Indian Journal of Agricultural Sciences **88** (4): 573–8, April 2018/Article

Assessing productivity and profitability of a rejuvenated *ber* (*Ziziphus mauritiana*) based agri-horti system under arid rainfed conditions

AKATH SINGH[1], S P S TANWAR[2], P R MEGHWAL[3], ANURAG SAXENA[4] and MAHESH KUMAR[5]

ICAR-Central Arid Zone Research Institute, Jodhpur, Rajasthan 342 003

Received: 25 July 2016 ; Accepted: 22 December 2017

ABSTRACT

A field experiment was carried out at ICAR-Central Arid Zone Research Institute, Jodhpur, Rajasthan from 2011-15 to make senile orchard (33 years old) remunerative again. Trees were headed back from ground level in summer. Out of the numerous shoots emerged, 1-2 shoots were budded with early, mid and late season's cultivar. In subsequent years, inter-cropping was carried out in the *ber* (*Ziziphus maurtitiajna* Lam.) alleys with greengram (*Vigna radiata L.*), pearlmillet (*Pennisetum glaucum* L.) and senna (*Cassia angustifolia)* at two alleys spacing, i.e. 6 m and 12 m (plant to plant spacing in both the alleys was 6 m) tested over three *ber* varieties, viz. Gola, Seb and Umran in split-plot design replicated thrice. The rejuvenated trees attained profitable yield level within three years of rejuvenation. Gola ber recorded highest productivity (57.3 q/ha) followed by Seb and Umran. Amongst intercrops, the productivity of greengram as *ber* equivalent yield was 1.7 and 4.2 times higher over pearl millet and senna, respectively. Although, wider spacing increased the productivity of intercrops by 24%. But, the total system productivity in wider *ber* alleys was 50.47% less during first year followed by 30.3, 34.6 and 40% during subsequent years, respectively, compared to 6 m × 6 m spacing. The profitability was also higher under 6 m × 6 m spacing. The ber + greengram system gave highest net returns (84.79 $\times 10^3$ ₹/ha) over other. This agri-horti system also maintained the initial soil fertility status even after four crop cycles. Hence, the appropriate strategy should be to introduce intercrops preferably green gram at a recommended spacing (6 m × 6 m) of *ber* variety Gola for highest system productivity and profitability.

Key words: Agri-horti system, *Ber*, Economics, Rejuvenation, System productivity

Arid zones all over the world are being adversely affected by four-fold problems of climatic constraints,viz. land degradation, degeneration of bio-diversity and over exploitation of natural resources. Annual cropping generally does not provide sustainability in production and hence necessitate specialized integrated production systems with adapted plants species. Agri.-horticultural system is an integration of food crops with perennial fruit plants in land use systems that enhance productivity and ensures sustainability. *Ber* (*Zizizphus mauritiana* Lam.) is one of such species of arid landscape supplying fruits, fodder, fuel wood and fencing and could find place in every farming system of the region as a vital facet without any constraints. The total area under *ber* in India is more than 80 000 ha with an annual fruit production of 900 000 tonnes.

Generative potential of *ber* plantations proved solid solutions even at the age of thirty five years under rainfed conditions if managed properly. However, over the time, productivity of *ber* trees start declining because of aging, poor orchard management, biotic stress, seedling plantation etc. Vigour and yield in such orchard may be regained by rejuvenation and top working with selected varieties. Singh and Ball (2010) reported that after nine years, the fruit size, yield and fruit quality were better in rejuvenated trees of *ber* cultivar Sanaur 5 compared to non-rejuvenated trees under semi arid conditions of Punjab. Simultaneously, integration of dominant food crops of the region in such orchard may be an appropriate option to enhance overall system productivity and profitability which sustain livelihood of the poor farmers even in the severe drought. Pearl millet (*Pennisetum glaucum* L.) and greengram (*Vigna radiata* L.), a staple food of the arid region grown extensively in arid tropics in *kharif* season. Senna (*Cassia angustifolia*) is a perennial under shrub, commercially cultivated in arid and semi-arid regions of Rajasthan primarily for its leaves used as natural laxative to treat constipation and other medicines useful in the treatment of gonorrhoea, skin diseases, dyspepsia, fevers and haemorrhoids. As monocropping is unremunerative and risky under climatic conditions of the region, an attempt was made to rejuvenate a thirty three years old *ber* orchard and subsequently to develop agri-horti system with green gram, pearl millet and senna to identify most profitable variety for rejuvenation, identify suitable intercrop to be grown in *ber* alleys and for what

