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Rejuvenation of Nagpur Mandarin (*Citrus reticulata* Blanco.) through top working

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Abstract
The experiment was carried out at the farmers' field at Nimoda and Ummedpura villages, Jhalrapatan, Jhalawar during the year 2009-10. Declining plants of Nagpur Mandarin were subjected to different time of top working. It was observed that mid October time of budding as a part of top working on beheaded plants had significantly better effect on budding performance and growth. Maximum bud take per cent (75.80 %), minimum days required to first sprouting (18.27 days), minimum days required to 50 per cent sprouting (53.26 days) and the maximum budding success (70.23 %) were recorded in mid October budding time. Under this treatment maximum length of sprout shoot (14.19 cm), diameter of sprout shoot (4.97), number of nodes (11.04), length of internodes (1.29), plant height (31.01 cm) number of leaves on sprout shoots (15.23), leaf area (15.23 cm^2), perimeter of leaves (20.25 cm) and chlorophyll content (3.704 mg/g) were noted.

Key words : *Rejuvenation, Nagpur Mandarin, top working*

Introduction

Nagpur Mandarin (*Citrus reticulata* Blanco.) is the most valued member of citrus group. It belongs to the family Rutaceae. Mahararashtra, Rajasthan, Karnataka, Madhya Pradesh, Nagaland, West Bengal, Assam, Meghalaya and Tripura are the major mandarin producing states in the country. It covers 2.85 lac hectares area in India and the production is 20.84 lac tonnes. In Rajasthan, the fruit occupies 8900 ha area producing 1.35 lac tonnes of fruits annually (Anon., 2011). Mandarin fruits are rich in calcium and potassium. They are mostly consumed as fresh. Fruits are processed into various products and by-products. Essential oil and pulp are major by-products. Essential oils are used in cosmetics, soaps, perfumes and aromatherapy and for pharmaceutical purposes. The essential oil possesses anti-fungal property against phytopathogens. There are many reasons for low productivity, but the malady of citrus decline is the major contributing factor. All citrus species and varieties are susceptible to decline, but the mandarins are the most susceptible, followed by sweet oranges. The causes of this problem are still unknown. It may be due to several reasons such as mismanagement of the orchard, improper soil type, poor drainage, nutritional deficiencies, insects and diseases etc. Rejuvenation is resorted as an alternative to bring back the plant in its normal capability (Singh *et al*., 2010). Besides pruning, it may also be attempted through top working. Top working being feasible, it may be made use in averting the declining situation in citrus orchard provided extent of decline, age of tree, soil and climatic conditions etc also do favours. Keeping all these considerations in notion the present investigation was planned so as to observe the efficacy of top working on rejuvenation of the declining mandarin.

Materials and Methods

The experiment was carried out in declining orchard of mandarin during the year 2009-10 at the farmers' field at Nimoda and Ummedpura villages, Jhalrapatan, Jhalawar. Jhalawar falls at $23^0$45'20" to $24^0$52'17" N latitude and $75^0$27'35" to $76^0$56'46" E longitude in South Eastern Rajasthan. The district receives on an average 954.7 mm rainfall. Maximum temperature range in the summer is 43-48 ^{0}C and minimum 1 - 2.6 ^{0}C during winter. The pattern of weather parameters during investigation period are presented by Fig. 1. The treatments consisted of budding operation followed during the period of 15 September, 1 October, 15 October, 1 November and 15 November 2010. Declining plants of Nagpur Mandarin were subjected to different time of top working following beheading them at 15 cm height from ground level during the second week of

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May, 2009. With three plants as an experimental unit and five replications, considering 75 plants from among declining plants the experiment was carried out. Observations on budding performance, stem parameters and leaf parameters were recorded. Under budding performance, bud take was recorded on the basis of number of buds which manifested swelling on a particular rootstock. Total number of buds sprouted, whether survived further or not, constituted the observation on bud take. The number of sprouted buds in different treatments were recorded in order to calculate the percentage of bud take. The per cent bud take was calculated after a fortnight of budding operation. All the budded plants were visited regularly and date on which bud sprouted was recorded. The sprout which continued surviving till one month after sprouting were included to record budding success per cent.

