Improvement of old *ber* cv. Gola orchard through bunding and micro-nutrients management

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ABSTRACT

An experiment was conducted in 15-year-old established *ber* cv. Gola orchard. This orchard was showing zinc and boron deficiency and poor moisture retention. The plants were supplied with boron (0.3 and 0.6% borax) and zinc (0.2 and 0.4% zinc sulphate) at two stages *viz.,* before flowering and after fruit set. Maximum fruit set (7.7%), minimum fruit drop (20.83%) and maximum fruit yield (7.29 t/ha) were recorded with 0.6% borax and 0.4% zinc sulphate combinations. Under normal rainfall bunding influenced the fruit yield (6.49 t/ha) through maintaining the sufficient moisture regime during fruit growth and development phase. The physico-chemical composition of fruit was significantly influenced with foliar spray of 0.3-0.6% borax and 0.2-0.4% zinc sulphate. The tree produced 0.88 - 1.09 t leaves (*pala*) utilised as fodder by goats during lean period (April-May).

Key words: *Ber*, bunding, boron, zinc, foliar spray, fruit yield, quality.

INTRODUCTION

Ber (*Zizyphus mauritiana* L.) is an important fruit species suitable for rainfed situation due to its hardiness, can survive in only 400 mm yearly rainfall (Vashishtha, 17). It is being cultivated for its fresh fruits, which are rich in vitamins C, A and B complex, due to these it is known as poor's man fruit (Gill and Ball, 4). During lean period (April-May), its leaves (*pala*) provide fodder which contains 11-13 percent crude protein and is suitable for forage, hay and silage for goat (Tewatia and Khirwar, 16). Its pruned twigs/ stems are used as fuel wood in rural areas (Kumar *et al.*, 5). A 15-year-old *ber* cv. Gola orchard whose interspaces were utilized by different intercropping of pasture and fodder crops were earlier supplemented with N, P, and K only, resulting in relatively rapid utilization of micro-nutrients by plants and removal of micro-nutrients from soils. The orchard have shown symptoms of boron and zinc deficiencies by reduced yield as well as well as fruit cracking. Tandon (15) reported the critical level of zinc (2.5-50 ppm) and boron (20-200 ppm) in *ber* leaves. Chundawat (3) reported that for maintaining the productivity of orchard, it is essential to apply to soil what is harvested each year to maintain the status of nutrients in soil. Bhargava *et al.* (1) reported that on an average one tonne of edible *ber* fruit contains 5.27 kg protein, 61.9 g P, 1.09 kg K, 120.8 g Ca and 8.59 g Fe. In general, foliar feeding is practiced in old trees, where soil is poor in nutrient and lack of moisture. Under rainfed condition, moisture conservation through *in-situ* water harvesting plays a vital role in growth and productivity of fruit trees, so that runoff collecting at the root zone supply moisture for longer duration to get better quality fruit without irrigation. Thus, conservation of soil moisture and supply of balanced nutrients are very important for maintenance of productivity of orchard for long periods and its improvement. Keeping in view of these facts, the present study was conducted in a 15-year-old orchard of *ber* cv. Gola with foliar application of boron and zinc with simple soil and water conservation practice (bunding) under rainfed condition to improve the productivity of old orchard.

