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Effect of pruning time and bio-regulators on growth and yield of ber in semi-arid zone of Rajasthan

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Abstract
The results showed that pruning done at the 2nd week of April gave better results in terms of maximum gain in plant height, length of primary branch, number of secondary branches per primary branch, average fruit weight and fruit yield per hectare of ber in both the years as well as in pooled analysis. Among the different bio-regulators, application of thiourea @ 1000 ppm performed the better results in respect to growth and yield parameters of ber over other bio-regulators except thiourea @ 500 ppm was noted at par to it during the course of study.

Keywords: Ber, pruning time, bio- regulators, growth attributes, yield attributes thiourea, salicylic acid etc.

1. Introduction
The earliest civilization was evolved in the arid lands. These regions are now facing a grave situation because of ecological deterioration. Inherently, desert environment imposes biophysical constraints for intensive production. Therefore, there is a need for greater attention on drought and heat tolerant fruit trees and other plant species. Ber is of the most prominent among them. Ber (*Zizyphus mauritiana* Lamk.), a member of family Rhamnaceae, is one of the most common and ancient sub tropical fruits of India. In fact, it was one of the important fruits on which the Sage Vedvyas made his adobe among the ber trees and for that reason he was named Badrayan (a person living in the forest of ber trees). The cultivation of ber is gaining popularity in arid and semi-arid regions in India because of its low maintenance cost, wide adaptability, low water requirement, high yield, good returns, scope for value addition and suitability even under wastelands (Martinuzzo, 2006) [12].

Plants can tolerate PH more than 9 and soil as well as water salinity to a limited extent (Hooda *et al.*, 1990) [9]. Plants did not survive at 20 ds/m soil salinity, whereas 70 per cent reduction in yield at 15 dsm with no adverse effect on fruit quality was observed (Jain *et al*.1988) [8]. The flowering period lasts for about two and a half months from September to November. The fruit setting starts in the second week of October and continues up to the first fortnight of November. The fruit growth in terms of length and diameter follows a 'double sigmoid' curve. The flowers are borne on the current season's growth in leaf axils; the inflorescence is cymose (Bal, 1984) [1] and each cyme contains 15-28 flowers. The fruit is berry with a single stone and the shape of the fruit may vary from round to oblong, ovate, oval and oblate depending on the cultivars. It is a quick growing and early bearing fruit which yields a heavy crop every year. Moreover, the tree can tolerate hot and dry weather during May-June as the tree goes to dormant conditions which, in turn, reduce the total water requirements during the period of water scarcity especially in Rajasthan.

Pruning is essential to maintain vigour, productivity, quality and size of fruits (Singh *et al*., 2004) [24]. As pruning is determined by fruiting behavior of a crop it is primarily the most important annual operation in ber. In case of unpruned tree, the canopy area continue to enlarge year after year, branch lets become very weak, fruit size reduced and tree ultimately become unproductive whereas in case of judiciously pruned tree vigour and shape is maintained and fruit size as well as quality of fruits is improved. Thus, pruning is required every year in ber to induce maximum number of new healthy shoots which bear good quality fruits and removal of unproductive, over-crowded and portion of old branches for production of new fruit bearing shoots. The intensity of pruning in ber is depend on several factors like genotype (Nanthakumar and Shanmugavelu, 1990) [15], spacing (Bisla *et al.*, 1991) [3] and the agro-climatic conditions where the crop is being grown (Pandey *et al.*, 1998) [16]. Therefore, it is a need to standardize the extent of pruning time under different agro-climatic conditions.

The plant hormones and bio-regulators are extremely important agent in the integration of developmental activities in plants. Environmental factors often exert inductive effects by evoking changes in hormones in metabolism and distribution within the plant. Application of thiourea has also been reported beneficial in some crops grown in semi-arid regions (Shant and Singh, 1985) [23]. It is a sulfhydryl compound which contains one-SH group besides containing nitrogen in the form of NH_2. Thiourea contains 42.1 per cent sulphur and 36.8 per cent nitrogen. Thus, it behaves in physiology of plants both as sulfhydryl compounds and as amino compounds like urea and it has been recognized to have pronounced effect on diverse biological activities probably because of –SH group. Use of thiourea, recognized as plant growth regulator (Sahu and Solanki, 1991) [21] may be helpful in this regard. The exogenous supply of growth regulators also modifies plant growth by hormonal control, differentiation, morphogenesis and key physiological process such as carbon and nutrient assimilation process. Thiourea also helps in advancing vegetative & floral bud break and subsequent bud growth of Mango (Tongumpai *et al*.,1997) [26].