[1,5]Senior Scientist (e mail: akath2005@yahoo.co.in and maheshcazri@gmail.com); [2,3,4]Principal Scientist (e mail: spstanwar@gmail.com, meghwal_pr@yahoo.in, drasaxena@gmail.com).

duration, and whether additional income from intercrops if achieved due to widening of alleys could compensate the yield reduction in *ber* due to lowering of tree population.

MATERIALS AND METHODS

The present investigation was carried out at Central Research Farm, Central Arid Zone Research Institute, Jodhpur during 2011-15 under rainfed conditions. The experimental site lies between $26^0$18'N latitude and $73^0$04' E longitude at an elevation of 216 m above mean sea level. It typically represents weather conditions of arid region with very high temperature during the summer touching a maximum of 48ºC, short (December to mid- February) cool and dry winters (temperature varies from 4.1 to 14ºC), high evaporation (3.5 to 13.5 mm/day) and generally low humidity. Total rainfall during cropping season ranged from 334.6 mm to 453.3mm, mostly confined between July to September (Table 1). The experimental soil belongs to family coarse loamy Typic haplocambids. The site had loamy sand at surface followed by a brown sandy loam, weakly blocky negligible to slightly calcareous sub soil and followed by lime coated gravelly material of transported fragments of rhyolites and sandstones at depth around 80- 100 cm depth (Table 2).

Table 1 Rainfall received during the year 2012-2015 at the experimental site

Month	2012		2013		2014		2015	
	Rain-fall (mm)	Rainy days	Rain-fall (mm)	Rainy days	Rain-fall (mm)	Rainy days	Rain-fall (mm)	Rainy days
Jan	0.0	0	32.9	1	00	0	0.2	0
Feb.	0.0	0	19.3	2	0.1	0	0.1	0
March	0.0	0	0.6	0	0.1	0	12.4	1
April	29.2	2	0.0	0	9.0	2	28.8	2
May	2.1	0	4.2	1	22.8	3	6.8	2
June	17.7	3	46.2	5	4.1	1	43.5	4
July	11.7	1	155.8	6	93.2	7	173.0	11
August	291.1	12	89	5	88.1	4	88.9	3
Sep.	132.8	5	144.3	5	148.5	4	19.5	1
Oct.	0.0	0	0.8	0	0.3	0	00	0
Nov.	0.0	0	0.0	0	0.4	0	0.0	0
Dec.	0.0	0	0.0	0	0.0	0	0.0	0
Total	484.6	23	493.1	25	366.6	21	373.2	24

A senile orchard planted in 1978 having twenty two cultivars raised on rootstock of *Ziziphus rotundifolia* and managed rainfed was used as experimental material for rejuvenation. During May 2011, trees were headed back from the ground level and cut surfaces were smeared with copper oxychloride to check the microbial infections. Out of numerous shoots emerged, 2-3 shoots were kept and budded with early, mid and late season's cultivar Gola, Seb and Umran, respectively, in the month of July. The experiment was laid out in split-split plot design with 2 row spacing (6 m × 6 m and 12 m × 6 m) in main plot, 3 *ber* varieties (Gola, Seb and Umran) in sub plot and 3 *kharif* intercrops, viz. greengram, pearl millet and senna. Twenty seven trees of each variety were kept in each spacing with nine plants in each replication. The intercrops were grown from 2012 onwards. Fruit yield (kg/tree) of *ber* over the years was calculated by taking all the harvested fruit on

Table 2 Effect of spacing, *ber* variety and intercrops on productivity of *ber* and intercrops (*ber* equivalent yield)

