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Response of Single Bud Sprout Technique on Different Ginger (*Zingiber officinale* Rosc.) Cultivars under Sub-Himalayan Plains of West Bengal

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ABSTRACT

An experiment was carried out at Uttar Banga Krishi Vishwavidyalaya, Cooch Behar, West Bengal, during 2018–2019 and 2019–2020 to study the response of single bud sprout on six different ginger cultivars *viz.,* Suruchi, Surabhi, Suprabha, Bhaisay, Gorubathan and a Local cultivar. Planting materials were raised from the cut pieces of rhizome weighing 5–6 g containing single bud in po-tray. Thirty-five days old planting materials of each cultivar were laid in randomized block design with four replications. Observations on growth, yield and quality parameters were recorded in the field and in laboratory following standard procedure. Results revealed a significant variation among different cultivar with regards to various attributes. The cultivar Suprabha recorded maximum number of tillers plant^{-1} after 180 days (5.83) after transplanting followed by Surabhi. Bhaisay recorded maximum number of leaves plant^{-1}, plant height (50.27 cm) and produced significantly higher individual clump (145.59 g) with an average yield of 16.32 t ha^{-1}. The cultivar Bhaisay and Suruchi recorded the maximum number of primary fingers (3.04), however maximum secondary fingers was recorded by Suruchi (6.88) followed by Bhaisay (6.12) with higher length and breadth of primary and secondary finger. With respect to quality attributes, Suprabha had higher essential oil content (2.09%), Gorubathan excelled in oleoresin content (12.25%) and lowest crude fibre content (4.42%) was recorded by Suruchi. The yield and quality of ginger raised through single bud sprout particularly with the cultivar Bhaisay and Suruchi was comparable with conventional system and found as profitable tool for large scale commercial cultivation.

KEYWORDS: Cultivar, ginger, single bud sprout, quality, yield

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1. INTRODUCTION

Ginger (*Zingiber officinale* Rosc.) a monocotyledonous perennial herb in the family of Zingiberaceae grown mainly for its spicy and aromatic flavour (Ara et al., 2019). The term 'ginger' was originated from the Sanskrit word 'Sringavera', which means horn-shaped (Ravindran and Babu, 2004). Ginger is one of the key sources of foreign exchange (Shaikh et al., 2010). It acts as a flavouring agent because of its distinct flavour (Shukla and Singh, 2007). Ginger contains amino acids, shoagoals, gingerols, fibre, essential oils, and minerals, and it is used in flavoring and therapeutic ingredient in a variety of products (Camacho and Brescia, 2009, Rajyalakshmi and Umajoythi, 2014). Ginger is mostly used to cure nausea, ulcer, stroke, Sore throat, Hypertension, indigestion and Arthritis (Sekiwa et al., 2000, Kumari et al., 2021a). Fresh ginger contains 80–85% moisture and it is susceptible to microbial growth and deterioration (Babu et al., 2013, Mishra et al., 2004). The Gingerol and Shagoal are responsible for the pungency of ginger rhizome (Wohlmuth et al., 2005, Kallappa et al., 2015). The primary components in most ginger rhizome oils were zingiberene, -sesquiphellandrene, and ar-curcumene (Nampoothiri et al., 2012). India is the largest producer of the ginger in the world which accounts for 65% of the world's production of ginger.India is the leading producerof ginger in the worldwith the production 1,884,775 t from an area of 1,75,764 ha (Anonymous, 2021). Despite of Covid-19 pandemic situation, ginger export touched all-time record in 2020–21 with 145,974 t valued ₹ 84,982.34 lakhs (Anonymous, 2021). India is the largest consumer and exporter of the spices in the world (Kumari et al., 2021b). The country has highest number of spices varieties in the World. In India Major ginger growing states are Kerala, Sikkim, Meghalaya, West Bengal, Orissa, Tamil Nadu, Karnataka, Andhra Pradesh (Bheemudada and Natikar, 2016, Mennu and Kausal, 2017, Jyotsna et al., 2012). Gingeris conventionally propagated through seed rhizomes weighing 20–80 g depending upon the availability of seed rhizome and ability of the farmers to take the huge burden of seed cost.Planting larger seed rhizomes (20–80 g) promotes early seed sprouting, more vigorous growth, and higher yield (Sengupta et al., 1986). Depending on size of the planting materials and spacing, seed rate of ginger rhizomes ranges from 1500–2500 kg ha^{-1} (Parthasarathy et al., 2012). Larger quantitydisease free seed rhizome as planting materials, putting huge financial burden especially on small and marginal ginger growers of the North Eastern parts of the country,cost of planting materials alone accounting for 40–45% of the overall production costs under good management practice (Nybe and Raj, 2005). Conventional use of larger pieces of rhizomes as planting materials and farmers' practice of subsequent removal of the mother rhizome at later stage of crop growth invites number of diseases causing micro-organism and ultimate crop loss occur. Ginger transplanting technique involving rhizome containing single bud of approximately 5 g has been standardized by IISR, Kozhikode to produce high-quality healthy planting material at a lower cost and save large volume of seed materials. SBT involving transplantation of the sprouted buds having intact root system minimize the chances of disease infestation. The yield of SBT and conventional method are comparable (Prasath et al., 2014, Prasath et al., 2018). Yield of ginger depends on cultivar used, prevailing climate, planting season and maturity at harvest (Peter et al., 2005). Systematic study on the use of SBT with different cultivar in commercial scale has not been reported till date. The main objective of the present investigation to evaluate the performance of different cultivar of ginger raised through SBT underNorth Eastern Himalayan foot hills.

