointestinal diseases, including dyspepsia, nausea and diarrhea. The major active constituents in ginger are gingerol (23-25%), shagoal (18-19%) gingerone and zingiberene. Ginger is a herbaceous perennial and is an underground rhizome about 2 to 2.5 cm in diameter and is branched. Roots are fibrous and go up to 20 to 30 cm soil depth. Leaves are thin and lanceolate. Ginger grows best in warm and humid climate and mainly grown in tropic up to an elevation of 1500 m above sea level. It is a shade loving plant requires ample moisture for growth.

In Karnataka, it is grown in an area of 23.09 thousand hectares with annual production of 58.39 thousand metric tonnes (Anon., 2018) mainly in Shivamogga, Hassan, Chikkamagaluru, Uttara Kannada, Dakshina Kannada, Kodagu and Mysore districts.

Soilless culture system is the most intensive production method in today's agriculture industry, which can result in higher yields even in limited and adverse growing conditions. Soil-less culture mainly refers to the techniques of "Hydroponics" and "Aeroponics". In soilless production system, many types of growing media or substrates such as cocopeat, rockwool, perlite, vermiculite and peat have been used to grow many kinds of crops (Komada *et al*., 1997 [1].

Cocopeat was considered as a good growing media with acceptable pH, electrical conductivity and other chemical attributes. Perlite is a grey-white mineral of volcanic origin mined from lava flows and its composition is sodium potassium aluminum silicate. The main advantage to its success in hydroponics is maintaining a near constant water profile in the rooting medium. Sand as a growing media, provides an inert nature media with more pore volume (more oxygen transport), stable structure, less water retention and large volume of accessible water to the plants.

Fertilizer programmes for soilless-culture systems must supply all nutrients required by the plants. Carbon, hydrogen, and oxygen are provided from water and carbon dioxide in the air while nitrogen, phosphorus, potassium, calcium, magnesium, sulphur and micronutrients are to be supplied by the grower.

The high yield of ginger is a function of the adequate and timely supply of plant nutrients. Among the various agronomic technologies influencing the production of ginger, the nutrient is found to exert great influence on growth and yield of ginger. Imbalance and low or no fertilizer application is one of the most important factors in obtaining the poor yield.

Materials and Methods

The Rio de Janeiro variety of ginger was selected to evaluate the effect of media and nutrients on growth, yield and rhizomes under soilless culture under protected structure. Rio-de-Janiero is a high yielding exotic variety introduced from Brazil has become very popular among growers. Its yield potential is about 17.65 tonnes per hectare. The rhizome bits of 20 g were disinfected using fungicide (Bavistin 2g / l) and pesticide (Quinolphos 2 ml /l) and sown in the center of the grow bag. The experiment was laid out in Factorial Completely Randomized Design with two factors and three replications. Experimental details: An experiment was conducted during 2019-20. The experiment was laid out in factorial completely randomized design with two factors. Factor I includes three different media (cocopeat – 100%, cocopeat + perlite – 75:25 and cocopeat + sand – 75:25). Factor II includes nutrient levels (80%, 100%, 120% and 140% of RDF + Secondary nutrient and micronutrients). There were totally 12 treatment combinations in the study.

The RDF (Recommended dose of fertilizers) for ginger was taken as 100:50:50 kg / ha of NPK, secondary nutrients concentration was taken as 20 kg / ha of Calcium, Magnesium and Sulphur and micronutrients at the rate of 5 kg / ha. The nutrients were supplied through drip fertigation twice a week. The schedule for application was prepared and nutrients were provided to plants according to the schedule at different stages of growth.

The observations for growth, yield and quality of ginger were recorded. The growth parameters like plant height, number of leaves, number of tillers, leaf area and leaf area index were recorded at monthly interval. Rhizomes were harvested after complete yellowing and drying of aerial plant parts and the yield parameters were recorded.

Data obtained were subjected to statistical analysis using analysis of variance (ANOVA) procedures to test the significant effect of all the variables investigated. The statistical significance was tested by applying 'F' test at 0.05 level of probability and critical differences were calculated for those parameters which turned significant ($P < 0.05$) to compare the effects of different treatments.

Results and Discussion

There were significant differences in plant height, number of tillers and number of leaves between treatments (Table 1a). The tallest plants were observed in the media cocopeat + sand – 75:25 with an average height of 105.27 cm and the lowest was noticed in media cocopeat + perlite – 75:25 (93.53 cm). The mean maximum number of tillers and number of leaves were recorded in the media M_3 *i.e.* 11.77 and 120.01 respectively. This might be due to optimum physical properties of the media and high cat-ion exchange capacity of the media. The high cat-ion exchange capacity of M_3 acts as a reservoir of elements in its structure for slow release to the rhizosphere. Similar results were noticed by Suhaimi *et al*. (2012) [2] in ginger, Gul *et al*. (2007) [3] in cucumber and Fascella and Zizzo (2003) [4] in rose.

