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Effect of stockosorb on growth, flowering and yield of Khasi Mandarin (*Citrus reticulata*: Rutaceae) in Arunachal Pradesh, India

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Abstract

Khasi mandarin is the only species growing commercially by the farmers as rainfed orange crop in Arunachal Pradesh.The present study was conducted in Roing area on 6 years matured plants to know the effect of stockosorb on growth, flowering and yield of Khasi mandarin. Stockosorb ranging from 0–120 g/tree was used. Plants treated with 120 g stockosorb have shown the best result in term of growth (height and stem girth), flowering and yield of fruits. Thus, use of stockosorb in orange orchard should be promoted in rainfed areas like Arunachal Pradesh.

Keywords: Drought, orange, Roing, soil moisture conservation.

INTRODUCTION

The attractive evergreen foliage and flowers as well as the extraordinary fragrance are the added aesthetic value of Khasi mandarin tree. Khasi mandarin has great economic potential as it produces excellent fruit quality. The fruits are not only delicious and refreshing but also, they provide vitamins, minerals and many other substances. The principal edible portion of Khasi mandarin fruit is the juice present in vesicles. The juice of mandarins contains about 12% sugar, 0.5–1.5% titratable acidity and other soluble solids, 1% citric acid, about 50 mg/100 ml ascorbic acid/juice and about 70–90% water. Citric acid is the characteristic organic acid of all citrus fruits. It accounts for most acidity in the fruit juice with exception like sweet lime where it is so low that malic acid exceeds citric acid (Clements, 1964).

The total mandarin production in India is 62.19 lakh tons from a total area of 4,77,000 ha with the productivity of 12.54 t/ha (Press Information Bureau, 2022). Total production of Khasi mandarin in Arunachal Pradesh accounts 5.95 MT/ha, which is quite low as compared to the national production of 9.23 MT/ha (Mope *et al.*, 2021). This low productivity is due to negligence, malnutrition and general negligence of the citrus orchard (Chaturvedi *et al.*, 2018).

The main citrus growing districts in Arunachal Pradesh are East Siang, Lower Dibang Valley, Lower Subansiri, Siang, Upper Siang and West Siang. Though various species of citrus are found growing in wild habitat in Arunachal Pradesh and Northeast regions of India, the Khasi mandarin is the only species growing commercially by the farmers as rainfed crop (Singh *et al.*,2016). The pre-monsoon rain comes unpredictably during the month of April or May, though the maximum rainfall is received between June–October. The remaining part of the year remains dry.

Moisture stress caused during November–March induces dormancy and is a substitute of low temperature. But the failure of 'blossom shower' and subsequent failure of precipitation demands for irrigation, otherwise there will be no flowering or fruit setting. Therefore, realizing the importance of soil moisture conservation, the present study was conducted to know the effect of stockosorb on growth, flowering and yield of Khasi mandarin. The

soil of the experiment site is sandy loam with presence of gravels and stones which caused deep percolation and less moisture retentive. An attempt was made to conserve the soil moisture in the root zone of the plant, received through precipitation, by the application of stockosorb at different levels ranging from 0–120 g of dose per tree, with the objective to improve the yield and fruit quality of Khasi mandarin through application of stockosorb.

Stockosorb is a hydrogel soil conditioner that is applied for water and nutrient retention in the soil, improving water management and plant growth. It acts as a water reservoir and releases it according to the plant needs. Stockosorb hydrogel will absorb water and nutrients during rainfalls. It has the water retention capacity up to 500 times its own weight (Buchholz, 1998; Kazanskii and Dubrovskii, 1992); thereby stockosorb keeps the soil moist and hold the nutrients from leaching out and make them available to the plant in a long period of drought. Water and nutrients will remain stored into the hydrogel and released in the root zone during dryer times. Stockosorb can reduce irrigation frequencies up to 50 %. Stockosorb remains performant during 2–3 seasons (Bore, 2023).

Chemical name of stockosorb: Cross-linked Acrylamide/Potassium Acrylate Copolymer.

Composition of stockosorb hydrogel: 2-Propenoic acid, potassium salt, polymer with 2-propenamide

Current market price: Rs. 700/kg.