2. MATERIALS AND METHODS

A field experiment was carried out to evaluate the performance of six ginger cultivar *viz.,* Suruchi, Surabhi, Suprabha, Bhaisay, Gorubathan and a Local cultivar raised through single bud sprouts for their growth, yield and quality at the instructional farm of theDepartment of Plantation Crops and Processing, UBKV, Cooch Behar, West Bengal, India during the years June, 2018–January, 2019 to June, 2019–January, 2020. Geographically the experimental site is situated at 26°19'86" N latitude and 89°23'53" E longitude at an elevation of 43 m above the mean sea level.The experiment was laid in Randomized Block Design with fourreplications having plot size of 2.0 m×1.5 mand spacing of 20×30 cm^2.

2.1. Preparation of planting material

Disease-free ginger rhizomes were collected and the selected seed rhizomes were cut into pieces weighing 5 g containing single bud. The cut pieces were treated with a solution of Mancozeb 0.03% and Chlorpyriphos 0.02% for 30 m and dried in a well-ventilated shady place. The rooting media were prepared with thorough mixing of coir pith, well rotten farm yard manure and soil at proportion of 1:1:1 for raising of planting materialsin portrays from the single bud. Theportrays were kept under 50% shade nets and watering was done with Rose can at regular interval.Within 35 days of planting, the plants raised from bud were ready for transplanting into the main field (Figure 1 and 2).

2.2. Cultivation practices followed

Final land preparation was done incorporating FYM @ 15 t ha^{-1} along with full dose of phosphorousof the recommended dose of chemical fertilizers (N:P: K @ 60:90:60 kg ha^{-1}) in the form of single super phosphateas

Figure 1: Ginger seedlings are ready for transplantation to main field

Figure 2: Ginger seedling are uprooted for transplantation to the main field

basal. The nitrogenousand potassic fertilizers were applied as top dress at 45, 90, and 120 days after transplanting in the form of ureaand muriate of potash. The beds, after transplanting, were covered with straw mulch to prevent erosion, conserve soil moisture and provide organic matter to the crop. For proper growth and development, the crops were weeded, mulched, and earthed up after 45 and 90 days of planting. Irrigation and plant protection measures were taken according to the crop's need. The crop was harvested after eleven months of planting when the above ground plant parts dried completely.

Randomly selected plants from each replication were selected for recording of data with respect to different growth, yield and quality characters *viz.,* Number of tillers, Number of leaves tiller^{-1}, Height of the tillers at 120, 180 days of planting, Weight of clump, length and width of clump, Number of primary fingers, Length and width of primary fingers, Weight of primary fingers, Number of secondary fingers, Length and width of secondary fingers, Weight of secondary fingers, Fresh yield of clump and plotyield were recorded after harvesting. Different quality parameters of each cultivar like Dry recovery (%), Essential oil content (%),Oleoresin content (%)and crude fiber content (%) in dry ginger were computed as follows.