Table 1a: Growth parameters as influenced by media and nutrient levels

	Plant height (cm)					Number of tillers					Number of leaves				
Treatment	**N_1**	**N_2**	**N_3**	**N_4**	**Mean**	**N_1**	**N_2**	**N_3**	**N_4**	**Mean**	**N_1**	**N_2**	**N_3**	**N_4**	**Mean**
M_1	95.32	97.47	96.99	98.37	97.40	7.87	9.33	9.33	10.90	9.36	90.20	96.67	102.03	127.17	104.02
M_2	91.35	92.34	93.42	97.02	93.53	7.12	7.80	8.27	8.60	7.95	88.60	91.83	91.83	121.53	98.45
M_3	101.66	102.96	104.76	111.70	105.27	9.80	11.80	12.47	13.00	11.77	99.67	122.97	127.20	130.20	120.01
Mean	96.11	97.59	98.39	102.36		8.26	9.64	10.02	10.83		92.82	103.82	107.02	126.30	
	SEM±		CD @ 5%			SEM±		CD @ 5%			SEM±		CD @ 5%		
M	1.82		5.32			0.17		0.50			1.62		4.72		
N	2.10		6.14			0.20		0.57			1.87		5.45		
M x N	3.64		10.64			0.34		0.99			3.24		9.44		

Note- (RDF for Ginger is 100:50:50 kg / ha, secondary nutrients – 20 Kg / ha each and micronutrients – 2 kg / ha)

Factor 1: Media
M1-Cocoeat – 100%
M2- Cocopeat + perlite – 75:25
M3- Cocopeat + perlite – 75:25

Factor 2: Nutrient level
N1-80% RDF + Secondary and Micronutrients
N2-100% RDF + Secondary and Micronutrients
N3-120% RDF + Secondary and Micronutrients
N4-140% RDF + Secondary and Micronutrients

The nutrient levels also showed the significant effect on growth of ginger. Increase in the nutrient levels increased the growth of ginger. The nutrient level N_4 recorded the maximum mean plant height (102.36 cm), number of tillers (10.83) and number of leaves (126.30). While the nutrient level N_1 recorded minimum plant height (96.11 cm), number of leaves (92.82) and number of tillers (8.26). An increase in plant height might be attributed to water availability and indirectly nutrients provided through frequent drip fertigation, which have been reported to increase the activity of cell division, cell expansion and cell elongation, ultimately leading to an increased plant height. Linear response was evident in plant growth for increased level of nutrition, which can be attributed to the basic exhaust nature of ginger crop. These results are in line with Dayankatti and Sulikeri (2000) [5] and Olojede *et al.* 2009 [6]. Increasing levels of nitrogen application resulted in corresponding increase in plant height, leaf numbers and size. This observation is in agreement with previous studies by Olojede *et al.* (2009) [6] in turmeric.

Same trend as that of growth parameters was noticed with respect to leaf area and Leaf Area Index (Table 1b.). The media M_3 (cocopeat + sand – 75:25) recorded maximum leaf area (4013.25 cm^2/ clump) and LAI (4.46). While the minimum leaf area (2954 cm^2/ clump) and Leaf Area Index (2.98) was recorded in M_2 (Cocopeat + perlite – 75:25).

Table 1b: Growth parameters as influenced by media and nutrient levels

	Leaf Area (cm^2)					Leaf Area Index				
Treatment	**N_1**	**N_2**	**N_3**	**N_4**	**Mean**	**N_1**	**N_2**	**N_3**	**N_4**	**Mean**
M_1	2619	2941	3255	4174	3247.25	2.91	3.27	3.62	4.64	3.61
M_2	2284	2610	3529	3393	2954.00	2.54	2.54	2.90	3.92	2.98
M_3	3173	4040	4337	4503	4013.25	3.53	4.49	4.82	5.00	4.46
Mean	2692	3197	3707	4023		2.99	3.43	3.78	4.52	
	SEM±		CD @ 5%			SEM±		CD @ 5%		
M	41.41		120.91			0.05		0.13		
N	47.84		139.62			0.07		0.15		
M x N	82.86		241.82			0.09		0.27		

Note- (RDF for Ginger is 100:50:50 kg / ha, secondary nutrients – 20 Kg / ha each and micronutrients – 2 kg / ha)

Factor 1: Media
M1-Cocoeat – 100%
M2- Cocopeat + perlite – 75:25
M3- Cocopeat + perlite – 75:25

