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Effects of pruning and nutrient application on yield and quality of *ber* under hot arid environment

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ABSTRACT

A three-year experiment was conducted to assess effect of different time of pruning (P_1: 15th May, P_2: 30th May, P_3: 15th June and P_4: 30th June) and nutrient management (N_1 : control, N_2 : 500 g N + 500 g P_2O_5 + 250 g K_2O, N_3 : 1000 g N + 750 g P_2O_5 + 500 g K_2O and N_4 : 1500 g N + 1000 g P_2O_5 + 750 g K_2O per tree) treatments on fruit yield and quality of 10-year-old established orchard of *ber* cv. Gola on *Ziziphus rotundifolia* rootstock under hot arid environment conditions. The time of pruning, nutrient application and their interaction had significant influence on fruit yield. The fruit set increased with delay in pruning time and nutrient application. The pruning at 30th May and 15th June recorded 30.9 and 39.6% higher fruit yield, respectively compared to pruning at 15th May. Application of nutrient had significant influence on fruit yield, and the yield obtained with N_2, N_3 and N_4 were 27.7, 43.2 and 52.7% higher than control (N_1). The results suggest that pruning at 15th June should be combined with application of 1000 g N + 750 g P_2O_5 + 500 g K_2O per tree to achieve higher and quality fruit yields in *ber* under hot arid environment.

Key words: *Ber*, pruning time, nutrient application, yield, quality.

INTRODUCTION

Ber (*Ziziphus mauritiana* Lamk.), belongs to the family Rhamnaceae, which is widely distributed in tropical, sub-tropical and temperate climates in the world (Bailey, 3). It is an important fruit crop of arid and semi-arid regions of India and widely grown in Punjab, Rajasthan, Haryana and Gujarat states (Chandra *et al.*, 4; Singh and Bal, 11). Pruning is an essential operation to maintain vigour of trees, fruit productivity and quality of *ber* (Singh *et al.*, 12). Fruit bearing in ber occurs on the current season's shoots and remains confined to the secondary and tertiary branches. Pruning should therefore, induce the emergence of maximum number of secondary and tertiary branches. The time of the pruning determines the vegetative growth, tree canopy, advancement of bud sprouting, flowering and fruiting. The suitable time of pruning depends on cultivar, age and agro-ecological conditions (Azam *et al.*, 2) and deviation from appropriate time of pruning results in the lower yield and poor quality fruits (Singh and Bal, 14).

The *ber* tree removes huge amount of nutrients, hence, judicious nutrient application is necessary to replace nutrient losses, to correct deficiencies and improve yield and quality of fruits due to imbalances in the soil or plant (Lal *et al.*, 9). Application of 500-1000 g N, 400-800 g P and 100-200 g K per tree is advocated depending upon the age of tree, climatic and edaphic conditions of the area (Azam *et al.*, 2). The information pertaining to pruning time and nutrient (N, P_2O_5 and K_2O) application on yield and quality of ber under hot arid agro-ecological conditions is meagre. Hence, keeping in view the above, the present investigation was undertaken.

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MATERIALS AND METHODS

Field experiments were carried out at Farmer Participatory Action Research Programme (FPARP)'s site in village Geegasar of district Bikaner, Rajasthan for three years (2008-09, 2009-10 and 2010-11). The experimental site has 10-year-old plantation of *ber* cv. Gola budded on *Ziziphus rotundifolia* rootstock. Climate of the experimental site represents hot arid with annual rainfall of ~250 mm. Most (70-80%) of rainfall occurs during July-September. The soil of the experimental site was sandy, with pH 7.9, bulk density 1.4 g/ cm^3 in upper 15 cm depth. The soil had 0.05% organic carbon, 7.56 kg available P_2O_5/ ha and 232.2 kg available K_2O/ ha. The trees were planted at 6 m × 6 m in 1998. The treatment consisted four pruning time, *viz.*, P1: 15th May, P_2: 30th May, P_3: 15th June and P_4: 30th June and four levels of nutrient application, *viz.*, N_1: control, N_2: 500 g N + 500 g P_2O_5 + 250 g K_2O/ tree, N_3: 1000 g N + 750 g P_2O_5 + 500 g K_2O/ tree and N_4: 1500 g N + 1000 g P_2O_5 + 750 g K_2O/ tree. The experiment was laid out in randomized block design with three replications. Each replication consisted of 48 trees. In pruning treatments, all the secondary branches were removed from base and primary branches were pruned to 25 buds. The required

amount of nutrients as per treatment was applied as chemical fertilizers (urea, single super phosphate and muriate of potash for N, P and K, respectively). Full dose of P_2O_5 and K_2O was applied in July. The half dose of N was applied in July and remaining half dose was applied in the last week of September. The moderate intensity of pruning was undertaken as per the treatment schedule each year.

