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Role of agrochemical sprays on enhancing the seedling growth of *Citrus* sp*

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Citrus is one of the most important fruit crop and ranking third in India. Among several species and varieties of Citrus, mandarin finds its premier position in Maharashtra, Karnataka, Northeastern States, Tamil Nadu, Kerala, Uttar Pradesh and West Bengal. Among the mandarins grown in the country, 3 cultivars occupy the place of prominence, ie 'Nagpur Santara', 'Khasi Mandarin' and 'Coorg Mandarin'. Most of the mandarins are raised through budded plants using a variety of rootstocks. Work carried out at Central Horticultural Experiment Station, Chettalli during 2001–03 shows that the most suitable rootstocks for 'Coorg mandarin' are 'Rangpur Time', 'Troyer Citrange' and 'Trifoliate Orange'. In the production of planting materials for 'Coorg Mandarin' the time required for the seedlings to attain the suitable size for budding may be as long as 2 years. Shortening this time would benefit nurserymen by reducing various inputs and their cost and also facilitate year round multiplication of rootstocks in the production of budlings.

'Trifoliate Orange' seedlings are extremely poor in growth and require usually 22–24 months for budding (Ganapathy *et al.* 1991). The sprays of gibberellic acid (GA_3) combined with urea were found to be most successful in improving the growth of 'Cleopatra Mandarin', 'Sour Orange' and 'Rough Lemon' (Tayder *et al.* 1992). In order to reduce the long time before the seedlings attain the buddable stage an experiment was carried out to find the efficacy of agrochemicals on the seedling growth of 3 different Citrus rootstock species under the high rainfall zone of Kodagu, Karnataka.

The present investigations on acceralation of seedling growth in the nursery stage of three citrus rootstocks, viz 'Rangpur Lime' (S_1), 'Troyer Citrange' (S_2) and 'Trifoliate Orange' (S_3) were conducted during 2001–2003 at the Central Horticultural Experiment Station (IIHR), Chettalli, Kodagu, Karnataka. The trial was conducted in a factorial randomized block design with 3 replications and in each treatment 15 polybags were maintained. The treatments consisted of foliar sprays of GA_3, urea and $ZnSO_4$ in following treatment combinations were imposed. T_1, GA_3 50 ppm + urea 0.5%; T_2, GA_3 100 ppm + urea 0.5%; T_3,GA_3 200 ppm + urea 0.5%; T_4,GA_3 50 ppm + $ZnSO_4$ 0.2%; T_5, GA_3 100 ppm + $ZnSO_4$ 0.2%; T_6, GA_3 200 ppm + $ZnSO_4$ 0.2%; T_7, GA_3 50 ppm + urea 0.5% + $ZnSO_4$ 0.2%; T_8, GA_3 100 ppm + urea 0.5% + $ZnSO_4$ 0.2%; T_9, GA_3 200 ppm + urea 0.5% + $ZnSO_4$ 0.2% and T_{10}, control.

Rootstock seeds were sourced from the citrus germplasm maintained at CHES, Chettalli. Seeds were extracted from good quality fruits obtained from 15-year-old healthy trees. Fresh seeds were sown in the primary nursery and seedlings raised by following the regular nursery practices. Forty-five-days-old healthy seedlings from primary nursery were selected and transplanted in polythene bags (30 cm × 10.5 cm) filled with farmyard manure, forest soil and sand (2:1:1). Regular nursery practices including plant protection measures were followed to keep the seedlings healthy and free from pests and diseases. The first foliar application of treatments was done at 30 days after transplanting of seedlings and the remaining 2 applications were scheduled at monthly intervals thereafter. Observations on the growth parameters, like plant height, stem diameter, leaves/plant, root length, root diameter, root volume and fresh weight were recorded. The plants were separated into stem and root portions after taking observations on growth parameters and were dried in hot air oven for determination of dry matter content.