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MATERIALS AND METHODS

Ber (cv. Gola) planted at 6 m × 6 m was established in 1990. The inter spaces between trees were utilized through different intercropping in phase manner *viz., Cenchrus ciliaris* + *Stylosanthes hamata* (8 years), bajra (fodder) with nitrogen application (2 years) and intercropping with *Panicum maximum* (Guinea grass), *Pennisetum pedicellatum* (Dinanath grass) + *S. hamata* (5 years). Experiment was conducted on 15-year-old established *ber* plantations at Central Research Farm of Indian Grassland and Fodder Research Institute, Jhansi for three consecutive years (2006 to 2009). Leaf samples (6th leaf two month after pruning) were taken for nutrient assessment as per method suggested by Bhargava *et al.* (2) which depicted 11 ppm zinc and 62-71 ppm boron. The soil of experimental field was sandy loam, poor in available N (182.2 kg/ha), P (6.8 kg/ha), organic carbon (0.41%) and medium in available K (111.6 kg/ha). The experiment was laid out under RBD with three replications having two factors; 1: bunding (formed in June 2006 with 0.72 m^2 cross-sectional area and repaired every year) and factor-2: micronutrient combinations (5). The whole orchard was divided in two parts *viz.,* with bund and without bund, each part having 24 trees. Two trees per treatment were selected and one was left as border in each part and was replicated thrice in each part. The selected two trees in each block bunded and without bunded plots were foliar sprayed twice in a year (1st before flowering and 2nd after fruit set) in 2006, 2007, and 2008 with five combinations *viz.,* T_1 (0.3% borax + 0.2 % $ZnSO_4$), T_2 (0.3% borax + 0.4 % $ZnSO_4$), T_3 (0.6 % borax + 0.2% $ZnSO_4$), T_4 (0.6 % borax + 0.4 % $ZnSO_4$), and T_5 (water spray). The different nutrients solutions were prepared separately by dissolving the required amount of salts. Leaf samples (6th leaf two month after pruning) taken for nutrient assessment as method suggested by Bhargava *et al.* (2) which depicts 11 ppm zinc and 62-71 ppm boron. The soil of experimental field was sandy loam, poor in available N (182.2 kg/ha), P (6.8 kg/ha), organic carbon (0.41%) and medium in available K (111.6 kg/ha). The experiment was laid out under RBD with three replications having two factors-1: bunding (formed in June 2006 with 0.72 m^2 cross-sectional area and repair every year) and factor -2: micronutrient combinations (5). The orchard was divided in two parts *viz.,* with bund and without bund, each part had 24 trees. Two trees per treatment were selected and one left as border in each part and replicated thrice in each part. The two selected trees in each block bunded and without bunded plots were foliar sprayed twice in a year (1st before flowering and 2nd after fruit set) in 2006, 2007, and 2008 with five combinations *viz.,* T_1 (0.3% borax + 0.2% $ZnSO_4$), T_2 (0.3% borax + 0.4% $ZnSO_4$), T_3 (0.6 % borax + 0.2% $ZnSO_4$), T_4 (0.6% borax + 0.4% $ZnSO_4$), and T_5 (water spray). The different nutrients solutions were prepared separately by dissolving the required amount of salts in lukewarm water and neutralized by adding slack lime in $ZnSO_4$ (half the amount). To each solution a surfactant (Teepol®) was added at the rate of 0.1%. Recommended doses of FYM (50 kg/year) and fertilizers (500 g N, 200 g P_20_5 and 300 g K_2O) were applied to each tree per year. The observations were recorded on fruit set, fruit drop, fruit yield, fruit quality, and ber leaf fodder (*pala*) yield. Production data were analysed annually while data on fruit quality parameters were pooled and analysed as per methods suggested by Panse and Sukhatme (10). The ascorbic acid was determined by method suggested by Sadasivam and Thymoli (13). The total acids were measured by titrating known volume of juice against N/10 NaOH using phenolphthalein as an indicator. Available soil moisture was recorded by simple fresh soil weight and oven dry weight basis at monthly intervals from October to March every year at 20 and 40 cm depth. The weather parameters (Table 1) *viz.,* rainfall (mm), rainy days, was collected from meteorological observatory of Central Research Farm of IGFRI, Jhansi during the experimental period (June- March).

RESULTS AND DISCUSSION

Foliar application of nutrient (macro or micro) is known to affect the metabolic activities in plant apart from serving as a mode of supplementary feedings, thereby mobilizing the yield and other potentialities of plants. The data presented in Table 2, showed that two foliar applications of borax (0.3-0.6%) and zinc sulphate (0.2 - 0.4%) significantly improved the fruit set (7.08 - 7.29%) over control (5.35-5.46%) in each consecutive year of experiment. Maximum fruit set (7.70%) was recorded with 0.6% borax + 0.4% $ZnSO_4$ (T 4), followed by T_3 (0.6% borax + 0.2% $ZnSO_4$), and minimum with control (5.46%). The beneficial effect of $ZnSO_4$ and borax in increasing fruit set might be due to the higher availability of photosynthates. These micro-nutrients are also associated with hormone metabolism

Table 1. Rainfall and rainy days during the experimental period.