The observations were recorded on fruit set, fruit drop, fruit yield, fruit quality, and *ber* leaf fodder (*pala*) yield. Total soluble solids (TSS) were estimated with the help of hand refractometer. Titratable acidity and ascorbic acids were estimated by following the standard procedures (AOAC, 1). Data were analyzed using analysis of variance (ANOVA). Analysis of variance of the experimental data was carried out as per factorial RBD (Gomez and Gomez, 6). The data of production were analysed annually, while data on fruit quality parameters were pooled and analysed.

RESULTS AND DISCUSSION

The data presented in Table 1 suggest that time of pruning and nutrient application had significant influence on fruit set and fruit drop. Fruit set varied from 4.49-8.07%. Averaged across the nutrient application treatments the highest fruit set was recorded with pruning at 15th June followed by 30th June, 30th May and 15th May. The pruning at 30th May, 15th June and 30th June recorded 8.6, 25.0 and 17.6% higher fruit set compared to pruning at 15th May. Fruit set showed significant response to nutrient application. Averaged across the pruning times, the N_3 and N_4 treatments had significantly higher fruit set compared to N_1 and N_2. Application of N_2, N_3 and N_4 (1500: 1000: 750 g N, P_2O_5 and K_2O respectively) recorded 4.6, 11.8 and 17.3% higher fruit set compared to control. Application of nutrient is known to affect the metabolic activities required for fruit set. Among the different combinations of treatments, pruning on 15th June combined with application of N_3 or N_4 recorded significantly higher fruit set.

Fruit drop percentage showed significant response to time of pruning. Fruit drop varied from 16.5-31.7%. The difference in fruit drop between 15th May and 30th May was non-significant. The pruning on 15th June had significantly lowered fruit drop (21.88%, range 21.51-22.26%) followed by pruning at 30th June, 30th May and 15th May. The early pruning induces early flowering but the incidence of flower drop is higher, whereas the tree pruned at 15th June retained the maximum fruit.

Nutrient application resulted in reduction in fruit drop, and fruit drop with N_2, N_3, and N_4 were 8.0, 12.8 and 18.6% less compared to control (N_1). Pruning is known to affect the balance between vegetative and reproductive growth of fruit trees, and appropriate time of pruning dictate the efficiency to regulate the balance between these two stages. The higher fruit set and lower fruit drop incidence under nutrient application might be attributed to adequate nutrition under these treatments, which resulted into favourable metabolic process, availability of photosynthates to fruit development and adequate hormonal balance to augment fruit setting. The results are in agreement with those reported by Lal *et al*. (9).

Fruit and leaf fodder yield in *ber* showed significant response to time of pruning, nutrient application and their interaction (Table 2). Fruit yield varied from 13.85-43.16 kg / tree. Averaged across all the nutrient application treatments and years pruning at 30th May, 15th June and 30th June recorded 30.9, 39.6 and 12.3% higher fruit yield, respectively compared to pruning on 15th May. The pruning at 15th June gave significantly higher fruit yield than pruning at 15th May and 30th June. The *ber* trees being summer deciduous are in deep dormancy during May and 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 towards the induction phase (April) and breaking phase (July) resulted in lower yield (Singh and Bal, 14). The results are in agreement that appropriate time in accordance with agro-climatic conditions, cultivar and age of tree helps to achieve better yields of *ber* as reported by Gill and Bal (5), and Singh and Bal (11, 14).

Application of nutrient had significant influence on fruit yield, and the yield obtained with N_2, N_3 and N_4 were 27.7, 43.2 and 52.7% higher than control (N_1). The highest fruit yield was recorded with N_4, which was significantly higher than other nutrient application treatments except N_3. The higher yields with N_3 and N_4 might be attributed to better fruit setting and retention under aforesaid treatments. The results are in accordance with the findings of Singh (13), Katyar *et al.* (7), Kumar and Kumar (8), and Mishra *et al*. (10). Among the different combination of pruning times and nutrient application treatments, pruning at 15th May with application of 1000 g N + 750 g P_2O_5 + 500 g K_2O/ tree (N_3) or 1500 g N + 1000 g P_2O_5 + 750 g K_2O/ tree (N_4) gave the significantly higher fruit yield.