	Ber (q/ha)					Intercrop (*Ber* equivalent yield, q/ha)				
	2012-13	2013-14	2014-15	2015-16	Pooled	2012-13	2013-14	2014-15	2015-16	Pooled
Spacing (m)										
6 × 6	39.24	72.8	63.2	69.0	61.1	6.92	12.16	6.43	6.44	7.99
6 ×12	13.74	44.7	37.5	37.0	33.2	9.12	14.46	7.99	8.00	9.89
Sem±	0.59	1.8	1.3	2.4	0.8	0.05	0.29	0.20	0.16	0.10
CD (*P*=0.05)	3.60	10.8	7.8	14.9	2.7	0.32	1.78	1.22	0.99	0.32
Variety										
Seb	19.91	61.8	51.2	55.6	47.1	7.24	12.91	7.75	7.75	8.91
Gola	37.17	67.6	60.2	64.4	57.3	8.51	14.31	7.53	7.46	9.45
Umran	22.41	46.9	39.6	39.0	37.0	8.31	12.71	6.35	6.44	8.45
SEm±	0.85	1.7	1.5	1.3	0.7	0.32	0.43	0.24	0.27	0.16
CD (*P*=0.05)	2.78	5.4	4.8	4.3	2.0	1.03	1.41	0.80	0.87	0.47
Intercrop										
Greengram	31.16	73.9	57.5	62.0	56.1	16.00	18.33	11.82	12.59	14.69
Pearl millet	26.92	65.0	49.5	53.0	48.6	4.68	18.40	6.38	5.19	8.66
Senna	21.40	37.4	44.1	44.0	36.7	3.38	3.20	3.43	3.88	3.47
SEm±	0.91	1.8	1.4	1.4	0.7	0.32	0.55	0.24	0.26	0.18
CD (*P*=0.05)	2.66	5.2	4.2	4.1	2.0	0.94	1.61	0.70	0.75	0.51

each picking at maturity and then converted into q/ha. At harvest, yield and yield attributes of different intercrops was recorded. To compare different crops, the individual crop yields were converted to ber equivalent yield based on average market price during that year.

Land equivalent ratio (LER) is the relative land area under sole crops that is required to produce the yields achieved in intercropping (Mead and Willey 1980). The value of unity is the critical value. The LER was calculated as LER = (LER_{ber}+ $LER_{intercrop}$). In particular, LER_{ber} = (Y_{ab}/Y_{aa}) and LER intercrop = (Y_{ba}/Y_{bb}), where, Y_{aa} and Y_{bb} are the yields of *ber* and intercrop as sole crop, respectively; Y_{ab} is the yield of *ber* grown in combination with intercrop and Y_{ba} is the yield of intercrop grown in combination with linseed. The data were analysed statistically and also pooled over four years.

RESULTS AND DISCUSSION

The orchard under study was 33 years old where average fruit production dropped to 8 kg/tree with misshapen and poor quality fruits. Hence rejuvenation was carried out. The rejuvenated trees came to fruiting in the year of rejuvenation itself (2011-12) but the yields were nominal. The weather over the years varied (Table 1). During 2012, the onset of monsoon delayed as far as 6th August and hence adversely affected yield of intercrops. However, cropping season of 2013 received timely and well distributed rainfall hence favoured the crop growth and yield. During 2014, occurrence and frequency of rainfall was optimum but total amount was insufficient for timely crop sowing. Similarly, during 2015, the monsoon receded early, affecting the productivity adversely. Hence year effect was observed statistically significant in almost all the productivity parameters. When yields were compared on individual tree basis, the rejuvenated trees attained the production at par with the trees of the same verities in the adjacent well managed rainfed orchard during third year of rejuvenation irrespective of spacing (Fig 1). The yield was recorded in the range of 36.4 kg/tree in Gola and minimum (23.0 kg/tree) in Umran in the third year of rejuvenation. Since, removal of old, unhealthy woods by heading back from ground level during the process of rejuvenation, ceased all physiological processes of such trees. At the same time, well established root systems of rootstock governed favorably the greater uptake of moisture and nutrient, initiated new and healthy vegetative growth, leaves and established better source and sink relation. Growth of new healthy shoots and luxuriant leaves tend to exhibit high photosynthetic efficiency thereby, keeping a balance between vegetative and reproductive growth (Baba *et al.* 2011). The rejuvenated tree had manageable height with open architecture with outwardly growth facilitating maximum light penetration and its utilization by the plant. It is well established fact that better light penetration into the tree canopy improves tree growth, productivity, and yield and fruit quality. Similarly, Mishra *et al.* (2007) and Mistry and Patel (2009) also recorded improved canopy growth, yield and fruit quality in different fruit crops after