Month	2006-07		2007-08		2008-09	
	Rainfall (mm)	Rainy days	Rainfall (mm)	Rainy days	Rainfall (mm)	Rainy days
June	53.7	4	143.3	5	640.8	13
July	138.6	9	140.3	13	321.8	20
August	93.3	8	85.5	9	149	10
September	7.6	2	119.8	6	114.4	4
October	0	0	0	0	2.4	0
November	0	0	0	0	16	2
December	4.8	1	0	0	0	0
January	1.8	0	0	0	6.2	1
February	39.2	4	0	0	0	0
March	0	0	0	0	0	0
Total	339	28	488.9	33	1250.6	50

that promotes synthesis of auxin, essential for fruit set and growth. In addition, low boron reduces male fertility primarily by impairing microsporogenesis and pollen tube growth. Data pertaining to fruit drop indicated that foliar spray of borax and $ZnSO_4$ reduced fruit drop significantly in all the years of experiments. Two foliar sprays of borax (0.3 and 0.6%) and zinc sulphate (0.2 and 0.4%) significantly reduced fruit drop (22.85 and 22.59%) over control (28.17 - 25.30%), which might be due to positive role of zinc sulphate and in metabolic activity. Bunding in old (15 years) ber plantations did not show significant effect on fruit set and fruit drop. It might be due to below average rainfall over two years *viz.,* 2006 and 2007 (339 & 488.9 mm) and continuous and heavy rainfall in 2008 (1250.6 mm) up to vegetative phase (September), which ultimately reduced flowering and fruit set (Table 2).

The managed *ber* trees produced significantly higher fruit yield in all the years of experiments (Table 3) as compared to control. However, the tree sprayed with 0.6% borax and 0.4% zinc sulphate gave maximum fruit yield (7.23 with bunded and 6.98 t/ha under un-bunded plot). Samant *et al.* (14), have also reported significantly higher fruit yield by spraying 0.4 % $ZnSO_4$ in *ber* var. Umran. In third year of experiment in general, low fruit yield was recorded due to continuous rainfall from June to September that promoted luxuriant vegetative growth which has adversely affected fruit set. The fruit production of *ber* respond favourably to early rainfall (May-August), while rainfall > 50 mm during September caused detrimental effect on fruit productivity (Kumar *et al.*, 8). It was also observed that early onset of monsoon (May to August) resulted in early shoot production and sufficient synthesis of C: N ratio as a result of balance growth in between vegetative growth and fruit production (Kumar and Ram, 6).

The fruit production was not influenced with bunding in 1st year of experiment because of poor rainfall during the year (Table 1). However, in the 2nd and 3rd year of experiment, bunded plot produced significantly higher (7.57 and 5.76 t /ha) fruit yield which

Table 2. Effect of bunding and micro-nutrients on fruit set and fruit drop in *ber* cv. Gola.

