Productivity and economics of Ber based Agri-Horticultural systems under semi-arid condition of Akola in Vidarbha

ABSTRACT

Alternate land use system is applicable in areas where subsistence farming is practiced in unstable ecosystems, and it poses more potentiality and flexibility in land use than the traditional crop production systems. The alternate land use systems are effective means of stabilizing both productivity of dryland and incomes of dryland farmers, besides generating more counter potential. Ber is very hardy to drought conditions due to well-developed long tap root system than other perennial components. To increase the land use efficiency, there is scope for growing field crops during initial growth stages of Ber in between the inter spaces. The experiment with objectives for studying the productivity and the economics of Ber based Agro-Horticulture system under dryland condition was conducted at the research farm of the AICRP for Dryland Agriculture, Dr. PDKV, Akola. The experiment was conducted in Randomized Block Design having four treatments and five replications. The data of pooled results of six years indicated that the treatment cotton + soybean (1:1) recorded significantly highest value of Ber equivalent yield (970 kg ha^{-1}). The gross monetary returns (Rs. 69643), net monetary returns (Rs.22106) and rainwater use efficiency (1.17 kg $ha^{-1}mm^{-1}$) was observed significantly superior in Cotton+ Soybean (1:1) intercropping system over other treatments.

Keywords: Agri horticulture, Ber, Intercropping, Soybean, Cotton, GMR, NMR

1. INTRODUCTION

The ever-growing pressure of human and animal population and the transforming food habits have led to intensive cultivation of marginal lands leading to land degradation intensely under rainfed conditions. The partial arid regions with minimal intensity rainfall and poor soil coat produce high substance per unit area (Ramamohan Reddy et al., 2013). Traditional farming practices and monoculture production systems that are prevalent in the areas often result in subnormal production from the farmland. To make best use of these lands, there is need to plan land use based on its supporting ability keeping in view the short-term goals of market demands, profitability and the long-term goal of sustainability. The extent of human pressure and the effects of conflicting land use systems need to be addressed. Catchment area can be envisioned based on the landscape/ topography and is the idea for designing in-situ conservation formations for water management (Patode et al. 2017). An alternate land use system is appropriate in areas where subsistence farming is practiced in fragile ecosystems, and it poses more potentiality and flexibility in land use than the traditional crop production systems. An ideal system for dry land areas should have a judicious mix of crops, trees and grasses only then the natural resources will be judiciously utilized and returns maximized without any detrimental effect to environment (Narain, 2008). The alternate land use systems are surer means of stabilizing both productivity of dryland and incomes of dryland farmers, besides generating more complement potential. Day by day demand for food fodder and fuel is growing, which could be solved by selecting suitable land use system, improvement of degraded, marginal and sub-marginal lands by introduction of suitable alternate land use systems (Gupta et al*.,* 2019). The most water economizing horticultural crops having multiple uses can be grown in association with annual crops with less or no competition and in some cases synergistic relationship was also observed (Pareek, 1999; Pareek and Awasthi, 2008; Bhandari et al., 2014; Singh et al., 2017 and Tanvar et al., 2018). Ber is planted with wider spacing of 6 m and the inter row spacing provides conditions for growing of field crops. Ber is very hardy to drought conditions due to well-developed long tap root system than other perennial components (Meena, 2015 and Meena et al., 2019). To increase the land use efficiency, there is scope for growing field crops during initial growth stages of Ber in between the inter spaces. Ber needs pruning every year which is usually done in April/May, and it takes about four to five months to develop full canopy during this period annual crops can be grown in the inter row space (Yaragattikar and Itnal, 2003). In view of this, the present investigations were carried out. The objectives of this experiment were to study the productivity and the economics of Ber based Agro-Horticulture system under dryland condition.