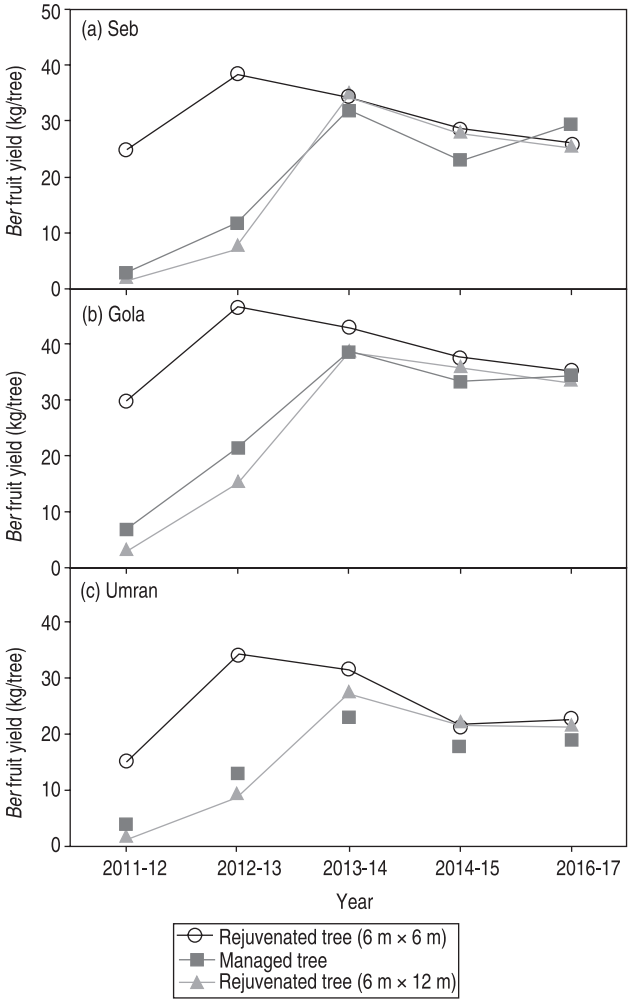

Fig 1 Fruit yield of *ber* varieties (kg/tree) over the years after rejuvenation.

rejuvenation. Findings of the present study on yield and productivity of rejuvenated *ber* were in agreement with Singh and Bal (2010) and Bal *et al.* (2004) reported under semi arid conditions of Punjab.

Third year onwards, although the per tree basis yield was higher in wider spacing but on per ha basis, this increase could not compensate the yield reduction due to reduction of tree population by 50%. Compared to 6 m × 6 m spacing, the yield reduction was 65% during first year (2012-13) and by 38.6, 40 and 58% during subsequent years under wider spacing (6 m × 12 m), respectively averaging 45.6% reduction. Such an increase in production as a result of higher plant population has been demonstrated in different fruit crops (Gupta and Bist 2005). Amongst the *ber* varieties, Gola yielded highest with the average increment of 21.65% and 54.8% over Seb and Umran.

Growing of intercrops (greengram, pearl millet and senna) between the alleys of *ber* significantly influenced the productivity of *ber*. Over the years, higher production of *ber* was recorded when green gram was intercropped. It was 15.4 and 54 % higher than when *ber* was intercropped with pearl millet and senna, respectively. These finding

corroborates with the findings of Jain *et al.* (2006) and Raut (2006). It might be due to increase in nitrogen status in the soil fixed by green gram being a leguminous crop which attributed to better vegetative growth of treated plants which resulted in higher photosynthates and the translocation to fruits, thus increasing the yield compared to pearl millet and senna. This is also evident with higher organic carbon content after four crop cycles which is also an indication of higher available nitrogen in soil (Table 4). At the same time, biological feasibility of green gram with *ber* is more compatible as cropping duration of green gram is short and completed its cropping season (July to early October) before fruit setting of *ber*. This supported green gram has less competition for space, moisture, light, pollinating insect and nutrient from the *ber* compared to pearl millet and senna.