As a part of stem parameters the length of sprouted scion shoot was measured with the help of a meter scale. The diameter of new shoot was measured with the help of Vernier caliper. It was measured at the very base of its sprouting near the bud union. The height of the plant was measured from the level of soil surface to the highest tip of the plant with the help of a meter scale. The number of nodes was recorded by counting the number of nodes on entire plant.The length of internodes was measured between length of two nodes with the help of a meter scale.Leaves emerging from the newly sprouted scion shoot were counted to make observation on number of leaves present on the scion shoot.

Leaf area was measured with the help of a leaf area meter. The same leaves as used for recording leaf area were used to measure perimeter. Chlorophyll content was measured as per the method suggested by Sadasivam and Manickam (1997). The RWC (relative water content) of leaves was also measured using the following formulae (Yadav,2009) :

$$RWC\,(\%) = \frac{FW\text{-}DW}{TW\text{-}DW} \times 100$$

Where: FW = Fresh weight; DW = Dry weight and TW = Turgid weight. As a part of the formulae (a) Fresh weight of leaves was measured selecting three fully grown leaves from the plants randomly at 15 days interval followed by weighing them with the help of an electronic balance (b) Turgid weight of the leaves was recorded selecting the same leaves as used for recording fresh weight followed by dipping them in distilled water for 24 hours and recording their weight with the help of an electronic balance (c) Dry weight of leaves was recorded by subjecting the turgid weight measured leaves to drying treatment in oven at 60°C for 24 hours and recording the weight their of.

Results and Discussion

Budding performance

The maximum bud take percentage (75.80 %), minimum days required to first sprouting (18.27), 50 % sprouting (53.23) and budding success (70.23 %) were observed when budding was done on 15 October (Table 1, Fig. 2). It may be due to rapid and complete union of xylem and cambium tissues favouring closer matching of the scion to the rootstock tissues (Hartmann *et al.* 1997). The low bud-take percentage as observed in case of 15 September budding might be due to low callus formation (Hartmann *et al*., 1997) under comparatively higher temperature prevailing during the period as compared to 15 October budding. Morton *et al.* (1972) observed the role of weather in bud union and sprouting in custard apple. Budding attributes being dependent upon climatic conditions especially temperature, humidity, rainfall, sunshine hours etc, the climatic condition prevailing during October might have favoured better response as observed under 15 October budding treatment. Hartmann *et al*. (1997) reported 24-28^{0}C temperature was optimum for budding which coincides with the prevailing temperature prevailed during October. Less bud take and budding success with September budding might be due to comparatively higher prevailing temperature and also the occurrence of rain attributing rotting and thus failure of bud intake. Bruno (1962) reported poor bud break in rainy season (May-September) owing to *Fusarium* and *Phytophthora* infections. Decline in per cent bud sprouting during second week of September due to unfavorable weather conditions has also been recorded by Singh *et al.* (2003) in aonla. The findings of present investigation are in consonance with the results as observed by Mukherjee and Singh (1966) who reported best results by budding Sweet orange (cv. Pineapple) on *Citrus jambhiri* rootstock in October under Delhi condition.

Growth parameters

The length and diameter of newly emerged shoot got influenced significantly by the time of budding (Table 2). As regard to the effect of time of budding on the length (14.19 cm) and diameter (4.97 mm) of newly emerged shoots, it was observed that plant when budded on 15 October had significantly higher length of scion shoot. Under this time of budding, the plant also had maximum plant height (31.01 cm) (Table, 2, 4 and Fig. 2, 3, 4). It may be due to quick and strong formation of union between the rootstock and bud and increased sap flow (Skene *et al.*, 1983) and subsequently due to greater utilization of nutrients by sprouted shoot. The prevalent climatic conditions during October might favour maximum length, diameter and the height of scion shoot, during growth phase of scion. The results are in conformity to the results as observed by Pandey and Prasad (1980) in case of aonla budding. The data on number of nodes and length of internodes were influenced significantly by different

periods of budding. With, 15 October budding, maximum number of nodes (11.04) and length of internodes (1.29 cm). The role of low temperature in restriction of growth has been highlighted by Singh (2002). Minimum plant height (23.27 cm), were recorded when budding was done on 15 November and observations were made on 15 March. It may be due to falling winter soon after budding which might restrict growth more to plants budded during 15 November as compared to those budded during 15 October. Further, the period of growth also got lessened with budding performed during November. The role of low temperature in restriction of growth has been highlighted by Singh (2002).