2.3. Dry recovery (%)

Freshly harvested ginger rhizomes were thoroughly washed in running tap water and sliced into small pieces. Sliced rhizomes were dried in hot air oven at 65°C until it reached constant weight. Dry recovery % of the ginger rhizomes was calculated using following formula.

Dry recovery %=weight of dry ginger (g)/weight of fresh ginger (g)×100 .....(1)

2.4. Essential oil content (%)

Essential oil content in the dried and powdered ginger rhizomes were analyzed by hydro-distillation. Fresh ginger rhizomes (100 g) were hydro-distilled with 500 ml distilled water for 6 h in a Clevenger apparatus. The oil separated was collected in small glass bottles. It was dried over anhydrous sodium sulphate to remove traces of moisture (Jayashree et al., 2014). Essential oil content was calculated using following formula. Essential oil (%)=Amount of essential oil obtain (g)/Amount of sample used (g)×100 .....(2)

2.5. Oleoresin content (%)

Oleoresin content in the dry ginger powder was analyzed by solvent extraction in Soxhlet apparatus (Pelican Equipment's, model: Socsplus-SCS 04R) using petroleum ether as solvent. Oleoresin content in the sample was calculated from the weight of empty cup and weight of cup with extract using following formula.

Oleoresin (%)=Weight of oleoresin (g)/Solid present in 5 g weight of sample×100.....(3)

2.6. Crude fiber content (%)

The samples were defatted using petroleum ether, digested with Sulphuric acid (1.25%, w/v) and Sodium hydroxide Solution (1.25%, w/v)) and then dried. Residue was washed and transferred to boiling NaOH (1.25 N) solution for exactly 30 m. The solution was filtered through linen cloths. The residue was thoroughly washed successively with hot water, alcohol and petroleum ether. After proper washing, the sample was placed over a thin layer of asbestos in Gooch crucible and dried in hot air oven at 105°C for 3 h, after cooling, weight was recorded until the difference between two consecutive weighing is less than 1 mg. The residue was incinerated in a muffle furnace maintained at 550°C for 3 h. Dried sample was weighed.

Crude fiber content of the sample was calculated as below.

Loss in weight on ignition=(W2-W1)-(W3-W1) .....(4)

Crude fibre %=(W2-W1)-W3-W1/Weight of samle (g)× 100.....(5)

Where,

W_1=Weight of residue before drying

W_2=Weight of residue after drying

W_3=Weight of residue after ignite for 3 hours at 550°C

2.7. Statistical analysis

The collected data were analysed and mean values were adjusted by DMRT using the statistical package SPSS statistics 17.0. Pooled analysis of the two years data was made following the recommendation of Gomez and Gomez (1984).

3. RESULTS AND DISCUSSION

Plant growth and development determine the yield and ultimate economic return from any crop. Similarly, in case of ginger the growth and yield attributing characters like number of tillers, plant height and number of leaves plant^{-1} also have an impact on the rhizome yield. The growth as well as yield of any ginger cultivar depends on genotypes, nutrient management and other cultural practices adopted. Pooleddata presented in the Table 1 on different growth attributing characters of 6 different ginger cultivars raised through single bud sprout recorded significant variations during active growth and rhizome development phase of the crop at 120 and 180 days after planting respectively and ultimately reflected on individual weight of the clump (Table 2) as well as rhizome yield (Table 3).

The cultivar Suprabha recorded maximum number of tillers both at 120 days after planting (4.23) and 180 days after planting (5.83) and was closely followed by the cultivar Surabhi.Similar finding on growth characters of different ginger cultivars was also reported by Rajyalakshmi and Umajoythi (2014) and Balakumbahan and Joshua (2017) under conventional method of ginger cultivation. The cultivar Bhaisay had maximum number of leaves plant^{-1} and maximum plant height (50.27 cm), which was statistically *at par* with cultivar Suruchi (47.87 cm). Among the different growth parameter plant height with more number of leaves is one of the most important yield indicating growth parameter (Goudar et al., 2017). Leaves are the site for photosynthesis and the photosynthates, later translocated to underground ginger rhizomes,the storage organ and

Table 1: Effect of single bud sprout technique on number of tillers, plant height and number of leaves at 120, 180 days after transplanting (DAT)of different ginger cultivars