Amongst intercrops, the productivity of green gram calculated as *ber* equivalent yield was 1.7 times higher over pearl millet and 4.2 times over senna. Increasing the alley spacing from 6 m × 6 m to 6 m × 12 m improved the productivity of intercrops (as *ber* equivalent yield) by 24% (Table 2). *Ber* varieties also affected the productivity of intercrops and highest productivity was recorded under Gola followed by Seb and Umran (Table 2). The year effect was more visible in intercrop yields. Intercrop yield was visibly affected by amount and distribution of rainfall but average yield of pearl millet was affected more compared to greengram and senna because of insufficient rains for sowing in 2012-13 and 2014-15 as shown in Table 1. Green-gram performed better with higher grain yield in 2012-13 and 2013-14 compared to 2014-15; however, pearl millet perform best during 2013-14 because of timely sowing and well distributed rainfall (Table 1). Though the biomass yield of senna was pretty low compared to green gram and pearl millet but it was least affected over the years. This indicates that diversification of annual crops is a good strategy to combat weather anomalies of arid region.

Higher partial LER of *ber* indicate that the intercropping did not adversely affect the *ber* and it is the dominant species over green gram, pearl millet and senna. The total LER greater than unity indicates higher combined yield advantage of intercrops over separate planting. It is higher under wider spacing (Fig 2a). Amongst the intercrops, the total LER was in the order green gram > pearl millet > senna (Fig 2b). This justifies that *ber*-greengram association is complimentary. Since, LER indicate the biological compatibility amongst intercrops, it should be complimented with economic analysis of the system.

Highest total system productivity (*ber* equivalent yield) was achieved after two year of rejuvenation (2013-14). Since the contribution of *ber* in total system productivity was very high, increasing in productivity of intercrops could not compensate the subsequent reduction in *ber* yield due to increased spacing (6 m × 12 m). The total system productivity in 6 m × 12 m spacing was less 50.47% during first year followed by 30.3, 34.6 and 40% during subsequent years, respectively, compared to 6 m × 6 m spacing. Hence the appropriate strategy should be to introduce intercrops

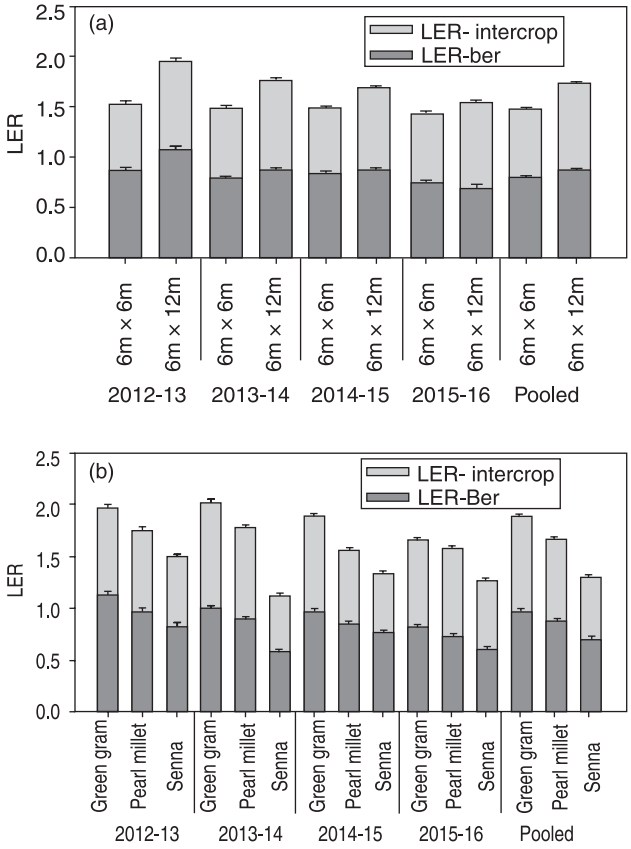

Fig 2 Effect of spacing, *ber* variety and intercrops on LER.

at recommended spacing of *ber*, no matter if sub optimal yields of intercrops are achieved. Amongst the intercrops, total system productivity was found in order of green gram, followed by pearl millet and senna. On pooled basis, total system productivity under green gram was 23.7% higher over pearl millet and 76% higher over senna (Table 3). These results were in accordance with findings of Sharma and Gupta (2001), Singh *et al.* (2003), Bhati *et al.* (2008) who reported that agri-horti system comprising *Zizyphus* + greengram found very promising in <250-300 mm rainfall zone. Amongst the varieties, Gola outperformed Seb and Umran. The total system productivity of Gola was 47% higher over late cultivar Umran and 19.2% higher over Seb.