Dry leaf fodder yields varied from 2.0-6.3 kg/ tree. The leaf fodder yields decreased with delaying time of pruning, *i.e.*, pruning at 30th May, 15th June and 30th June yielded 13.4, 23.1 and 34.9% less leaf fodder

Table 1. Effect of pruning time and nutrient application on fruit set and fruit drop in *ber.*

Treatment	Fruit set (%)				Fruit drop (%)			
	2008-09	2009-10	2010-11	Mean	2008-09	2009-10	2010-11	Mean
Pruning time								
P_1: 15th May	5.91	5.79	5.95	5.88	27.47	27.93	26.98	27.46
P_2: 30th May	6.57	6.26	6.34	6.39	26.27	26.84	26.29	26.47
P_3: 15th June	7.69	7.12	7.25	7.35	21.86	22.26	21.51	21.88
P_4: 30th June	7.19	6.79	6.78	6.92	25.41	25.76	24.96	25.38
CD at 5%	0.48	0.43	0.37		1.48	1.57	1.64	
Nutrient management (per tree)								
N_1 : control	6.39	6.02	5.95	6.12	27.80	28.35	28.05	28.07
N_2 : 500 g N + 500 g P_2O_5 + 250 g K_2O	6.62	6.21	6.38	6.40	25.83	26.13	25.48	25.81
N_3 :1000 g N + 750 g P_2O_5 + 500 g K_2O	6.99	6.72	6.82	6.84	24.55	24.96	23.89	24.47
N_4 : 1500 g N +1000 g P_2O_5 + 750 g K_2O	7.36	7.01	7.16	7.18	22.84	23.35	22.32	22.83
CD at 5%	0.48	0.43	0.37		1.48	1.57	1.64	
Interaction effect								
P_1N_1	4.87	4.49	4.69	4.68	30.74	31.74	31.21	31.23
P_1N_2	5.64	5.62	5.78	5.68	27.49	27.80	26.67	27.32
P_1N_3	6.13	6.08	6.21	6.14	26.65	26.72	25.50	26.29
P_1N_4	7.00	6.99	7.12	7.03	25.00	25.45	24.53	24.99
P_2N_1	6.43	6.18	6.08	6.23	29.70	30.07	31.00	30.26
P_2N_2	6.52	6.13	6.22	6.29	26.27	26.67	26.28	26.41
P_2N_3	6.62	6.20	6.35	6.39	24.03	24.71	23.67	24.13
P_2N_4	6.70	6.52	6.69	6.64	25.09	25.93	24.20	25.07
P_3N_1	7.36	7.03	6.79	7.06	24.46	24.84	24.00	24.43
P_3N_2	7.27	6.41	6.71	6.80	23.73	23.99	23.50	23.74
P_3N_3	8.07	7.67	7.75	7.83	22.58	23.04	22.05	22.56
P_3N_4	8.07	7.38	7.73	7.73	16.67	17.18	16.50	16.78
P_4N_1	6.90	6.37	6.23	6.50	26.28	26.74	26.01	26.34
P_4N_2	7.04	6.70	6.81	6.85	25.81	26.07	25.45	25.78
P_4N_3	7.15	6.92	6.99	7.02	24.94	25.40	24.35	24.89
P_4N_4	7.66	7.15	7.09	7.30	24.60	24.83	24.03	24.49
CD at 5%	NS	0.86	0.74		2.95	NS	3.28	

than 15th May pruning. Averaged across all pruning times for three years, the application of N_2, N_3 and N_4 recorded 15.7, 41.9, and 48.9% higher fodder yields compared to control (N_1). The difference in fodder yields between N_3 and N_4 was non-significant in all the three years of experimentation. The combination of 15th May pruning and application of N_4 gave the highest fodder yield.

The pruning time failed to cause any significant influence on size of fruit (Table 3). Application of nutrient significantly improved the fruit weight. The fruit weight recorded with N_2, N_3 and N_4 were 12.6, 17.3 and 18.1% higher, respectively compared to control. The difference in fruit weight between N_2 and N_3 was non-significant; similarly, the difference between N_3 and N_4 was non-significant. Total soluble solids content of fruit showed significant variation due to time of pruning and nutrient application. Delay in pruning caused reduction in TSS, and its content with 15th and 30th June were 2.6 and 5.1% less than fruits of 15th May pruned tree.

Table 2. Fruit and leaf fodder yield of *ber* as influenced by pruning time and nutrient application.