Cultivars	No. of tillers at 120 DAT	No. of tillers at 180 DAT	Plant height (cm) at 120 DAT	Plant height (cm) at 180 DAT	No. of leaves at 120 DAT	No. of leaves at 180 DAT
Local	4.18^{ab}	5.38^{c}	42.55^{bc}	45.43^{bc}	13.65^{ab}	15.86^{ab}
Suprabha	4.23^{a}	5.72^{ab}	39.57^{de}	44.57^{bcd}	12.43^{bc}	15.43^{ab}
Surabhi	4.09^{abc}	5.83^{a}	41.50^{cd}	43.03^{cd}	12.35^{bc}	15.52^{ab}
Suruchi	3.65^{cd}	5.52^{bc}	44.48^{b}	47.87^{ab}	13.25^{abc}	16.42^{a}
Bhaisay	3.66^{bcd}	5.30^{c}	47.83^{a}	50.27^{a}	13.85^{a}	15.90^{ab}
Gorubathan	3.17^{d}	3.43^{d}	38.80^{e}	41.26^{d}	12.23^{c}	15.03^{b}
SEm±	0.18	0.10	0.76	1.12	0.44	0.46
CD (p=0.05)	0.53	0.31	2.27	3.37	1.33	1.38

Table 2: Effect of single bud sprout technique on weight of clumps, length of clumps, breadth of clumps, number, weight, length and width of primary fingers of different ginger cultivars

Cultivars	Weight of clumps (g)	Length of clumps (cm)	Width of clumps (cm)	No. of primary fingers	Weight of primary fingers (g)	Length of primary fingers (cm)	Width of primary fingers (cm)
Local	56.40^{d}	8.84^{c}	4.71^{c}	2.40^{b}	28.48^{d}	2.89^{ab}	3.73^{b}
Suprabha	68.94^{c}	9.84^{b}	5.09^{bc}	2.33^{b}	32.45^{c}	2.87^{ab}	3.50^{b}
Surabhi	66.19^{c}	9.30^{bc}	5.18^{bc}	2.38^{b}	29.24^{cd}	2.64^{b}	3.84^{b}
Suruchi	113.69^{b}	11.54^{a}	5.79^{b}	2.86^{a}	48.17^{b}	3.04^{a}	4.19^{a}
Bhaisay	145.59^{a}	11.88^{a}	6.61^{a}	2.91^{a}	62.10^{a}	3.04^{a}	4.31^{a}
Gorubathan	53.63^{d}	8.95^{c}	5.36^{bc}	2.30^{b}	25.476	2.30^{c}	3.59^{b}
SEm±	2.14	0.25	0.23	0.07	1.26	0.11	0.11
CD (p=0.05)	6.46	0.75	0.72	0.23	3.79	0.33	0.35

Table 3: Effect of single bud sprout technique on number, weight, length, width of secondary fingers, plot yield, yield ha^{-1} of different ginger cultivars

Cultivars	No. of sec fingers	Weight of sec fingers (g)	Length of sec fingers (cm)	Width of sec fingers (cm)	Yield plot^{-1} (kg)	Yield ha^{-1} (t)
Local	5.75^{bc}	39.39^{c}	3.51^{b}	2.90^{abc}	2.82	6.59
Suprabha	5.26^{cd}	36.89^{d}	3.55^{ab}	2.79^{bc}	3.45	8.05
Surabhi	4.95^{d}	32.17^{e}	3.49^{b}	3.00^{ab}	3.42	7.98
Suruchi	6.12^{b}	53.92^{b}	3.60^{ab}	2.97^{ab}	5.67	13.24
Bhaisay	6.88^{a}	65.93^{a}	3.77^{a}	3.21^{a}	7.00	16.32
Gorubathan	3.89^{e}	29.39^{f}	3.18^{c}	2.62^{c}	2.68	6.25
SEm±	0.18	0.75	0.08	0.11	0.14	0.32
CD (p=0.05)	0.54	2.27	0.24	0.33	0.41	0.95