The effects of foliar sprays on various vegetative parameters, such as plant height, root length, shoot:root ratio, stem girth, root girth, number of leaves, dry weight and root volume are presented in Table 1. A perusal of the data indicate that among the rootstocks tried, the plant height, root length, stem girth, root girth, number of leaves, dry weight and root volume were significantly better in 'Troyer Citrange'. However 'Rangpur Lime' was best when shoot:root ratio was considered.

Among various treatments the maximum increase in growth was recorded in the combined spray of GA_3 50 ppm + urea 0.5% + $ZnSO_4$ 0.2% (T_7) which was significantly superior to all other treatments. This was followed by GA_3 100 ppm + $ZnSO_4$ 0.2% (T_5) and GA_3 100 ppm + urea 0.5% + $ZnSO_4$ 0.2% (T_8) which were at par. In case of root growth

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Table 1 Effects of urea, gibberellic acid and zinc sulphate foliar sprays on the seedling growth of three citrus species

Treatment	Plant height (cm)	Root length (cm)	Shoot:root ratio	Stem girth (cm)	Root girth (cm)	No. of leaves	Dry weight (g)	Root volume (ml)
'Rangpur Lime' (S_1)	54.31	25.41	1.48	0.52	0.63	37.01	9.45	8.01
'Troyer Citrange' (S_2)	57.38	40.96	1.19	0.60	0.78	39.70	15.07	9.23
'Trifoliate Orange'(S_3)	52.85	37.56	1.19	0.55	0.53	37.62	7.26	6.74
SEm±	0.78	0.67	0.01	0.006	0.009	0.41	0.16	0.17
CD ($P = 0.05$)	2.20	1.90	0.05	0.01	0.02	1.19	0.46	0.47
T_1	54.63	35.27	1.27	0.60	0.70	38.13	11.24	8.16
T_2	51.54	34.26	1.24	0.56	0.67	36.24	10.94	8.10
T_3	52.52	29.35	1.36	0.54	0.62	34.37	8.85	7.38
T_4	52.81	32.95	1.29	0.56	0.66	37.02	10.89	7.89
T_5	60.87	36.65	1.30	0.54	0.68	41.16	11.49	8.03
T_6	54.32	30.78	1.36	0.52	0.65	37.90	9.37	7.62
T_7	62.28	42.74	1.22	0.62	0.74	42.54	13.57	9.76
T_8	59.10	40.23	1.25	0.62	0.65	41.00	12.15	9.53
T_9	58.19	38.02	1.28	0.57	0.64	39.38	11.06	8.62
T_{10}	42.22	26.16	1.29	0.44	0.48	33.37	6.37	5.16
SEm±	1.42	1.22	0.03	0.01	0.017	0.77	0.29	0.30
CD ($P = 0.05$)	4.01	3.46	0.98	0.03	0.05	2.17	0.83	0.86

T_1, GA_3 50 ppm + urea 0.5%; T_2, GA_3 100 ppm + urea 0.5%; T_3, GA_3 200 ppm + urea 0.5%; T_4, GA_3 50 ppm + $ZnSO_4$ 0.2%; T_5, GA_3 100 ppm + $ZnSO_4$ 0.2%; T_6, GA_3 200 ppm + $ZnSO_4$ 0.2%; T_7, GA_3 50 ppm + urea 0.5% + $ZnSO_4$ 0.2%; T_8, GA_3 100 ppm + urea 0.5% + $ZnSO_4$ 0.2%; T_9, GA_3 200 ppm + urea 0.5% + $ZnSO_4$ 0.2% and T_{10}, control

and number of leaves, GA_3 50 ppm + urea 0.5% + $ZnSO_4$ 0.2% was superior to all other treatments. Increased growth of seedlings may be attributed to the fact that vegetative growth is greatly influenced by the foliar spray of GA_3 and urea (Sheo Govind and Singh 1999; Modesto *et al.* 1999, Dalal *et al.* 2002, Tayder *et al.* 1992 and Ganapathy *et al.* 1991). Further it is established that gibberellins are typically responsible for promoting stem growth by increasing the size of the internode cells.

