Role of Growth Regulators and Chemicals on Growth, Yield and Quality Traits of Ginger (Zingiber officinale Rosc.)

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Abstract Investigations were undertaken in ginger (Zingiber officinale Rosc.) to assess the influence of growth regulators and chemicals on yield and quality under Lower Pulney Hills condition at Horticultural Research Station, Tamil Nadu Agricultural University, Thadiyankudaisai, India. The variety Rio-de-Janeiro was utilized for the experiment. Eight treatments viz., brassinolide 0.1 ppm, paclobutrazol (pp333) 250 ppm, CCC 500 ppm, potassium chloride one per cent, salicylic acid 100 ppm, panchagavya three per cent, water were applied as foliar spray at third and fifth month after planting and control (untreated). Observations were recorded on growth, yield and quality. Plant height was higher in panchagavya treated plants whereas other growth parameters like number of tillers per plant and number of leaves per plant were higher in CCC treated plants. Yield characters viz., number of primary and secondary rhizomes per plant, length and girth of primary and secondary rhizomes, fresh and dry weight of rhizomes, yield per plot and yield per hectare were recorded highest in CCC 500 ppm foliar sprayed plants. For obtaining highest yield with good quality of ginger rhizomes, foliar application of CCC at 500 ppm could be recommended to the growers.

Keywords Ginger; Zingiber officinalis; Growth regulators; CCC; Yield; Quality

Introduction Ginger (Zingiber officinale Rosc.) belonging to the family gingerberaceae is one of the oldest and renowned commercial spice esteemed for its aroma, flavour and pungency. It is much valued as a spice, medicine as well as vegetable since very ancient days (Sasikumar, 1996). According to the ayurvedic medical system, ginger is considered to be carminative, stimulant and given in dyspepsia and flatulent colic. It is also prescribed as an adjunct to many tonics and stimulating remedies. The folk use of this ancient spice for gastrointestinal problems has been given scientific approval. Today, it is used mainly to check the symptom of travel sickness (Langner, 1998). It is used as inflammatory, anti-emetic and to treat rheumatic conditions. In western medicine it is used to prevent motion sickness, dizziness as well as post operative vomiting and vomiting during pregnancy (Grant, 2000).

Ginger has been considered indispensable in the culinary art for flavouring of foods. A number of alcoholic beverages such as brandy, wine and beer are prepared in foreign countries. Ginger oil also finds use in perfumery, pharmaceuticals and has industrial use (Pruthi, 1998). In the present day, the use of ginger in different forms is increasing which has resulted in a hike in demand the world over. In the global scenario, India still continues to be the largest producer, consumer and exporter of ginger and its products. In India during the year 2001-2002 ginger was cultivated in an area of 149,100 ha with a production of 702,000 tonnes (Bijay Kuamr et al., 2011).

The use of synthetic growth regulators and chemicals that reduce the growth of the foliage and better partitioning of dry matter in to the rhizome is much emphasized (Maruthi et al., 2003a). However the information regarding the use of plant growth regulators and chemicals in ginger crop is very limited. Hence, the present investigation was taken up to investigate the influence of growth regulators and chemicals on the yield and yield components.

Results and discussion The rhizome, yield and quality character recorded were shown significant differences among the treatments.
The data recorded are given in table 1, table 2 and table 3. For the plant height, *panchagavya* three per cent recorded highest plant height (82.43 cm). It was followed by water treatment, which recorded 77.82 cm. The lowest height of 65.72 cm was registered in the plants sprayed with CCC 500 ppm. Plant height is an important trait that decides the rhizome growth of ginger. The reduction in plant height by growth regulators and chemicals are effective in moderating the vegetative growth by mobilizing the photosynthates from other parts to the rhizomes and activating synthetic enzymes thereby increasing the rhizome growth. In this present study, the lowest plant height was obtained in CCC sprayed plants. This might be attributed due to the reduction in internodal length and the inhibition of cell division (Maruthi et al., 2003a) and the anti-gibberellin activity of CCC (Ravisankar, 1983). These results are in conformity with Nambiar et al (1976) in sweet potato, Ravisankar (1983) in ginger, Vijayakumar and Abdhul Khader (1986) in cassava and Phogat and Singh (1987) in turmeric.