2. Materials and Methods

The experiment was carried out at Horticulture Farm, S.K.N. College of Agriculture, Jobner (Rajasthan) during two subsequent years *i.e.* 2018-19 and 2019-20. It consisted of 20 treatment combinations with five levels of bio-regulators (Control, Thiourea @ 500 ppm and 1000 ppm Salicylic acid @ 100 ppm and 150 ppm) and four pruning time (Pruning at 4th week of March, Pruning at 2nd week of April, Pruning at 4th week of April and Pruning at 2nd week of May) in Randomized Block Design with three replications. Growth attributes of experimental trees were recorded twice in both the years of experimentation separately. The first observation before application of treatments was recorded in the month of September, 2018 and 2019. However, the second observation was recorded at full bloom stage in the month of mid October, 2018 and 2019. Further, the gain in these parameters was calculated. The number of primary branches per plant and no of secondary branches per primary branch were measured at full bloom stage in the month of October, 2018 and 2019 separately. Yield Attributes of experimental trees were recorded twice in both the years of experimentation separately. Average fruit weight per tree the Ten fruits from each treatment were selected at random in all the pickings during experimentation and weighed separately on electronic balance and average fruit weight in 'g' was drawn. Fruit yield per hectare It was calculated by the following formula:

$$\text{Yield (q/ha)} = \frac{\text{Yield per plant (kg)}}{100} \times 278 \text{ (plant/ha)}$$

3. Results

3.1 Gain in plant height

The maximum gain in plant height (75.72 cm), (76.89 cm) and (77.81 cm) were observed in treatment when Pruning was done in the 2nd week of April during both the years and in pooled analysis, respectively. which was significantly superior to the rest of the treatments except Pruning at 4th week of March. Pruning at the 2nd week of April registered a 10.98 % gain in plant height over Pruning at 4th week of March during pooled analysis.

Data further indicated that application of various bio-regulators also significantly enhanced the plant height during experimentation. Application of Thiourea @ 1000 ppm significantly affected the gain in plant height over rest of the treatments except Thiourea @ 500 ppm which was statistically at par to it during experimentation. Thiourea @ 1000 ppm registered 30.58, 25.82 and 28.12 per cent gain in plant height during 2018-19, 2019-20 and pooled analysis respectively over control.

3.2 Gain in average length of primary branch

The maximum gain in average length of primary branch was recorded with Pruning at 2nd week of April which was significantly better when Pruning was done at 4th week of May during both the years as well as pooled analysis but remained at par when Pruning was done at 4th week of April. Pruning at the 2nd week of April registered 23.01 per cent more length of primary branch than Pruning at 4th week of May during pooled analysis.

Similarly, the application of various bio-regulators also significantly influenced the average length of primary branch. The maximum gain in length of primary branch throughout the study was recorded with application of Thiourea @ 1000 ppm, which was found significantly higher over control. Application of Thiourea @ 1000 ppm also registered 24.8 per cent more average length of primary branch than control during pooled analysis.

3.3 Gain in number of secondary branches per primary branch

Pruning in the 2nd week of April proved the best and significantly superior over Pruning in the 4th week of March. However, Pruning at 4th week of April and 2nd week of May remained at par to it. Pruning at 2nd week of April noted an increase of 27.16 per cent more number of secondary branches per primary branch as compared to pruning done at 4th week of March during pooled analysis.

Data mentioned in the same table also revealed that application of bio-regulators significantly affected the gain in the number of secondary branches per primary branch. Application of Thiourea @ 1000 ppm proved to be the best treatment in respect to gain in number of secondary branches per primary branch over rest of the treatments except Thiourea @ 500 ppm which was found statistically at par to it during pooled analysis.

Table 1: Effect of pruning time and bio-regulators on gain in plant height, length of primary branch and number of secondary branches per primary branches of ber

Treatments	Gain in Plant height (cm)			Length of primary branch (m)			Number of secondary branches/ primary branch		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
Pruning time									
P_1 - Pruning at 4th week of March	68.20	72.01	70.11	1.46	1.61	1.54	5.12	4.81	4.97
P_2 - Pruning at 2nd week of April	75.72	79.89	77.81	1.55	1.68	1.62	6.75	5.89	6.32
P_3 - Pruning at 4th week of April	74.45	78.18	76.32	1.50	1.62	1.56	6.69	5.83	6.26

P_4 - Pruning at 2nd week of May	72.45	76.85	74.65	1.26	1.39	1.33	6.60	5.58	6.09
SEm ±	1.69	1.72	1.20	0.04	0.04	0.03	0.10	0.15	0.09
CD (P = 0.05)	4.83	4.92	3.38	0.10	0.11	0.07	0.28	0.42	0.25
Bio-regulators									
B_1 - Thiourea @ 500 ppm	80.55	84.11	82.33	1.52	1.66	1.59	6.72	5.83	6.27
B_2 - Thiourea @ 1000 ppm	82.59	85.72	84.16	1.59	1.72	1.66	7.11	5.94	6.53
B_3 - SA @ 100 ppm	69.58	73.91	71.74	1.43	1.57	1.50	6.53	5.59	6.06
B_4 - SA @ 150 ppm	67.56	71.79	69.67	1.40	1.54	1.47	6.03	5.54	5.78
B_5 - Water spray (Control)	63.25	68.13	65.69	1.26	1.39	1.33	5.06	4.75	4.90
SEm ±	1.89	1.92	1.35	0.04	0.04	0.03	0.11	0.16	0.10
CD (P = 0.05)	5.45	5.55	3.78	0.11	0.12	0.08	0.32	0.47	0.28