consequently, significantly higher individual clump weight (145.59 g), plot yield (7.00 kg) and yield ha^{-1} (16.32 t ha^{-1}) was recorded in the cultivar Bhaisay, followed by Suruchi. The lowest individual clump weight (53.63 g), plot yield (2.68 kg) and yield ha^{-1} (6.25 t ha^{-1}) was recorded in the cultivar Gorubathan. Variations of the rhizome yield among the cultivars are mainly due to variation in number of nodes in the rhizome and tillers, which is genetically control character and also might be due to better adoptability in a particular ecological condition (Kallappa et al., 2015). It is also attributed the yield of a variety depends on vigour of the plant and other rhizome characters (Shetty et al., 2015). All the yield attributing characters significantly varied among different ginger genotypes. The cultivar Bhaisay recorded maximum length (11.88 cm) and breadth (6.61 cm) of the individual clump, number (2.91) and weight (62.10 g) of primary finger and length (3.04 cm) and breadth (4.31 cm) of primary fingers. Similarly, variations in number (6.88), weight (65.93 g), length (3.77 cm) and breadth (3.21 cm) of secondary fingers was also observed due to its higher individual clump weight (Table 2 and Table 3). Similar pattern of growth and yield parameters were also reported by Jyotsna et al. (2012) at Imphal, Manipur propagated through conventional method of propagation. The yield of different ginger cultivars raised through single bud sprout technique was found to be comparable with conventional propagation method (Prasath et al., 2018) particularly for the cultivar Bhaisay and Suruchi might be due to their better adoptability to sub-Himalayan foot hills. The essential oil, oleoresin, crude fibre and dry recovery % of the 6 ginger cultivars are shown in Table 4. Cultivar Suprabha yielded maximum essential oil (2.09%), followed by Suruchi (2.00%), similar essential oil percent (2.35%) was reported by Babu et al. (2017) in cultivar Suprabha, however, Goudar et al. (2017) also obtained the highest essential oil (2.25%) in Surabhi. The cultivarSuruchirecorded the lowest crude fibre content (4.42%), followed by cultivar Bhaisay (4.64%) and

Table 4: Effect of single bud sprout technique on quality parameter of different ginger cultivars

Cultivars	Essential oil (%)	Crude fibre (%)	Oleoresin (%)	Dry recovery (%)
Local	1.91	5.74	5.85	24.76
Suprabha	1.90	5.07	9.03	20.61
Surabhi	2.09	4.65	11.99	24.47
Suruchi	2.00	4.42	11.00	23.57
Bhaisay	1.71	4.64	4.56	25.94
Gorubathan	1.56	5.17	12.25	22.77
SEm±	0.015	0.049	0.084	0.166
CD (p=0.05)	0.046	0.150	0.256	0.505

it was in the lower range as found by Sanwal et al. (2012) and Neerja and Korla (2007). Dried ginger rhizome of Gorubathan had the maximum oleoresin content (12.25%) followed by Surabhi (11.99%) and Bhaisay had minimum oleoresin content (5.85%). Similar finding was reported by Chongthan et al. (2013) and reported maximum oleoresin (10.25%) in Surabhi. Oleoresin is an important parameter in deciding quality of ginger Ravi et al. (2018). Jyotsna et al.

Figure 3: Clumps of the cultivars Bhaisay after harvesting

(2012) reported the identical result with respect to oleoresin percentage in Bhaisay (5.12%). The cultivar Bhaisay had also recorded highest dry recovery percentage (25.9) of the rhizome, followed by Local (24.7). The difference in quality parameters might be due to the inherent characters of the different varieties (Borthakur, 1992; Yadav et al., 2004) (Figure 3 and 4).

Figure 4: Clumps of the cultivars Suruchi after harvesting

4. CONCLUSION

Ginger transplantation is not common, however, propagating ginger through single bud technique (SBT) produce good yield and quality at harvest. The cultivar Bhaisay and Suruchi were found to be best in terms of growth, yield and quality parameters. These cultivars can be considered as good option for resource poor ginger growers of the sub-Himalayan foot hills of West Bengal to obtain diseases free planting material at lower cost and low investment in seed rhizome through SBT.

5. REFERENCES

Anonymous, 2021. Export data, Spice Board of India. Available at http://indianspices.com/sites/default/files/MajorItemwiseExport5years_2022.pdf Accessed on 6th July, 2022.

Anonymous, 2021. Production Data, Spice board of India. Available at http://indianspices.com/sites/default/files/majorspicewise2021.pdf. Accessed on 6th July, 2022.