The spray of growth regulators and chemicals revealed that plants treated with CCC 500 ppm recorded the highest number of tillers (13.22) per plant, which was followed by paclobutrazol (pp333) 250 ppm recorded 10.44 and it was on par with *panchagavya* three per cent. The lowest values (8.25) were recorded in the

### Table 1 Role of growth regulators and chemicals on growth parameters

| Treatments          | Plant height (cm) | Number of tillers per plant | Number of leaves per plant |
|---------------------|-------------------|-----------------------------|---------------------------|
| Brassinolide 0.1 ppm| 76.71             | 9.33                        | 91.40                     |
| Paclobutrazol (pp333) 250 ppm | 68.90           | 10.44                       | 97.70                     |
| CCC 500 ppm        | 65.72             | 13.22                       | 105.20                    |
| Potassium chloride 1% | 77.03            | 9.11                        | 90.50                     |
| Salicylic acid 100 ppm | 75.15            | 9.33                        | 90.90                     |
| Panchagavya 3%     | 82.43             | 10.25                       | 112.90                    |
| Water              | 77.82             | 8.25                        | 88.70                     |
| Control            | 76.71             | 8.25                        | 87.20                     |
| SEd                | 1.84              | 0.16                        | 1.59                      |
| CD at 5%           | 4.02              | 0.35                        | 3.41                      |

### Table 2 Role of growth regulators and chemicals on rhizome characters

| Treatments          | Number of primary rhizomes | Number of secondary rhizomes | Length of primary rhizomes (cm) | Girth of primary rhizomes (cm) | Length of secondary rhizomes (cm) | Girth of secondary rhizomes (cm) |
|---------------------|-----------------------------|-------------------------------|---------------------------------|-------------------------------|---------------------------------|---------------------------------|
| Brassinolide 0.1 ppm| 6.36                        | 10.20                         | 7.72                            | 7.69                          | 6.36                            | 6.34                            |
| Paclobutrazol (pp333) 250 ppm | 7.01                 | 11.28                        | 8.13                            | 8.23                          | 7.24                            | 6.98                            |
| CCC 500 ppm        | 7.98                        | 12.20                         | 9.31                            | 9.83                          | 7.95                            | 7.93                            |
| Potassium chloride 1% | 6.40                        | 9.92                          | 7.70                            | 7.53                          | 6.27                            | 6.31                            |
| Salicylic acid 100 ppm | 6.56                        | 9.96                          | 7.68                            | 7.51                          | 6.23                            | 6.27                            |
| Panchagavya 3%     | 6.96                        | 10.98                         | 8.01                            | 8.11                          | 7.16                            | 6.97                            |
| Water              | 6.19                        | 8.60                          | 7.38                            | 7.28                          | 5.60                            | 5.78                            |
| Control            | 6.12                        | 8.47                          | 7.17                            | 7.19                          | 5.53                            | 5.67                            |
| SEd                | 0.11                        | 0.17                          | 0.13                            | 0.13                          | 0.11                            | 0.16                            |
| CD at 5%           | 0.24                        | 0.36                          | 0.28                            | 0.27                          | 0.23                            | 0.35                            |
Table 3 Role of growth regulators and chemicals on yield and quality characters

| Treatments            | Fresh weight of rhizomes (g) | Yield per plot (kg) | Yield per ha (tonnes) | Crude fiber (%) | Essential oil (%) |
|-----------------------|-----------------------------|---------------------|-----------------------|-----------------|------------------|
| Brassinolide 0.1 ppm  | 186.62                      | 8.96                | 21.50                 | 4.60            | 1.55             |
| Paclobutrazol (pp 333) 250 ppm | 206.38              | 9.91                | 23.77                 | 5.56            | 1.56             |
| CCC 500 ppm           | 226.36                      | 10.87               | 26.08                 | 6.60            | 1.91             |
| Potassium chloride 1% | 183.12                      | 8.79                | 21.10                 | 4.65            | 1.58             |
| Salicylic acid 100 ppm | 182.95                      | 8.78                | 21.07                 | 4.66            | 1.55             |
| Panchagavya 3%        | 200.76                      | 9.64                | 23.13                 | 4.71            | 1.73             |
| Water                 | 155.25                      | 7.45                | 17.88                 | 4.17            | 1.34             |
| Control               | 151.85                      | 7.29                | 17.50                 | 4.11            | 1.32             |
| SEd                   | 3.10                        | 0.15                | 0.36                  | 0.08            | 0.03             |
| CD at 5%              | 6.66                        | 0.32                | 0.72                  | 0.17            | 0.56             |