The dry weight of the plant was also increased significantly by the treatment which has received GA_3 50 ppm + urea 0.5% + $ZnSO_4$ 0.2% (T_7) in all the 3 rootstocks. The combined effect of the chemicals on the growth may be due to the absorbed nitrogen, which is a constituent of amino acids, amides, proteins, nucleic acids, nucleotides, coenzymes and hexosamines essential for cell division, growth and respiration. $ZnSO_4$ activate the normal nitrate reduction phenomenon for synthesis of protein, which protects chlorophyll destruction. In the presence of GA_3 a large amount of newly synthesized proteins led to the increased plant growth.

The data on the interaction effects of various treatments with different rootstocks are presented in Table 2. The combination of GA_3 50 ppm + urea 0.5% + $ZnSO_4$ 0.2% in 'Rangpur Lime' and 'Troyer Citrange' rootstocks gave the maximum values for plant height, root length, stem girth, root girth, number of leaves and dry weight, which was found to be superior over the control. In case of 'Trifoliate Orange' the treatment combination GA_3 50 ppm + urea 0.5% + $ZnSO_4$ 0.2% gave the maximum plant height, root girth and dry weight, where maximum root length, number of leaves, stem girth and root volume was recorded in GA_3 100 ppm + urea 0.5% + $ZnSO_4$ 0.2%. Among the 3 rootstocks the treatment combinations of GA_3 50 ppm + urea 0.5% + $ZnSO_4$ 0.2% and GA_3 100 ppm + urea 0.5% + $ZnSO_4$ 0.2% were at par for most of the characters except stem girth. The increased dry matter production could be caused by the combined effect of gibberellic acid, urea and $ZnSO_4$. Further study concluded that application of 3 sprays of GA_3 50 ppm + urea 0.5% + $ZnSO_4$ 0.2%, first spray 30 days after transplanting and remaining 2 sprays at monthly intervals thereafter in the nursery produced buddable seedlings in 9 months in all the 3 citrus rootstocks.

SUMMARY

An experiment was conducted during 2001–2003 on acceralation of seedling growth of 3 citrus rootstocks at Central Horticultural Experiment Station, Chettalli, Kodagu, Karnataka. The treatments consisted of foliar sprays of GA_3 (50, 100, 200 ppm), urea (0.5%) and $ZnSO_4$ (0.2%) in different combinations. The growth of 'Rangpur Lime', 'Troyer Citrange' and 'Trifoliate Orange' seedlings in the nursery was significantly accelerated with spraying combination of GA_3 50 ppm + urea 0.5% + $ZnSO_4$ 0.2% (T_7) as compared to control. The combined application of GA_3 50 ppm + urea 0.5% + $ZnSO_4$ 0.2% was more effective for enhancing the height (62.28 cm), girth (0.62 cm), number of leaves (42.54), root length (42.74 cm), root girth (0.74 cm), root volume (9.76 ml) and dry matter content (13.57 g) of three citrus rootstocks. Among the rootstocks tried 'Troyer Citrange' has responded better to the treatments. The results showed that the growth of all the 3 citrus rootstock seedlings could be

Table 2 Interaction effects of the three rootstocks and foliar applications of urea, gibberellic acid and zinc sulphate on seedling growth