Properties of stockosorb hydrogel:

Appearance : White powder
Odor : None
Physical state : Solid
pH : 6.75 (1 g/l in water)
Vapor Pressure : <15 mm Hg@20ºC (68°F)
Melting Point : >199°C (390˚F).
Solubility (H2O) : Essentially insoluble
Specific Gravity : ~0.7 g/cm
Particle Size : 200 – 4000 microns
Bulk Density : ~660 kg/m

MATERIALS AND METHODS

Effect of stockosorb on growth, flowering and yield of Khasi mandarin was carried out during 2021–2022. Field experiments were conducted at orchards of progressive farmer in Roing, Lower Dibang Valley district. Six years old uniform healthy Khasi mandarin trees at 6×6 m grown under rainfed were selected for the experiment. The experiment was laid out in randomized block design with three replication and seven treatments. The treatment was imposed during the month of December 2021 after the harvest of previous year crop. The basin of the tree was properly cleaned and the soil was loosened by slight digging. Stockosorb was applied in 30 cm wide×15 cm deep circular trench made around the tree at a radius of 2 m from the tree trunk. Stockosorb was uniformly spread in the trench and then covered with pulverized soil. 450 g each of Nitrogen and Phosphorus pentoxide, and 900 g of Potassium oxide was supplemented to each plant in a year. Nitrogen was given in a single dose, whereas Phosphorus pentoxide and Potassium oxide were given in two doses. Fertilizers were uniformly broadcasted and incorporated in the soil by light digging.

Stem girth was recorded at 25 cm above ground level. For flowering percentage, one year old healthy branches were selected, counted the number of flowering buds, and tagged accordingly. Ten average sized fruits from each treatment (tree) were taken as representative samples for measuring weight. The yield of fruit was calculated by multiplying number of fruits with average weight.

RESULTS AND DISCUSSION

Growth of plants: The effect of stockosorb showed significant influence in the plant height and stem girth (Table 1). It was observed that the maximum increase in plant height (25.7cm) and stem girth (0.86cm) were recorded in T_7, whereas the lowest was recorded in control T_1 i.e., 20.7cm and 0.65 cm respectively. Similar results were also reported by Pattanaaik *et al.*, (2015).

Many researchers have already worked on effect of hydrogel on various plants except for Khasi mandarin, which give us an opportunity and a strong supporting led to the current experiment. Sivalapan (2001) reported that the application of polymer (ALCOSORB®400) into the soil have increased the plant height of soybean cv. Stephens. Similar results were also observed by Sendur *et al.,* (2001) in tomato, Azavedo *et al.,* (2002) in coffee cv. Tupi, Jiang *et al.,* (2005) in *Parthenocissus quinquefolis* and Anupama *et al.,* (2005) in *Chrysanthemum* cv. Yellow bouquet.

The increase in plant height is due to more retention of moisture and indirectly the availability of nutrients provided by stockosorb, where it might have helped to increase the activity of cell division, expansion and elongation, ultimately leading to increased plant height.

Table 1: Effect of stockosorb on plant height, stem girth and canopy size of Khasi mandarin.

Treatment: Stockosorb used	Plant height in m			Stem girth in cm			Canopy size in m (North–South direction)			Canopy size in m (East–West direction)		
	Mean Initial	Mean Final	Differ-ence	Mean Initial	Mean Final	Differ-ence	Mean Initial	Mean Final	Differ-ence	Mean Initial	Mean Final	Differ-ence
T1: 0 g/tree	4.600	4.807	0.207	40.85	41.50	0.65	2.72	2.92	0.20	2.80	3.05	0.24
T2: 20 g/tree	4.583	4.806	0.223	40.07	40.73	0.66	2.76	2.98	0.22	2.41	2.67	0.26
T3: 40 g/tree	4.636	4.856	0.220	33.98	34.70	0.72	2.37	2.60	0.23	2.46	2.73	0.27
T4: 60 g/tree	4.480	4.717	0.237	39.78	40.53	0.75	2.69	2.95	0.26	2.56	2.85	0.29
T5: 80 g/tree	4.497	4.737	0.240	32.66	33.48	0.83	2.84	3.10	0.26	2.55	2.83	0.28
T6: 100 g/tree	4.447	4.694	0.247	43.97	44.80	0.83	2.93	3.21	0.28	2.78	3.10	0.31
T7: 120 g/tree	4.613	4.870	0.257	40.91	41.80	0.86	3.25	3.54	0.29	2.74	3.08	0.34
CV	–	–	2.705	–	–	3.733	–	–	7.853	–	–	4.468
CD at 5%	–	–	0.011	–	–	0.050	–	–	0.034	–	–	0.023

Table 2: Effect of stockosorb on flowering and yield of Khasi mandarin.