control. CCC has decisive role in the suppression of apical dominance and diverting the polar transport of auxin towards the basal buds leading to increased tiller production. These findings are in accordance with the reports of Ravisankar (1983) in ginger, Vijayakumar and Abdhul Khader (1986) in cassava, Phogat and Singh (1987) and Maruthi et al (2003a) in ginger.

For the trait number of leaves per plant, the plants sprayed with panchagavya three per cent recorded the highest values (112.9). It was followed by CCC 500 ppm (105.2) and the lowest number of leaves per plant of 87.2 was registered in control. This indicated that panchagavya played a decisive role in inducing the apical growth of plant and accelerating the formation of highest number of leaves per plant. The indole acetic acid, GA and chemolitho autotrophic nitrifiers in panchagavya contributed for the highest number of leaves per plant (Somasundaram et al., 2003). Number of leaves per plant in the plants treated CCC 500 ppm was on par with panchagavya treatment. This might be due to increased number of tillers per plant (Ravisankar, 1983 and Maruthi et al., 2003a).

The effect of growth regulators and chemicals on number of primary rhizomes per plant showed that the highest number of primary rhizomes per plant was recorded in CCC 500 ppm (7.98). It was followed by paclobutrazol (pp333) 250 ppm (7.01) which was on par with panchagavya three per cent. The minimum value was recorded with control (6.12). The number of secondary rhizomes per plant exhibited the similar pattern as that of number of primary rhizomes. The more number of secondary rhizomes was recorded with the plants treated with CCC 500 ppm (12.20). It was followed by paclobutrazol (pp333) 250 ppm (11.28), which was on par with panchagavya three per cent. The lowest values were registered in control (8.47).

The effect of CCC on suppressing vegetative growth resulted in better utilization of carbohydrates and its effective translocation resulted in more number of primary and secondary rhizomes per plant. This is in agreement with the results of Nambiar et al (1976) in sweet potato, Das et al (1980) in garlic, Ravisankar (1983) in ginger, Vijayakumar (1984) in Chinese potato and Phogat and Singh (1987) in ginger.

The highest length of primary and secondary rhizomes (9.31 cm and 7.95 respectively) was noticed in CCC 500 ppm. It was followed by paclobutrazol (pp333) 250 ppm (8.13 cm and 7.24 cm respectively). The lowest value (7.17 cm and 5.53 cm respectively) was observed in control. Similar trend were observed for girth of the primary and secondary rhizomes. The girth of the primary and secondary rhizomes (9.83 cm and 7.93 respectively) was noticed in CCC 500 ppm that followed by paclobutrazol (pp333) 250 ppm (8.23 cm and 6.98 cm respectively). The lowest value (7.19 cm and 5.67 cm respectively) was observed in control.

The length and girth of primary and secondary rhizomes also important yield contributing characters. In this present study, the plants sprayed with CCC
recorded highest length and girth of primary and secondary rhizomes. The CCC might have enhanced the translocation of carbohydrates to the developing sink and contributed for better enlargement of rhizomes. Another reason could be the reduced vegetative growth there by increased the production of sizable rhizomes. The present results are in similarity with the findings of Nambiar et al (1976) and Abdhul Vahab and Mohana Kumaran (1980) in sweet potato and Phogat and Singh (1987) in ginger.