Profitability also followed the similar trend. During first year, the net returns were less and even negative for *ber* + pearl millet and *ber* + senna due to minimal *ber* yield and additional expenditure incurred in rejuvenation and aftercare. However second year onwards, the systems showed good net returns averaging 84.79 $\times 10^3$ ₹/ha with green gram (Table3).

Soil organic carbon (%) was slightly improved (0.180 % to 0.202%) at the end of experiment (Table 4). This increase in soil organic carbon may be attributed to litter fall and its decomposition and addition of FYM in initial years of experiment. Available phosphorus, potassium and iron content in soil were decrease over five years. But Zn content was slightly improved over its initial status. *Ber* alleys as well as intercropping of green gram,

Table 3 Effect of spacing, *ber* variety and intercrops on system productivity and economics

	System productivity (*Ber* equivalent yield, q/ ha)					Cost of cultivation (× 10^3 ₹/ha)					Net returns (× 10^3 ₹/ha)				
	2012-13	2013-14	2014-15	2015-16	Pooled	2012-13	2013-14	2014-15	2015-16	Pooled	2012-13	2013-14	2014-15	2015-16	Pooled
Spacing (m)															
6 × 6	46.16	84.97	69.61	75.42	69.04	81.43	70.53	81.59	86.45	80.00	10.90	99.42	57.64	102.11	67.52
6 ×12	22.86	59.17	45.53	44.96	43.13	45.55	40.17	45.71	48.36	44.95	0.17	78.18	45.35	64.04	46.93
SEm±	0.55	1.61	1.22	2.30	0.78						1.10	3.22	2.43	5.75	1.78
CD (*P*=0.05)	3.34	9.79	7.40	14.00	2.53						6.67	19.58	14.80	35.01	5.80
Variety															
Seb	27.15	74.75	58.97	63.34	56.05	63.49	55.35	63.65	67.41	62.47	-9.20	94.15	54.29	90.95	57.54
Gola	45.67	81.91	67.76	71.83	66.79	63.49	55.35	63.65	67.41	62.47	27.85	108.48	71.87	112.17	80.09
Umran	30.72	59.56	45.99	45.41	45.42	63.49	55.35	63.65	67.41	62.47	-2.06	63.77	28.33	46.11	34.04
SEm ±	0.81	1.58	1.50	1.51	0.69						1.63	3.15	3.00	3.78	1.50
CD (*P*=0.05)	2.65	5.14	4.89	4.93	2.00						5.31	10.28	9.78	12.31	4.31
Intercrop															
Green gram	47.16	92.24	69.34	74.58	70.83	66.23	59.12	67.80	71.61	66.19	28.08	125.37	70.88	114.84	84.79
Pearl millet	31.60	83.37	55.83	58.15	57.24	64.97	58.16	65.76	69.71	64.65	-1.77	108.58	45.91	75.66	57.10
Senna	24.78	40.60	47.54	47.85	40.19	59.28	48.76	57.38	60.91	56.58	-9.72	32.44	37.70	58.73	29.79
SEm ±	0.91	1.90	1.50	1.51	0.75						1.83	3.81	2.99	3.77	1.60
CD (*P*=0.05)	2.67	5.56	4.37	4.40	2.10						5.33	11.12	8.73	11.00	4.49