Leaf parameters

The data as regard to leaf parameters are presented in Table 3 and 5 and Fig.4. Number of leaves, leaf area and other leaf parameters got influenced significantly by time of budding. The maximum number of leaves on sprouted scion (15.29), leaf area (15.23), perimeter of leaves (20.25 cm) and chlorophyll content (3.704 mg/g) was observed when budding was done on 15 October. It might be due to absorption and translocation of nutrients besides photosynthetic ability which might get promoted by more number of leaves on the scion shoot. The role of leaves in photosynthetic production and consequently growth has been highlighted by Sestak (1981). Significant variation in leaf parameters were noted with advancement of growing periods. It may be due to on going development process accounting to cell division, expansion and differentiation governing size, shape and structure of plants (Taiz and Zeiger, 2002). The results obtained are in accordance with the earlier findings as quoted by Dubey and Singh (2003). The maximum chlorophyll content (4.263 mg/g) and relative water content of leaves (78.07 %) were found when budding was done on 15 October. It may be due to temperature dependent synthesis of chlorophyll in leaves on shoots appeared after budding and their better resumed growth budding afterwards. During 15 March, the plant had maximum relative water content (71.14 %) of leaves. All other period manifested significant effect on relative water content of leaves. The interaction reflects that the plant budded on 15 October had maximum relative water content in leaves (78.58 %) on 15 March which was significantly superior over all other interactions. The RWC in leaves showed progressive decline with advancement of period from March towards April. Such observation may be linked to stomatal conductance of leaves and prevailing temperature and relative humidity of atmosphere. Higher the temperature and lower the relative humidity, lower the RWC. The lower RWC of leaves during the September month may be ascribed owing to increased temperature and consequent loss of water through stomata. The loss of water from stomata of leaves has been highlighted by Malik and Srivastava (1980).

Table 1. Effect of time of budding on budding performance in top worked plants of Nagpur Mandarin

Budding time	Bud take percentage (%)	Days required to first sprouting	Days required to 50 % sprouting	Budding success (%)
15 Sept	62.43	23.09	59.72	43.47
1 Oct.	63.55	20.87	55. 33	53.23
15 Oct.	75.80	18.27	53.26	70.23
1 Nov.	68.36	25.18	92.19	34.55
15 Nov.	66.29	27.46	95.09	25.19
SE(m) $\pm$	0.103	0.083	0.133	0.115
CD at 5%	0.311	0.250	0.403	0.347

Table 2. Effect of time of budding on growth parameters in top worked plants of Nagpur Mandarin

Budding time	Length (cm) of sprou ted scion	Diameter (mm) of sprouted scion	No. of nodes	Length of internodes (cm)
15 Sept	11.98	4.22	9.30	1.26
1 Oct.	12.82	4.55	10.18	1.27
15 Oct.	14.19	4.97	11.04	1.29
1 Nov.	11.42	4.10	8.98	1.25
15 Nov.	10.23	3.92	8.03	1.23
SE(m) $\pm$	0.0484	0.011	0.0417	0.0036
CD at 5%	0.1372	0.0311	0.1181	0.0102

Table 3. Effect of time of budding on leaf parameters in top worked plants of Nagpur Mandarin.

Budding time	Number of leaves	Leaf area (cm)	Perimeter of leaves (cm)	Chlorophyll content (mg/g)
15 Sept	12.89	13.33	18.69	2.928
1 Oct.	14.62	13.93	18.93	3.340
15 Oct.	15.29	15.23	20.25	3.704
1 Nov.	11.84	12.71	17.47	2.438
15 Nov.	10.85	11.52	17.16	2.205
SE(m) ±	0.0565	0.0663	0.0606	0.0156
CD at 5%	0.1602	0.1901	0.1718	0.0442

Table 4. Effect of time of budding on plant height (cm) in top worked plants of Nagpur Mandarin during different period

Budding time	Plant height (cm)			
	15 March	1 April	15 April	Mean
15 Sept	24.95	28.27	30.89	28.04
1 Oct.	26.03	29.24	31.97	29.08
15 Oct.	27.19	30.81	33.71	30.57
1 Nov.	24.02	26.78	29.67	26.82
15 Nov.	23.27	25.85	28.79	25.97
Mean	25.09	28.19	31.01	
	SE(m) ±	CD at 5%		
Budding time (BT)	0.0517	0.1464		
Period (P)	0.04	0.1134		
BT x P	0.0895	0.254		