Treatment	Plant height (cm)	Root length (cm)	Shoot:root ratio	Stem girth (cm)	Root girth (cm)	No. of leaves	Dry weight (g)	Root volume (ml)
S_1T_1	57.53	27.17	1.47	0.56	0.70	39.00	10.01	7.78
S_1T_2	51.43	25.80	1.42	0.51	0.64	36.04	10.82	8.88
S_1T_3	54.93	21.37	1.61	0.53	0.59	31.45	8.60	8.55
S_1T_4	49.53	23.20	1.46	0.50	0.62	34.82	9.89	7.71
S_1T_5	58.97	31.20	1.39	0.50	0.70	40.57	10.11	7.88
S_1T_6	52.02	20.97	1.58	0.47	0.60	37.45	7.53	8.00
S_1T_7	62.27	33.20	1.38	0.59	0.72	41.72	12.01	9.11
S_1T_8	55.97	26.97	1.47	0.57	0.63	37.82	9.50	10.00
S_1T_9	56.20	24.10	1.54	0.54	0.59	37.22	9.66	8.70
S_1T_{10}	44.23	20.10	1.49	0.47	0.53	34.00	6.41	4.44
S_2T_1	60.38	43.42	1.18	0.64	0.87	40.75	16.81	10.89
S_2T_2	58.35	39.54	1.21	0.59	0.82	37.98	15.14	9.51
S_2T_3	57.64	37.38	1.24	0.57	0.80	38.77	13.34	8.21
S_2T_4	57.71	40.97	1.19	0.58	0.84	37.90	15.72	9.70
S_2T_5	58.92	38.01	1.25	0.59	0.77	40.67	14.84	8.22
S_2T_6	52.37	35.86	1.21	0.57	0.82	38.21	13.42	8.07
S_2T_7	63.49	49.04	1.14	0.70	0.89	44.66	19.12	11.59
S_2T_8	60.48	46.87	1.14	0.68	0.71	41.78	17.53	9.88
S_2T_9	57.49	47.91	1.10	0.60	0.76	40.58	15.75	9.55
S_2T_{10}	47.02	30.58	1.24	0.48	0.51	35.70	9.06	6.70
S_3T_1	45.98	35.22	1.14	0.60	0.53	34.62	6.91	5.81
S_3T_2	44.84	37.44	1.09	0.57	0.53	34.71	6.87	5.92
S_3T_3	45.00	29.30	1.23	0.53	0.45	32.87	4.60	5.37
S_3T_4	51.18	34.66	1.21	0.59	0.54	38.32	7.07	6.26
S_3T_5	54.72	40.74	1.26	0.54	0.58	42.24	9.54	8.00
S_3T_6	58.57	35.50	1.29	0.51	0.54	38.03	7.16	6.79
S_3T_7	61.09	45.99	1.15	0.59	0.60	41.23	9.58	8.59
S_3T_8	60.86	46.85	1.14	0.62	0.60	43.42	9.43	8.71
S_3T_9	60.88	42.06	1.20	0.58	0.57	40.34	7.76	7.63
S_3T_{10}	35.39	27.81	1.13	0.38	0.39	30.41	3.65	4.33
S Em ±	2.46	2.12	0.05	0.02	0.03	1.32	0.51	0.52
CD ($P = 0.05$)	6.96	6.00	0.17	0.056	0.087	3.75	1.45	1.48

S_1, 'Rangpur Lime'; S_2, 'Troyer Citrange'; S_3, 'Trifoliate Orange'

T_1, GA_3 50 ppm + urea 0.5%; T_2, GA_3 100 ppm + urea 0.5%; T_3, GA_3 200 ppm + urea 0.5%; T_4, GA_3 50 ppm + $ZnSO_4$ 0.2%; T_5, GA_3 100 ppm + $ZnSO_4$ 0.2%; T_6, GA_3 200 ppm + $ZnSO_4$ 0.2%; T_7, GA_3 50 ppm + urea 0.5% + $ZnSO_4$ 0.2%; T_8, GA_3 100 ppm + urea 0.5% + $ZnSO_4$ 0.2%; T_9, GA_3 200 ppm + urea 0.5% + $ZnSO_4$ 0.2% and T_{10}, control

hastened by 3 sprays of GA_3 50 ppm + urea 0.5% + $ZnSO_4$ 0.2% (first spray 30 days after transplanting and remaining 2 sprays at monthly intervals) compared to control and the seedlings could become buddable in about 9 months against 12–15 months in conventional multiplication.

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