Table 4 Effect of spacing, *ber* variety and intercrops on soil properties

	pH	EC (dS/m)	OC (%)	P_2O_5 (kg/ha)	K_2O (kg/ha)	Fe (mg/kg)	Zn (mg/kg)
Spacing							
6×6	8.47	0.10	0.203	37.66	362.33	5.40	0.985
6×12	8.43	0.11	0.201	38.52	365.89	5.51	1.034
SEm±	0.43	0.00	0.004	0.72	12.12	0.15	0.034
CD	NS	NS	NS	NS	NS	NS	NS
Variety							
Seb	8.43	0.11	0.195	37.69	366.00	5.42	1.007
Gola	8.46	0.11	0.204	38.62	365.92	5.40	1.053
Umran	8.47	0.10	0.207	37.96	360.42	5.56	0.968
SEm±	0.23	0.00	0.007	1.42	10.94	0.25	0.033
CD	NS	NS	NS	NS	NS	NS	NS
Intercrop							
Green gram	8.40	0.11	0.209	39.08	370.25	5.46	0.990
Pearl millet	8.42	0.11	0.202	37.19	354.42	5.42	0.993
Senna	8.54	0.10	0.196	38.01	367.67	5.49	1.045
SEm±	0.29	0.00	0.006	1.20	9.40	0.19	0.026
CD	NS	NS	NS	NS	NS	NS	NS
Initial (2011) v/s final (2015)							
Initial (Avg.)	8.40	0.13	0.189	41.02	386.50	5.62	0.991
Final (Avg.)	8.45	0.10	0.202	38.09	364.11	5.46	1.009

pearl millet and senna had not significantly effect on soil quality parameters studied but maintained over the period. This may be elucidated by beneficial effect of *ber* litter fall and incorporation of root biomass of intercrops that on its decomposition might have retained the nutrient status. Awasthi and Singh (2010) also reported similar findings with *ber* in arid Rajasthan.

From the above experiment, it can be concluded that old senile orchards of *ber* can be rejuvenated successfully and productivity could be restored within three years. Gola found more productive than Seb and Umran for rejuvenation. Intercrops mainly green gram can be introduced in the alleys of *ber* at the recommended spacing (6 m × 6 m). Though the biological feasibility of intercrops is accompanying under wider spacing but total system productivity and profitability can not be compensated by reducing the *ber* population by 50%.

REFERENCES

Awasthi O P and Singh I S. 2010. Effect of *ber* and pomegranate plantation on soil nutrient status of typic torripsaments. *Indian Journal of Horticulture* **67**: 138–42.

Baba Jahangeer A, Ishfaq Akbar P and Vijai Kumar. 2011. Rejuvenation of old and senile orchards: a review. *Annals of Horticulture* **4**: 37–44.

Bal J S, Randhawa J S and Singh J. 2004. Studies on the rejuvenation of old *ber* trees of different varieties. *Journal of Research* (PAU) **41**: 210–3.

Bhati T K, Tewari J C and Rathore S S. 2008. Productivity and dynamics of integrated farming systems in western Rajasthan. (*In*) *Diversification of Arid Farming System,* pp. 23-30. Pratap Narain, Singh M P, Kar A, Kathju S and Praveen-Kumar (Eds). Arid Zone Research Association of India and Scientific Publisher (India).

Gupta N K and Bist L D. 2005. Effect of different planting system and paclobutrazol on vegetative growth of Babughosa pear. *Indian Journal of Horticulture* **62**: 20–3.

Jain P K, Raut R L and Rajwade V B. 2006. Mango based intercropping under the watershed of Kymore plateau of Madhya Pradesh. *Indian Journal of Horticulture* **65**: 486–7.

Mishra D, Pandey D, Mishra Rajneesh and Pathak R K. 2007. Performance of improved aonla cultivars during top working on senile trees. *Indian Journal of Horticulture* **64**: 396–8.

Mistry P M and Patel B N. 2009. Impact of heading back plus paclobutrazol on rejuvenation of old and over crowded alphonso orchards. *Indian Journal of Horticulture* **66**: 520–2.

Raut R L. 2006. Performance of various intercrops in relation to land equivalent ratio (LER) and their influence on yield attributes and yield of mango (*Mangifera indica* L.). *Journal of Soils and Crops* **16**: 295–9.

Sharma A K and Gupta J P. 2001. Agroforestery for sustainable production under increasing biotic and abiotic stresses in arid zone. (*In*) *Impact of Human Activities on Thar Environment*, pp 95-96. Arid Zone Research Association of India, Jodhpur.

Singh H and Bal J S. 2010. Studies on the performance of rejuvenated trees of different *ber* varieties. *Indian Journal of Horticulture* **67**: 315–7.

Singh R S, Gupta J P, Rao A S and Sharma A K. 2003. Micro-climatic quantification and drought impacts on productivity of green gram under different cropping systems of arid zones. (*In*) *Human Impact on Desert Environment,* pp 74-80. Naraian P, Kathju S, Kar A, Singh M P and Praveen-Kumar (Eds). Scientific Publishers, Jodhpur.