3.4 Average fruit weight

It is amply clear from data that average fruit weight of ber was significantly affected by different pruning time and bio-regulators in both the years as well as in pooled analysis of the study. Pruning at the 2nd week of April recorded maximum and significantly better average fruit weight of ber over rest of the treatment during experimentation. Pruning at the 2nd week of April registered 16.81, 13.19 and 5.13 per cent more average fruit yield than pruning done at the 2nd week of May, 4th week of March and 4th week of April, respectively, during pooled analysis.

The application of bio-regulators also tended to significant variation in the average weight of fruit during both the years and in pooled analysis. The maximum average fruit weight was displayed with the application of thiourea @ 1000 ppm which was significantly superior to the rest of the treatments and registered 24.32 per cent more average fruit weight than control in pooled analysis.

3.5 Fruit yield per hectare

The data pertaining to fruit yield per hectare clearly indicated that different pruning time and bio-regulators had significant effect on fruit yield in individual year as well as in pooled analysis. Pruning done at the 2nd week of April recorded maximum fruit yield of 176.42, 138.19 and 157.31 q/ha during 2018-19, 2019-20 and pooled mean, respectively which were significantly better than rest of the pruning treatments during experimentation. However, a minimum fruit yield of 128.50 q/ha was recorded in treatment when pruning was done in the 2nd week of May during pooled analysis. Pruning at the 2nd week of April registered 22.42 per cent more fruit yield over pruning done at the 2ndweek of May in pooled analysis.

It is also clear from the table that application of different bio-regulators had perceptible variation on fruit yield of ber. The maximum fruit yield of 155.40 q/ha was obtained with application of thiourea @ 1000 ppm during the course of study and registered 20.36 per cent more fruit yield than control in pooled analysis.

Table 2: Effect of pruning time and bio-regulators on average fruit weight and fruit yield (q/ha) of ber

Treatments	Average fruit weight (g)			Fruit yield (q/ha)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
Pruning time						
P_1 - Pruning at 4th week of March	16.53	18.94	17.74	151.82	122.35	137.08
P_2 - Pruning at 2nd week of April	18.80	21.35	20.08	176.42	138.19	157.31
P_3 - Pruning at 4th week of April	17.74	20.45	19.10	161.86	127.71	144.79
P_4 - Pruning at 2nd week of May	15.64	18.16	16.90	140.65	116.34	128.50
SEm ±	0.29	0.27	0.20	2.13	1.67	1.35
CD (P = 0.05)	0.82	0.77	0.55	6.09	4.78	3.80
Bio-regulators						
B_1 - Thiourea @ 500 ppm	18.13	21.22	19.68	168.98	133.50	151.24
B_2 - Thiourea @ 1000 ppm	18.81	21.77	20.29	173.30	137.50	155.40
B_3 - SA @ 100 ppm	17.04	19.40	18.22	153.41	123.22	138.31
B_4 - SA @ 150 ppm	16.43	19.06	17.74	150.52	120.55	135.54
B_5 - Water spray (Control)	15.48	17.17	16.32	142.25	115.97	129.11
SEm ±	0.32	0.30	0.22	2.38	1.87	1.51
CD (P = 0.05)	0.93	0.87	0.62	6.87	5.39	4.25

4. Discussion

Pruning is done during the hot and dry season when the tree sheds leaves and enters into dormancy. Tree spread was also greater in pruning during the second week of April and this might have the association with proper pruning time when there was mild temperature. In case of later pruning the tree spread decreased, probably due to sharp rise in the temperature. However, the differences between spread of trees pruned in the second and fourth week of April were statistically non-significant, while significant when the above treatments were compared with other pruning treatments. Similarly, the number of branches were remarkably greater in April pruned trees and this happened mainly associated with proper pruning time coupled with the temperature more conducive for sprouting of the branches.

The time of pruning influences bud sprouting and determines annual vegetative growth of the plant. Devi and Babu (1993) [5] reported delayed bud sprouting as a result of delayed pruning. They observed that trees pruned on 14th April produced the tallest plants and maximum number of branches per tree. The increase in growth parameters might be due to an optimization of the light environment inside the tree which likely to promote the rate of photosynthesis. The other possible reason for increased growth parameters of ber might be due to maximum availability of space and light for growth and development of the tree especially in the month of April. Similar findings were also reported by Gupta *et al.* (1990) [6].