Treatment: Stockosorb used	Flowering percentage	Number of Fruits/tree	Mean weight/fruit in g	Weight of total fruits/tree in kg	Weight of fruits/ hectare in ton
T1: 0 g/tree	23.67	105.04	109.22	11.48	3.17
T2: 20 g/tree	34.67	113.77	112.13	12.76	3.53
T3: 40 g/tree	42.33	124.74	114.52	14.29	3.96
T4: 60 g/tree	45.33	149.67	115.85	17.33	4.80
T5: 80 g/tree	49.00	169.00	117.43	19.84	5.49
T6: 100 g/tree	56.00	180.67	118.44	21.38	5.92
T7: 120 g/tree	66.33	178.57	120.12	21.45	5.94
CV	3.591	5.793	1.239	5.517	5.520
CD at 5%	2.897	15.040	2.544	1.662	0.461

Photo plate-I

Orange orchard

Circular trench prepared around the trees

Adding stockosorb to soil

Layering with pulverized soil

Treatment 3

Treatment 4

Treatment 5

Treatment 7

In the case of stem girth, T_7, T_6 and T_5 have depicted a similar effect. Though maximum increase in stem girth was found in T_7 i.e., 0.86 cm. Similarly, Szwonek (2012) reported the effect of superabsorbent gel on sweet cherry trees associated with a doubling of trunk cross sectional areas.

The effect of treatmentsT_7, T_6, T_5 and T_4 were at par to each other on the canopy spread in North–South direction, whereas T_1, T_2 and T_3 were at par to each other as well. The canopy spread of T_7 was significantly higher than all other treatments. The highest North–South direction canopy spread (0.29m) was found in T_7, while the lowest was recordedin T_1(0.20 m). Also, in the East–West direction, the canopy spread was measured highest in T_7 (0.34m) and lowest in T_1(0.24 m). Similar results were also reported in West Indies mahogany (*Swietenia mahagoni*) by Svenson (1993). WhileYazdani *et al.,* (2007) reported the plants which grew in soil with highest rate of polymer had greater 'leaf area index' as well as crop growth rate. Similarly, Anupama *et al.,* (2005) reported in *Chrysanthemum* cv. Yellowbouquet grown under controlled environment in soil less media with hydrogelexhibited most prominent growth in respect of plant height, stem diameter, number of leaves per plant, number of flowers per plant and flower size as compared to control.

Flowering percentage

The highest flowering was observed in T_7(66.33%) and lowest in controlled T_1(23.67%). The present finding goes parallel with the findings of Pattanaaik *et al.,* (2015). Use of hydrogel kept the soil moistened for a longer period which helped in reducing flower and fruit dropdue to water stress. Anupama *et al.,* (2005) also reported similar effect of hydrogelin Chrysanthemum cv. Yellow bouquet and in Sweet cherry trees by Szwonek (2012).

Fruit yield

The highest number of fruits/tree was found in treatment T_6 (180.67), whereas leastnumber of fruits/tree was recorded in T_1 (105.04). T_7 which have proved better in terms of plant growth and flowering has showed lesser number of fruits/tree (178.57) as compared to T_6. In terms of total weight of fruits, T_7showed better result (21.45 kg/tree; 5.94 ton/ha) than all other treatments. Similar results were also reported by Pattanaaik*et al.,* (2015) performed on Khasi mandarin, Szwonek (2012) on Sweet cherry, Langaroodi*et al.,* (2013) on Peanuts, Singh (1998) on potatos and onions, Tripathi *et al.,* (1997) on Indian mustard cv. Varuna, and Volkamar and Chang (1995) on Barley.

An increase in growth and yield related attributes in the present investigation could be because of sufficient availability of water and indirectly nutrients supplied by the stockosorb to the plants in water stress condition, which in turn led to better translocation of water, nutrients and photoassimilates and finally better plant development.

CONCLUSION

Application of stockosorb (hydrophilic polymer) can increase the growth, flowering and fruit yield in Khasi mandarin. Application of stockosorb should be popularised in areas lacking assured irrigation facilities and in areas with undulating topography where layout of irrigation facilities is difficult with an objective to conserve soil moisture received through precipitation. Stockosorb will prove to be an important component in the integrated approach for conservation of soil moisture in Citrus cultivation.

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