Treatment	Fruit yield (kg/ tree)				Leaf fodder yield (kg/ tree)			
	2008-09	2009-10	2010-11	Mean	2008-09	2009-10	2010-11	Mean
Pruning time								
P_1: 15th May	22.59	18.14	24.62	21.78	4.70	4.84	5.11	4.89
P_2: 30th May	29.29	23.21	33.06	28.52	4.12	4.27	4.43	4.27
P_3: 15th June	31.11	24.89	35.23	30.41	3.93	3.69	3.94	3.85
P_4: 30th June	24.82	20.88	27.67	24.46	3.41	3.02	3.33	3.25
CD at 5%	2.53	2.30	2.92		0.59	0.65	0.67	
Nutrient management (per tree)								
N_1 : control	20.88	16.02	23.37	20.09	3.28	3.06	3.32	3.22
N_2 : 500 g N + 500 g P_2O_5 + 250 g K_2O	26.28	21.01	29.63	25.64	3.89	3.59	3.84	3.78
N_3 : 1000 g N + 750 g P_2O_5 + 500 g K_2O	29.44	23.84	33.02	28.76	4.41	4.51	4.71	4.54
N_4 : 1500 g N + 1000 g P_2O_5 750 g K_2O	31.20	26.26	34.57	30.68	4.58	4.66	4.94	4.72
CD at 5%	2.53	2.30	2.92		0.59	0.65	0.67	
Interaction effect								
P_1N_1	19.07	13.85	20.41	17.78	3.90	3.78	3.99	3.89
P_1N_2	22.47	18.25	24.97	21.90	4.21	4.05	4.41	4.22
P_1N_3	24.30	20.21	26.45	23.65	5.13	5.55	5.79	5.49
P_1N_4	24.53	20.24	26.63	23.80	5.55	5.99	6.27	5.94
P_2N_1	20.67	15.74	23.79	20.07	3.36	3.23	3.31	3.30
P_2N_2	28.50	22.43	32.38	27.77	3.97	3.76	3.96	3.90
P_2N_3	33.34	26.77	37.45	32.52	4.51	4.99	5.17	4.89
P_2N_4	34.63	27.90	38.61	33.72	4.65	5.10	5.30	5.02
P_3N_1	22.37	17.07	25.37	21.60	3.33	3.20	3.45	3.33
P_3N_2	29.30	22.50	33.40	28.40	3.96	3.77	3.94	3.89
P_3N_3	34.05	26.30	39.01	33.12	4.20	3.88	4.09	4.06
P_3N_4	38.71	33.70	43.16	38.53	4.24	3.89	4.25	4.13
P_4N_1	21.40	17.40	23.90	20.90	2.53	2.03	2.52	2.36
P_4N_2	24.87	20.87	27.76	24.50	3.43	2.79	3.05	3.09
P_4N_3	26.07	22.07	29.17	25.77	3.81	3.62	3.79	3.74
P_4N_4	26.93	23.20	29.87	26.67	3.86	3.64	3.95	3.82
CD at 5%	5.06	4.61	5.84		1.18	1.29	1.34	

Gill and Ball (5) recorded highest TSS in fruit with the trees pruned on 30th May and TSS decreased with delay in pruning times. The change in TSS with pruning time might be attributed to alteration in sink source relationship under different time of pruning. Nutrient application significantly improved the TSS content of fruits. The TSS content with N_2, N_3 and N_4 were 4.1, 6.8 and 6.3% higher compared to no application of nutrients (N_1). However the difference in TSS content among N_2, N_3 and N_4 were non-significant. Katyar *et al*. (7), and Kumar and Kumar (8) reported highest TSS with the application of N, P, K in *ber*. The time of pruning and nutrient application did not show significant variation in acidity content of fruit.

The results of present experiment suggest that pruning at 15th June and application of N_3, *i.e.*, 1000 g N + 750 g P_2O_5 + 500 g K_2O/ tree/ per year helps to achieve higher fruit yield and quality of established ber orchard in hot arid environment of north-western India.

Table 3. Effect of time of pruning and nutrient application on fruit quality of *ber*.

Treatment	Fruit weight (g)	TSS (^{0}Brix)	Acidity (%)
Pruning time			
P_1: 15th May	22.17	17.54	0.526
P_2: 30th May	21.75	17.54	0.531
P_3: 15th June	21.21	17.09	0.536
P_4: 30th June	21.13	16.65	0.543
CD at 5%	NS	0.64	NS
Nutrient management (per tree)			
N_1 : control	19.26	16.49	0.529
N_2 : 500 g N + 500 g P_2O_5 + 250 g K_2O	21.68	17.17	0.536
N_3 : 1000 g N + 750 g P_2O_5 + 500 g K_2O	22.59	17.62	0.535
N_4 : 1500 g N + 1000 g P_2O_5 + 750 g K_2O	22.74	17.53	0.535
CD at 5%	0.99	0.64	NS

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