Ara, R., Ratna, R., Sarker, R., Ahmed, M.M., Rahman, M.M., 2019. Effect of rhizome cut on the yield of ginger. International Journal of Applied Research 5(11), 242-246.

Babu, M.S., Kumar B.P., Swami D.V., Krishna Uma, K., Emmanuel, N., 2017. Performance of ginger *Zingiber officinale* Rosc varieties under shade condition of Costal Andra Pradesh. International Journal of Current Microbiology and Applied Science 6(7), 494-498.

Babu, N., Srivastava, S.K., Agarwal, S., 2013. Traditional storage practices of spices and condiments in Odisha. Indian Journal of Traditional Knowledge 12(3), 518–523.

Balakumbahan, R., Joshua, J.P., 2017. Yield and quality evaluation of ginger (*Zingiber officinale* Rosc) genotypes under high rainfall zone of Tamil Nadu. Journal of Spices and Aromatic Crops 26(2), 135-140.

Bheemudada, A.B., Natikar, K.V., 2016. A study on knowledge level of farmers about the ginger cultivation practices and constraints in adoption of improved practices. Journal of Farm Sciences 29(1), 133–134.

Borthakur, D.N., 1992. Agriculture of the North Eastern Region with special reference to hill Agriculture. BeeceePrakashan, Guwahati, 47-52.

Camacho, H.E., Brescia, A., 2009. The Australian ginger industry- Overview of market trends and opportunities. The State of Queensland, Department of Employment, Economic Development and Innovation, Australia, 54.

Chongtham, T., Chatterjee, R., Hnamte, V., Chattopadhyay, P.K., Khan, S.A., 2013. Ginger (*Zingiber officinale* Rosc.) germplasm evaluation for yield and quality in southern West Bengal. Journal of Spices and Aromatic Crops, 22(1), 88–90.

Gomez, K.A., Gomez, A.A., 1984. Statistical procedures for Agricultural Research (2nd Edn.). John Wiley and Sons, New York, 680.

Goudar, S.A., Hussain, M.D.S., Dodamani, S.M., Mahantesh, P.S., Pujari, R., 2017. Evaluation of ginger (*Zingiber officinale* Rosc) genotypes for quality attributes. International Journal of Pure and Applied Bioscience 5(3), 832–836. DOI: http://dx.doi.org/10.18782/2320-7051.5033

Jayashree, E., Visvanathan, R., John Zachariah, T., 2014. Quality of dry ginger (*Zingiber officinale*) by different drying methods. Journal of Food Science and Technology 51(11), 3190–3198.

Jyotsna, N., Gosh, D.C., Meitei, W.I., 2012. Study of growth yield and quality of organically grown ginger varieties under rainfed condition of Manipur. Journal of Crop and Weed 8(1), 17–21.

Kallappa, N., Shetty, G.R., Nagaraj, G., Ravi, P., Sudeep, H.P., Shivakumar, H.J., 2015. Performance of ginger (*Zingiber offcinale* Rosc.). Ecology, Environment & Conservation 21(3), 259–262.

Kumari, A., Babu, Y.M., Ramesh, E., Lepcha, T.O., Tamang, S., Das. S., 2021a. Impact of different drying techniques on quality traits on (*Zingiber officinale* Rosc.) rhizomes. International Journal of Environment and Climate Change 11(12), 30–37.

Kumari, A., Das, S., Ramesh, E., Babu, Y.M., Lepcha, T.O., 2021b. Effect of different drying methods and drying time on the sliced ginger rhizomes (*Zingiber*

officinale Rosc.). The Pharma Innovation Journal 10(10), 486–489.

Mennu, G., Kausal, M., 2017. Diseases infecting ginger (*Zingiber officinale* Roscoe): A review. Agricultural Reviews 38(1), 15–28.

Mishra, B.B., Gauta, S., Sharma, A., 2004. Shelf- life extension of fresh ginger (*Zingiber officinale*) by gamma irradiation. Journal of Food Science 69(9), 274–279.

Nampoothiri, S.V., Venugopalan, V.V., Joy, B., Sreekumar, M.M., Menon, A.N., 2012. Comparison of essential oil composition of three ginger cultivars from Sub Himalayan region. Asian Pacific Journal of Tropical Biomedicine 2(3), S1347–S1350.