Raut and Diware (2005) [19] determined the optimum time of pruning, its severity and interaction for 3 commercial cultivars of ber, namely Gola, Punjab Chhuara and Kadaka. They reported that vegetative growth of the plant as indicated by shoot length, diameter and number of shoots on pruned branches were better in trees pruned moderately in May and it was superior in producing longer and higher number of secondary shoots.

Thiourea also mitigates the adverse effects of low temperature stress by acting as an ROS scavenger and enhancing the water utilization efficiency. Further, the beneficial effects of thiourea were attributed to its role in significantly increasing the net photosynthetic rates and concentration of total chlorophyll and starch in the leaves. Thiourea also reflects a positive role in enhancing nitrogen metabolism as it significantly increases the sugar metabolism and enhances the protein biosynthesis in the treated plants. It has been proved that application of thiourea as foliar spray could significantly improve growth and water use efficiency of ber under semi-arid conditions which might be due to enhanced photosynthesis and more efficient nitrogen metabolism. Similar findings of thiourea on plant growth and flowering in ber were also reported by Mishra *et al*. (2011) [13].

The ber trees being summer deciduous and are in deep dormancy during April, May & June and level of reserve metabolites such as carbohydrates starch and sugars are higher during this phase of dormancy. Pruning during this period led to more growth, higher fruit set, and greater yield. However pruning done during the induction phase (March) and breaking phase (May) resulted in lower yield. The fruit length, diameter and weight were significantly affected by time of pruning. The delayed and reduced growth and less time from flowering to fruit maturation in late pruned trees affect the development of fruit. Thus, reducing the size and weight of the fruit in the late pruned trees. Singh *et.al* (2004) [24] also concluded that pruning in the Sanaur-2 cultivar of the ber carried out during the third week of April at eight bud level of the previous year growth gave higher yield and better quality fruits.

Pareek and Nath, (1996) [17] in Maharashtra, western India, reported the best time for pruning is before the end of April and Deotate *et al*., (1997) [4] also concluded that delay in pruning causes reduction in fruit yield.

Raveendra and Ganiger, (2000) [20] conducted an experiment on pruning of ber trees and found that performance of all the cultivars was superior when pruning was carried out on 15 April. Moreover, in India Jawadagi *et al*., (2001) [9] also assessed pruning treatments in ber and found that performance of all the cultivars was optimum when pruning was conducted on 15 April.

Application of bio-regulators in present investigation significantly affected the fruit yield per plant as well as per hectare. However maximum values of production were recorded with foliar spray of thiourea @ 1000 ppm followed by thiourea @ 500 ppm, SA @ 100 ppm and SA @ 150 ppm. As yield is a complex character which depends on yield contributing characters. The application of thiourea was done when the first stage of flower bud development was detected. this can intensify the number of inflorescence per unit length of branch, resulting in a higher number of flowers per tree. A positive correlation between the effect of thiourea concentration and flower density was very promising. The application of thiourea increased the formation of fruitful buds in grape Balasubrahmanyam *et al*., (1975) [2] and mango Tongumpai *et al*., (1997) [26]. Application of thiourea exhibits bud breaking properties and synergistic effect to auxin as well as gibberellin's action Krishnamoorthy, (1993) [11]. It also induced early flowering, early maturity of fruits, increased the number of fruits per tree, fruit yield per tree and improved quality parameters like TSS content and shelf life of Kesar mango Patel *et al.*, (2016) [18]. This might be due to involvement of thiourea as bio-regulators in the breakdown of organic acids into sugars at the time of fruit ripening. Further, bio-regulators might assist the turn's location of sugars from vegetative parts to developing fruits. The foliar application of different bio-regulators has been found to increase the yield in fruit crops which is attributed to higher fruit set and reduction in fruit drop and increase in growth rate of fruits, Modise *et al,*. (2009) [14]. According to Stino *et al*., (2011) [25] concluded that the improvement in quality may be due to the effect of nutrients which enhance the synthesis and accumulation of sugar content in mango. The parallel results in quality and shelf life of fruits of treated trees with nutrient and thiourea had also been reported by Sankaran *et al*., (2005) [22] in pomegranate and Khan *et al*., (2009) [10] in aonla.

5. Conclusion

On the basis of the results emerged out from the present investigation, it can be concluded that Pruning at 2nd week of April along with application of Thiourea @ 500 ppm proved significantly superior combination in respect to growth and yield parameters of the ber as compared to rest of the treatment combinations except pruning at 4th week of April + Thiourea @ 1000 ppm which was statistically at par to it. Apportioning the Pruning at 2nd week of April + thiourea @ 500 ppm is worth recommendable as it fetched comparable fruit yield (q/ha) from ber.

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