For fresh weight of the rhizomes, the plants treated with CCC 500 ppm recorded highest value of 226.36 g per plant. It was followed by paclobutrazol (pp333) 250 ppm recorded 206.38 g, which was on par with panchagavya three per cent. The lowest fresh weight of rhizomes of 151.85 g was recorded in control. The increased rhizome weight could be attributed to enhanced photosynthetic activity and improved translocation of photosynthates to the developing rhizomes. The early tuberization also increased the activity of storage sink in mobilizing the photosynthates from leaves and stem. These results confirm the earlier findings of Radwan et al (1971) and Sarkar and Singh (1984) in potato, Mishra et al (1987) in sweet potato and Satheesan and Ramadasan (1988) in turmeric. Highest yield of rhizomes per plot and per hectare (10.87 kg and 26.08 tonnes respectively) was recorded in CCC 500 ppm that followed by paclobutrazol (pp333) 250 ppm registered 9.91 kg and 23.77 tonnes respectively. The lowest yield (7.29 kg and 17.50 tonnes respectively) of rhizomes per plot was noticed in control. The highest yield might be due to positive influence on yield contributing characters like increased number of rhizomes and size in terms of rhizome length and girth. The rapid proliferation of xylem parenchyma, formation of storage rhizomes earlier and production of more number of rhizomes also helpful in increasing the yield. The results are in consonance with the findings of Radwan et al (1971), Banerjee and Das (1984) and Sarkar and Singh (1984) in potato, Vijayakumar and Abdhul Khader (1986) in cassava, Mishra et al (1987) in sweet potato, Jayachandran and Sethumadhavan (1988) and Maruthi et al (2003b) in ginger.

Quality characters
The crude fibre content at harvest was highest (6.60 per cent) in CCC 500 ppm and it was followed by paclobutrazol (pp333) 250 ppm recorded 5.56%. The lowest crude fibre content (4.11%) was noticed in control. The mode of action behind the treatment is thickening of fibre cells with advancing maturity that would have resulted in more crude fibre content. The earlier works of Jayachandran and Sethumadhavan (1988) and Maruthi et al (2003b) in ginger supported the findings of present study. The observations on essential oil showed that the highest content (1.91 per cent) was noticed in CCC 500 ppm (T3) that followed by panchagavya three per cent (T6) recorded 1.73 per cent. The lowest value of essential oil (1.32 per cent) was recorded in control. The CCC has the ability to block the biosynthesis of gibberellins thereby improved the oil content. This is in agreement with the findings of Ravisankar (1983), Jayachandran and Sethumadhavan (1988) and Maruthi et al (2003b) in ginger.

From this experiment it can be concluded that for obtaining highest yield with good quality of ginger rhizomes, foliar application of CCC at 500 ppm could be recommended to the growers.

Material and Methods
The present investigations in ginger “Studies on influence of growth regulators and chemicals on dormancy and growth and development of ginger (Zingiber officinale Rosc.) under Lower Pulney Hills” were conducted at Horticultural Research Station, TNAU, Thadiyankudisai, Tamil Nadu, India. Well-sprouted seed rhizomes of the promising ginger variety Rio-de-Janeiro collected from the farmer’s field in Kottayam district of Kerala were utilized for experiment. The field was prepared well and 24 raised beds with the size of 3 m×1 m were taken at an inter space of 50 cm between the beds. Seed rhizome bits of 15–20 g weight, with one or two well-sprouted buds, were planted at a distance of 25 cm×25 cm in raised beds, accommodating 48 plants per bed. The crop was
maintained following the regular cultural, manurial and other plant protection operations as per the package of practices recommendations of Tamil Nadu Agricultural University (Anon, 2004). The treatments were imposed at third and fifth month after planting with different growth regulators and chemicals as foliar spray.

The experiment was conducted in field condition in a randomized block design with three replications. Observations were taken at the time of harvesting i.e., 210 days after planting. Growth character like plant height, number of tiller per plant and number of leaves per plant were observed. Yield characters viz., number of primary and secondary rhizomes per plant, length and girth of primary and secondary rhizomes, fresh and dry weight of rhizomes, yield per plot and yield per hectare were recorded.

The important quality parameters like crude fibre and essential oil content were also recorded. The crude fibre content at harvest was estimated on dry weight basis as per the procedure of (A.O.A.C., 1980) and expressed in percentage. Essential oil at harvest was extracted on dry weight basis using Soxhlet apparatus (A.S.T.A., 1968) and the yield is expressed in percentage.

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