Table 5. Effect of time of budding on relative water content (%) of leaves in top worked plants of Nagpur Mandarin during different period

Budding time	Relative water content (%) of leaves			
	15 March	1 April	15 April	Mean
15 Sept	65.22 (53.84)	64.74 (53.55)	64.32 (53.30)	64.76 (53.56)
1 Oct.	67.41 (55.17)	66.93 (54.88)	66.49 (54.61)	66.94 (54.89)
15 Oct.	78.58 (62.41)	78.01 (62.01)	77.61 (61.74)	78.07 (62.05)
1 Nov.	74.58 (59.70)	74.08 (59.37)	73.62 (59.07)	74.09 (59.38)
15 Nov.	69.92 (58.72)	69.32 (58.34)	68.90 (56.08)	69.38 (57.71)
Mean	71.14 (57.97)	70.62 (57.63)	70.19 (56.96)	
	SE(m) ±	CD at 5%		
Budding time (BT)	0.0277	0.0785		
Period (P)	0.0215	0.0608		
BT x P	0.048	0.136		

Note: Figures in parentheses indicate angular transformed value.

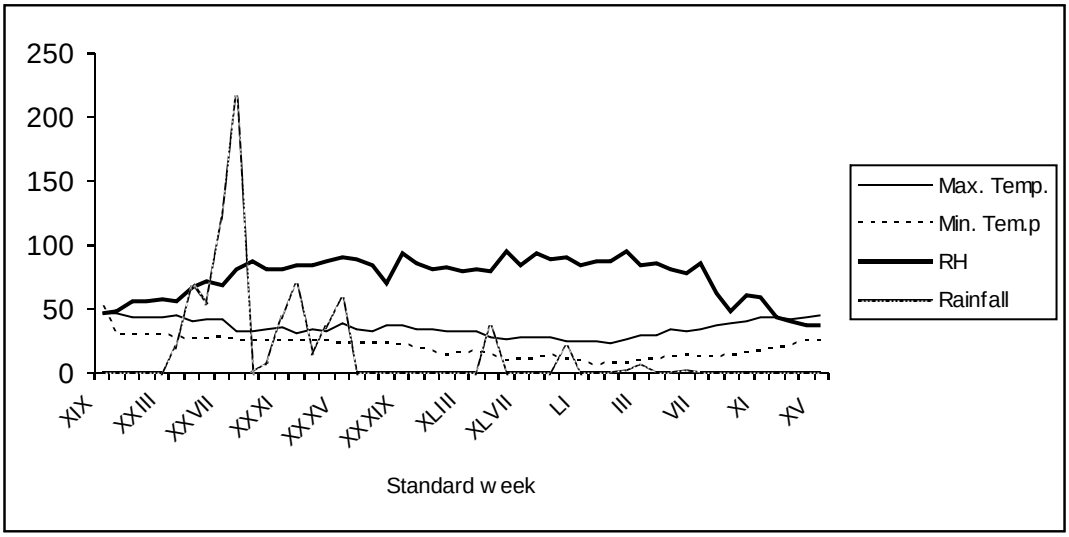

Fig 1. Pattern of weather parameters during 14 May, 2009 to 21April, 2010.

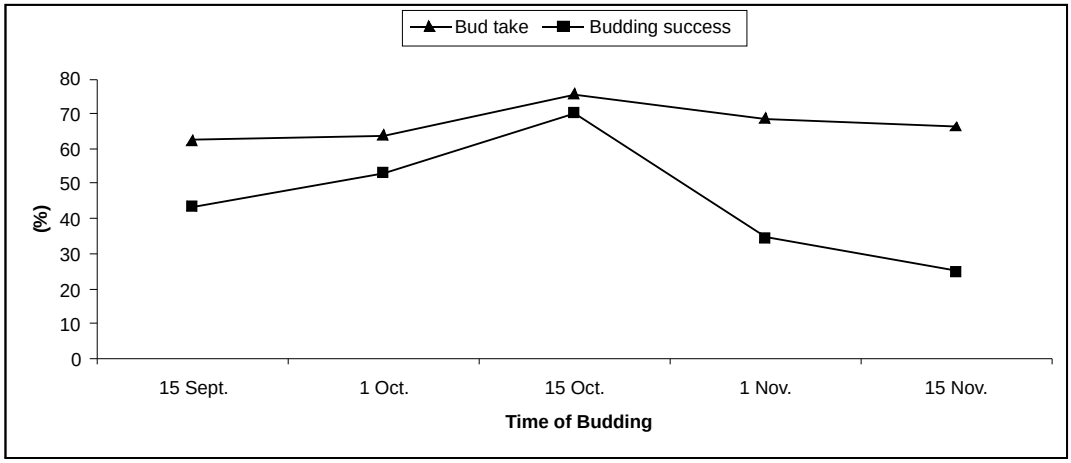

Fig.2. Effect of time of budding on bud take and budding success in top worked plants