Treatment With bund	Fruit set (%)				Fruit drop (%)			
	1st year	2nd year	3rd year	Mean	1st year	2nd year	3rd year	Mean
With bund								
T_1	7.43	7.53	5.81	6.92	22.81	22.78	24.09	23.23
T_2	7.55	8.06	6.19	7.23	22.07	22.04	23.10	22.40
T_3	8.02	7.75	6.19	7.32	20.61	20.55	21.64	20.93
T_4	8.12	8.20	6.78	7.70 (7.29)*	20.51	20.47	21.52	20.83 (21.85)*
T_5	6.25	6.31	3.81	5.46	24.81	24.73	26.37	25.30
Mean	7.47	7.57	5.76	6.93	22.16	22.11	23.34	22.54
Without bund								
T_1	7.12	7.32	5.68	6.70	23.61	23.57	24.65	23.94
T_2	7.39	7.64	5.83	6.95	21.50	21.46	23.00	21.98
T_3	8.03	7.65	6.21	7.30	22.53	22.45	23.85	22.94
T_4	8.04	7.80	6.25	7.36 (7.08)*	21.16	21.11	22.39	21.51 (22.59)*
T_5	6.17	6.09	3.79	5.35	27.73	27.67	29.13	28.17
Mean	7.35	7.30	5.55	6.73	23.36	23.23	24.60	23.71
CD at 5% due to bund	NS	NS	0.19		NS	NS	NS	
CD at 5% due to micro-nutrient	0.24	0.26	0.31		1.81	0.97	1.07	
CD at 5% (Bund × micro-nutrient)	NS	NS	NS		NS	NS	NS	

T_1 (0.3% borax + 0.2% $ZnSO_4$), T_2 (0.3% borax + 0.4% $ZnSO_4$), T_3 (0.6% borax + 0.2% $ZnSO_4$), T_4 (0.6% borax + 0.4% $ZnSO_4$), and T_5 (water); *Values in parentheses are average values of micro-nutrient spray.

Table 3. Effect of bunding and micro-nutrients (boron and zinc) on fruit and *pala* yield.

Treatment	Fruit yield (t/ha)				*Pala* (leaf) yield (t/ha)			
	1st year	2nd year	3rd year	Mean	1st year	2nd year	3rd year	Mean
With bund								
T_1	7.27	7.31	5.61	6.73	1.00	0.90	1.05	0.98
T_2	7.13	7.56	5.52	6.73	1.05	0.93	1.08	1.02
T_3	7.04	7.26	5.93	6.74	0.98	0.94	1.09	1.00
T_4	7.63	7.91	6.33	7.29 *(6.87)	1.05	0.99	1.05	1.03 *1.01
T_5	5.82	5.61	3.45	4.96	0.95	0.74	0.90	0.86
Mean	6.99	7.13	5.37	6.49	1.01	0.90	1.03	0.98
Without bund								
T_1	6.71	7.08	5.53	6.44	0.98	0.8	0.92	0.93
T_2	7.05	7.17	5.68	6.63	1.00	0.88	1.02	0.97
T_3	7.03	7.27	5.69	6.66	0.97	0.89	1.07	0.98
T_4	7.20	7.31	6.43	6.98 *(6.68)	1.02	1.09	1.04	1.05 *0.98
T_5	5.74	5.06	3.24	4.68	0.93	0.69	0.87	0.83
Mean	6.75	6.78	5.31	6.28	0.98	0.89	0.98	0.95
CD at 5% due to bund	NS	0.31	0.34		NS	NS	0.03	
CD at 5% due to Micronutrient	0.73	0.62	0.53		0.02	0.01	0.05	
CD at 5% (Bund × micronutrient)	NS	NS	NS		NS	NS	NS	

T_1 (0.3% borax + 0.2% $ZnSO_4$), T_2 (0.3% borax + 0.4% $ZnSO_4$), T_3 (0.6% borax + 0.2% $ZnSO_4$), T_4 (0.6% borax + 0.4% $ZnSO_4$), T_5 (water); *Values in parentheses are average values of micronutrient spray.

may be due to sufficient moisture regime during fruit growth and development phase (Fig. 1). The interactive effect of bunding and micronutrients application did not show significant effect on fruit production.

The fruit quality data were recorded each year and average value were analysed. Table 4 showed that foliar spray of borax and zinc sulphate had significant effect on physico-chemical quality of fruit (fruit weight, TSS, acidity and vitamin C). This may be due to association of boron with carbohydrate transportation within the plants. Similar findings were reported by Samant *et al.* (14). It may also be due to micro-nutrients which are known to impart direct and indirect effects on fruit yield and quality. Zinc catalyses the process of oxidation in plant cells and is vital for the transformation of carbohydrates and it also regulates the consumption of sugars. Zinc promotes the absorption of water and prevents stunting in plants. It also regulates the semi-permeability of cell wall by which more water is mobilized into fruits, resulting in maximum fruit diameter and increased juice percentage. Earlier, Rath *et al.* (12) reported that spraying of zinc sulphate increased fruit weight in mango by increasing fruit length, diameter and fresh weight. Similarly, Kumar and Shukla (7) also reported that fruit quality of litchi was increased by spray of borax and 0.3-0.5% zinc sulphate. The interactive effect of bunding and micronutrients application did not show significant effect on fruit quality.