Factor 2: Nutrient level
N1-80% RDF + Secondary and Micronutrients
N2-100% RDF + Secondary and Micronutrients
N3-120% RDF + Secondary and Micronutrients
N4-140% RDF + Secondary and Micronutrients

The level of nutrients showed significant difference on leaf area and leaf area index. The nutrient level N_4 (140% RDF + secondary and micronutrients) recorded maximum leaf area (4023 cm^2/ clump) ad leaf area index (4.52). The minimum leaf area and leaf area index was recorded in N_1 (80% RDF + secondary and micronutrients). Fertilizer and water supplied through fertigation leads to uniform moisture level and continuous and greater availability of nutrients might have helped in better uptake of nutrients throughout the crop growth period. Ginger is a heavy feeder crop and it responds well to fertilizer application. The nutrient availability at appropriate growth stages is imperative for the development of yield parameters in root crops (Hussain *et al.* 2005 [7] and Parthasarathy *et al.* 2010 [8]).

The yield parameters like yield per plant, yield per hectare and dry recovery were significantly influenced by media and nutrient levels (Table 2). The media M_3 (Cocopeat + sand - 75:25) recorded maximum yield per plant and dry recovery (576.40 g / clump and 24.85% respectively). while the minimum was recorded in the media cocopeat + perlite – 75:25. Increase in fresh weight and dry recovery of rhizome per clump was might be due to accumulation of carbohydrates, better translocation of assimilates from source to sink.

Table 2: Yield parameters as influenced by media and nutrient levels

	Yield per plant (g)					Yield per hectare (t)					Dry recovery (%)				
Treatment	**N_1**	**N_2**	**N_3**	**N_4**	**Mean**	**N_1**	**N_2**	**N_3**	**N_4**	**Mean**	**N_1**	**N_2**	**N_3**	**N_4**	**Mean**
M_1	538.22	523.23	554.44	541.00	539.22	32.29	31.39	33.27	32.46	32.35	21.43	17.92	19.95	24.62	20.97
M_2	531.13	496.21	516.72	524.79	512.71	31.87	29.77	31.00	31.49	31.03	21.43	21.88	25.95	28.05	24.33
M_3	528.91	549.86	594.86	631.98	576.40	31.73	32.97	35.69	37.92	34.58	18.91	25.53	25.44	29.53	24.85
Mean	532.75	523.10	555.34	565.92		31.93	31.37	33.32	33.95		20.55	21.78	23.78	27.40	
	SEM±		CD @ 5%			SEM±		CD @ 5%			SEM±		CD @ 5%		
M	0.05		0.14			0.49		1.42			0.53		1.55		
N	0.06		0.16			0. 32		0.92			0.62		1.79		
M x N	16.18		47.21			2.83		7.97			1.07		3.11		

Note-(RDF for Ginger is 100:50:50 kg/ha, secondary nutrients – 20 Kg / ha each and micronutrients – 2 kg / ha)

Factor 1: Media
M1-Cocoeat – 100%
M2- Cocopeat + perlite – 75:25
M3- Cocopeat + perlite – 75:25

Factor 2: Nutrient level
N1-80% RDF + Secondary and Micronutrients
N2-100% RDF + Secondary and Micronutrients
N3-120% RDF + Secondary and Micronutrients
N4-140% RDF + Secondary and Micronutrients

The increase in number of leaves and tillers in M_3 (Cocopeat + Sand – 75:25), led to improved yield parameters and ultimately increased the yield. Similar results were obtained by Sanwal *et al.* (2012) [9], Azeze *et al.* (2013) [10] and Chongtham *et al.* (2013) [11] in ginger. This may be due higher uptake of nutrients under shaded conditions which was attributed to better availability of nutrients which reflected in better growth and rhizome yield. The nutrient levels were found significant with yield and dry recovery per cent of ginger. The nutrient level N_4 (140% RDF + secondary and micronutrients) recorded maximum yield per plant (565.92 g / clump) and dry recovery (27.40%). Increase in rhizome yield might be due to better availability of nutrients at critical growth stages leading to high cell division and cell elongation, due to complete solubility and mobilization of water soluble fertilizer at regular intervals in split application (Varughese, 1989 [12]; Jayachandran *et al.* 1991 [13]; Ajithkumar and Jayachandra, 2001) [14].

Conclusion

From the results of the present investigation, it is evident that the growth, yield and quality of ginger can be influenced by the growing media and nutrition. The media with cocopeat and sand in 75:25 Ratio and fertigation with 140 per cent of RDF + secondary nutrients and micronutrients resulted in better growth and yield of ginger rhizomes. The same combination of media as well as the nutrients recorded highest benefit cost ratio.

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