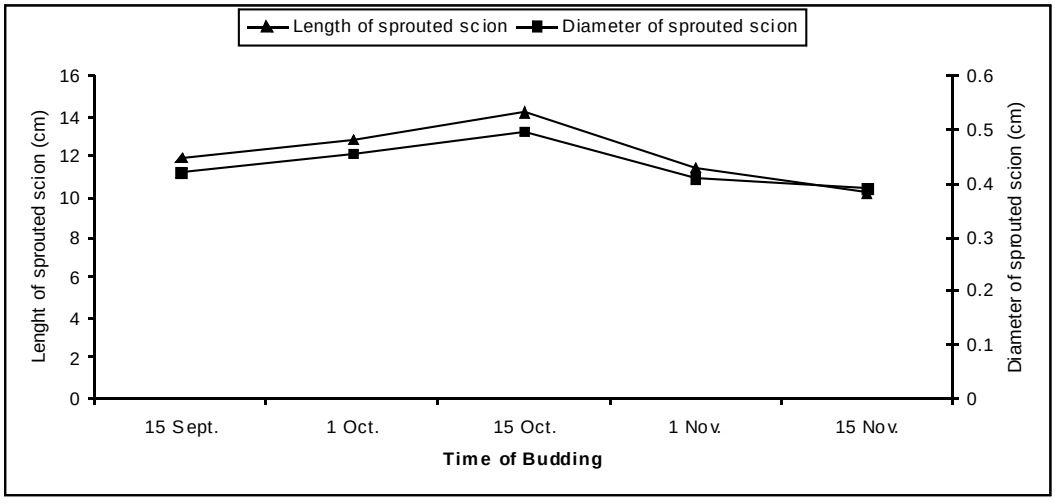

Fig. 3. Effect of time of budding on stem parameters in rejuvenation of Nagpur Mandarin

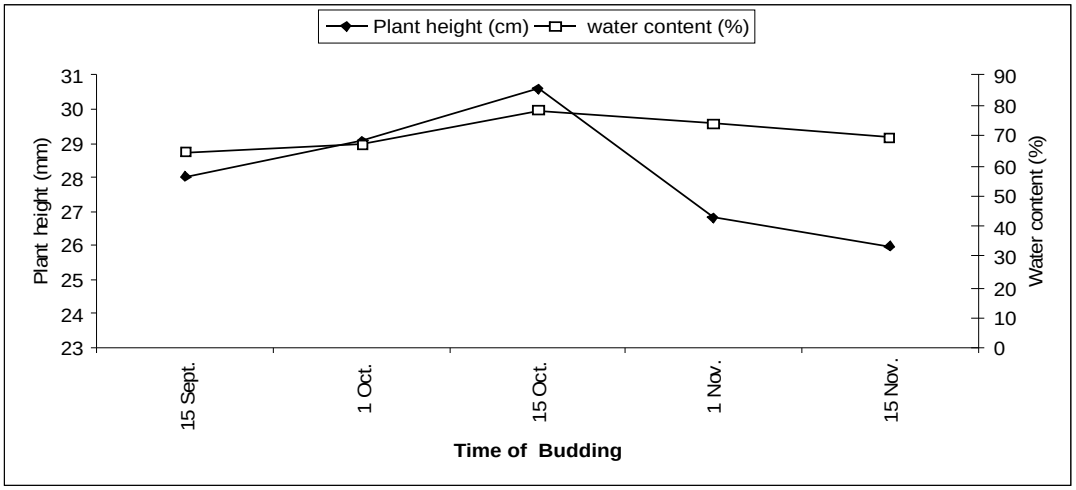

Fig. 4. Effect of time of budding on plant height (cm) and relative water content (%) of leaves in top worked plants of Nagpur Mandarin during different period

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