Ber leaves (*pala*) yield as fodder was recorded after fruit harvesting by pruning during April-May as a lean period of fodder availability. The average production ranged from 0.88 - 1.09 t/ha (Table 3). Ram *et al.* (11) had also reported *pala* production in the range of 0.82 - 1.01 t/ha. The tree supplied with micronutrient gave significantly higher *pala* yield (Table 3). The *pala* yield was not significantly influenced with bunding due to low rainfall during 1st and 2nd year. However, in third year of experiment bunded plot produced significantly higher yield (1.03 t/ha) as compared to un-bunded plot (0.98

Table 4. Effect of bunding and micro-nutrients (boron and zinc) on fruit quality of *ber*.

Treatment	Fruit weight (g)	TSS (°Brix)	Acidity (%)	Vitamin C (mg/100 g)
With bund				
T_1	20.83	18.02	0.24	68.0
T_2	22.51	18.14	0.30	69.3
T_3	22.44	18.13	0.31	69.7
T_4	23.12	18.21	0.31	70.0
	*(22.23)	*(18.13)	*(0.29)	*(69.25)
T_5	18.17	17.02	0.23	65.2
Mean	21.41	17.90	0.28	68.44
Without bund				
T_1	20.41	18.02	0.26	68.2
T_2	22.61	18.12	0.30	69.2
T_3	21.21	18.13	0.29	69.2
T_4	22.64	18.17	0.30	69.8
	*(21.72)	*(18.11)	*(0.29)	*(69.1)
T_5	18.21	17.02	0.23	65.3
Mean	21.00	17.89	0.28	68.4
CD due to bund	NS	NS	NS	NS
CD at 5% due to Micro-nutrient	1.21	0.13	0.16	0.66
CD at 5% (Bund × micro-nutrient)	NS	NS	NS	

T_1 (0.3% borax + 0.2% $ZnSO_4$), T_2 (0.3% borax + 0.4% $ZnSO_4$), T_3 (0.6% borax + 0.2% $ZnSO_4$), T_4 (0.6% borax + 0.4% $ZnSO_4$), and T_5 (water); *Values in parentheses are average values of micro-nutrient spray.

t/ha). It might be due to continuous rainfall up to September (vegetative phase of growth). Kumar *et al*. (8) reported that leaf fodder in *ber* is positively related with total rainfall during May to September.

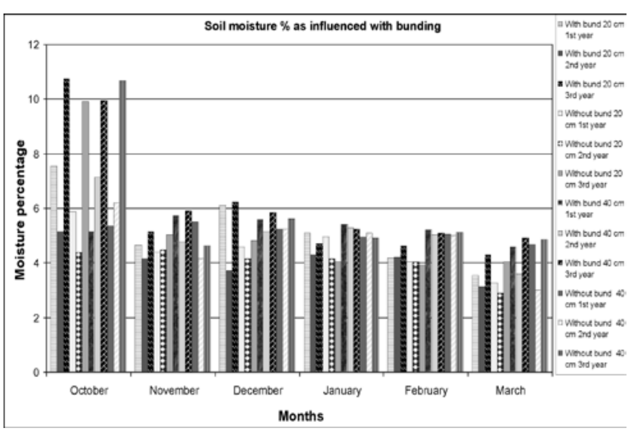

Fig. 1. Effect of bunding on available moisture (%) in soil from October-March during experiment (2006-09).