Neerja, R., Korla, B.N., 2007. Evaluation of ginger germplasm for yield and quality under mid hill conditions of Himachal Pradesh. Haryana Journal of Horticulture Science. 36(3/4), 393–394.

Nybe, E.V., Raj, M., 2005. Ginger production in India and other South Asian countries. In: Ravindran, P.N., Babu, K.N. (Eds.). Ginger: The Genus Zingiber (1stEdn.). CRC Press, Boca Raton, 211–240.

Part hasarathy, V.A., Srinivasan, V., Nair, R.R., Zachariah, T.J., Kumar, A., Prasath, D., 2012. Ginger: Botany and horticulture. Horticultural Reviews 39, 273–388.

Peter, K.V., Nybe, E.V., Kurien, A., 2005. Yield gap and constrains in ginger. In: Ravindran, P.N., Babu, K.N. (Eds.), Ginger: The Genus Zingiber. CRC Press, Boca Raton, 527–532.

Prasath, D., Kandiannan, K., Srinivasa, N.V., Leela, N.K., Anandaraj, M., 2018. Comparison of conventional and transplant production systems on yield and quality of ginger (*Zingiber officinale*). Indian Journal of Agricultural Sciences 88(4), 615–20.

Prasath, D., Kandiannan, K., Srinivasn, V., Anandaraj, M., 2014. Standardization of single-sprout transplanting technique in ginger. In: Proceedings of 6th Indian Horticulture Congress. Coimbatore, 6–9 November.

Ravi,Y., Varayanpur, V.B., Hiremath, J.S., Rathod, V., Erage, M.G., Mahantesh, P.S., 2018. Quality of ginger (*Zingiber officinale* Rosc.) genotypes grown under soppina betta ecosystem of Karnataka. Journal of Pharmacognosy and Phytochemistry 3, 479–481.

Rajyalakshmi, R., Umajoythi, K., 2014. Evaluation of ginger (*Zingiber officinale* Rosc.) varieties in high altitude and tribal zone of Srikakulam district of Andhra Pradesh. Journal of Spices Aroma Crops 23(2), 258–261.

Ravindran, P.N., Babu, K.N., 2004. Ginger: The genus zingiber. CRC Press, Boca Raton, London, New York, Washington D.C., 1.

Sanwal, S.K., Yadav, R.K., Singh, P.K., 2007. Effect of types of organic manures on growth, yield and quality parameter of ginger (*Zingiber officinale*). Indian Journal of Agriculture Science 77(2), 67–72.

Sekiwa, Y., Kubota, K., Kobayashi, A., 2000. Isolation of novel glycosides from ginger and their antioxidative activity. Journal of Agricultural and Food Chemistry 48(2), 373–377.

Sengupta, D.K., Maity, T.K., Som, M.G., Bose, T.K., 1986. Effect of different rhizome size on the growth and yield of ginger (*Zingiber officinale* Rosc.). Indian Agriculture 30, 201–204.

Shaikh, A.A., Desai, M.M., Shinde, S.B., Tambe, A.D., 2010. Yield and nutrient uptake of ginger (*Zingiberofficinale* Rosc.) as affected by organic manures and fertilizers. International Journal of Agricultural Sciences 6(1), 28–30.

Shetty, G.R., Narode, K., Venkatesha, J., 2015. Performance of ginger (*Zingiber officinale* Rosc.) varieties under hill zone of Karnataka. Journal of Environment and Ecology 33(3), 1196–2000.

Shukla, Y., Singh, M., 2007. Cancer preventive properties of ginger: A brief review. Food and Chemical Toxicology 45(5), 683–690.

Wohlmuth, H., Leach, D.N., Smith, M.K., Meyers, S.P., 2005. Gingerol content of diploid and tetraploid clones of ginger (*Zingiber officinale* Roscoe). Journal of Agriculture and Food Chemistry 53(14), 5772–577.

Yadav, R.K., Yadav, D.S., Rai, N., Sanwal, S.K., Sanna, P., 2004. Commercial prospects of ginger cultivation in North-Eastern region. In Himalayan Ecology. ENVIS Bulletin 12, 1–10.