Bunding is a simple soil and moisture conservation practice. Its response depends on physico-chemical composition of soil, rainfall amount and distribution. Fig. 1. showed that the bunding influenced in terms of increased soil moisture up to October - November which caused positive effect on understorey pasture and fruit yields. Similarly, Mukherjee *et al*. (9) found that mulching and kaoline spray in 9-year-old *ber* plantation gave positive response on growth and yield.

REFERENCES

1. Bhargava, B.S., Varalaksmi, L.R. and Raturi, G.B. 2003. Nutrient concentration and uptake of fruits by *ber* varieties. *Karnataka J. Agric. Sci.* **16**: 92-97.

2. Bhargava, B.S., Raturi, G.B. and Hiwale, S.S. 1990. Leaf sampling technique in *ber* (*Zizyphus mauritiana* L.) for nutritional diagnosis. *Singapore J. Prim. Ind.* **18**: 85-95.

3. Chundawat, B.S. 2001. Integrated nutrient management in tropical and subtropical fruits. *Indian J. Hort.* **58**: 59-69.

4. Gill, K.S. and Ball, J.S. 2006. Influence of pruning severity and time on yield and fruit quality of ber cv. Umran. *Indian J. Hort.* **63**: 162-65.

5. Kumar, S., Ram, S.N., Baig, M.J. and Roy, M.M. 2004. Productivity of ber based hortipastoral system on red alfisol: Effect of pruning intensities and pasture combinations. *Indian J. Agroforestry,* **6**: 23-26.

6. Kumar, S. and Ram, S.N. 2009. Performance of ber (*Zizyphus mauritiana*) based hortipastoral system as influenced by pruning intensities, pastures and weather. *Indian J. Agroforestry*, **11**: 14-19.

7. Kumar, S. and Shukla, H.S. 2005. Effect of NAA, B and Zn on fruit drop, cracking, growth and yield of litchi (*Litchi chinensis* Gaertn.) cv. Deheradun *Farm Sci. J.* **15**: 136-38.

8. Kumar, S., Singh, J.B. and Ram, S.N. 2005. Effect of rainfall distribution on productivity of ber and interspace pasture. *Range Mgmt & Agroforestry*, **26**: 127-29.

9. Mukherjee, S., Paliwal, R. and Pareek, S. 2004. Effect of water regime, mulch and kaoline on growth and yield of ber (*Zizyphus mauritiana*). *J. Hort. Sci. Biotech.* **79**: 991-94.

10. Panse, V.G. and Shukhatme, P. V. 1985. *Statistical Methods for Agricultural Workers*. Indian Council of Agricultural Research, New Delhi, 695 p.

11. Ram, S.N., Kumar, S. and Roy, M.M. 2005. Performance of jujube (*Zizyphus mauritiana*)-based hortipasture system in relation to pruning intensities and grass-legume association under rainfed condition. *Indian J. Agron.* **50**: 181-83.

12. Rath, S., Singh, R.L., Singh, B. and Singh, D.B. 1980. Effect of boron and zinc spray on the physico – chemical composition of mango fruits. *Punjab Hort. J.* **20**: 33-35.

13. Sadasivam, S. and Thymoli, B. 1987. *Practical Manual in Biochemistry*. Tamilnadu Agril. Univ., Coimbtore, pp. 14.

14. Samant, D., Mishra, N.K., Singh, A.K. and Lal, R.L. 2008. Effect of micronutrient sprays on fruit yield and quality during storage in ber cv. Umran under ambient conditions. *Indian J. Hort.* **65**: 399-404.

15. Tandon, H.L.S. 1995. *Methods of Analysis of Soil, Plant, Water and Fertilizer*. Fertilizer Dev. and Consultant Organization, New Delhi.

16. Tewatia, B.S. and Khirwar, S.S. 2002. Utilization of ber (*Z. mauritinan* L.) leaves hay and silage in goat. *Indian J. Anim. Nutr.* **19**: 329-33

17. Vashishtha, B.B. 1997. *Ziziphus* for dryland – A perennial crop solving perennial problems. *Agroforestry Today*, **9**: 10-12.

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