2. MATERIAL AND METHODS

The present investigation was carried out at research farm of All India Coordinated Research Project for Dryland Agriculture (AICRPDA), Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Maharashtra) during the year 2016-17 to 2021-22 under rainfed conditions. Akola is situated at 20^{0} 42' North latitude and 77^{0} 02' East longitude and lies in subtropical continental climate at 307.4 meters above the mean sea level. The experimental soil was clayey in texture. The soil of experimental site was slightly alkaline in nature (pH- 7.85) and soil was low in organic carbon content (5.17 g kg-1), low in available nitrogen (230.8 kg ha^{-1}), low in available phosphorus (18.5 kg ha^{-1}) and high in available potassium (330.6 kg ha^{-1}).

The experiment was conducted in Randomized Block Design having four treatments and replicated five times. The treatments comprised of sole cotton, sole soybean, cotton + soybean (1:1) intercropping system and cotton + soybean (3:3) strip cropping. Cotton crops were sown under high density planting in sole as well as in intercropping. Cotton cv. AKH 081 which is suitable for high density planting and a short duration variety. Soybean cv. was JS 335. The sowing of sole cotton, sole soybean and intercropping was sown in 45 cm row spacing. The intra row spacing in soybean was 5 cm and in cotton 10 cm. The crop was fertilized as per the recommended dose of fertilizer. The sole cotton was fertilized with 60:30:30 NPK kg ha^{-1}, soybean with 30: 75:30 NPK kg ha^{-1}. Cotton + soybean (1:1) intercropping and Cotton + soybean (3:3) strip cropping was fertilized with 50:55:30 NPK kg ha^{-1}. The plantation of Ber plant was done on 6 m x 6 m spacing and the cropping was done on 4.05 m. in alley. The variety of Ber was Mehrun. The gross and net plot size was 6.0 x 18.0 m. Row wise intermittent trenches were prepared in between two plants (Patode et al. 2015). Every year the pruning was done in the month of April/ May. The rainfall data of the experimental period is given in Table 1.

Table 1. Rainfall data from 2016-17 to2021-22

Rainfall	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22

Rainfall (June to Sept)	741.8	455.3	830.1	817.9	733.6	968.0
Rainy days	40	38	41	47	49	50
Rainfall (Oct. to Dec.)	90.5	62.0	4.5	111.1	38.0	116.0
Rainy Days	05	05	1.0	10	04	04
Total Rainfall (June – Dec)	832.3	517.3	834.6	929.0	771.6	1084.0
RD	45	43	42	57	53	54

Choice of fruit tree: It is generally preferred to grown multipurpose tree spp. which can cater domestic needs apart from tree fodder during the off season. Ber not only provide additional income, employment and nutritious fruits for balanced diet but also help in harvesting side branches for fodder or fencing purpose. It is fast growing, multipurpose, tolerant to drought and extremes of temperature and propitiate easily.

3. RESULTS AND DISCUSSION

3.1 Seed cotton and cotton stalk yield, Soybean seed and straw yield

During the years 2016-17, 2017-18, 2018-19, 2019-20, 2020-21,2021-22 and mean of six years, results showed that, the sole cotton and sole soybean crops recorded maximum yield than the intercropping and strip intercropping system. It was because plant population of the crop was more in sole cropping than the intercropping and strip cropping system (Table 2). Similar trend was observed in respect of cotton stalk and soybean straw yield during the period of experimentation (2016-17 to 2021-22).

Table 2. Seed cotton yield, stalk yield of cotton, soybean seed and straw yield as influenced by the various treatments (2016-17 to 2021-22)

Treatments	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	Mean
	Seed Cotton Yield (kg ha^{-1})						
T_1 : Sole Cotton	1271	608	685	744	658	622	607
T_2: Sole soybean	-	-	-	-	-	-	-
T_3: Cotton + Soybean (1:1)	699	302	545	539	454	308	388
T_4 : Cotton + Soybean (3:3)	844	365	518	476	442	422	391
	Soybean Seed Yield (kg ha^{-1})						
T_1 : Sole Cotton	-	-	-	-	-	-	-
T_2: Sole soybean	756	556	1307	572	614	621	738
T_3: Cotton + Soybean (1:1)	483	288	870	385	411	302	457
T_4 : Cotton + Soybean (3:3)	638	241	666	305	324	328	417
	Cotton Stalk Yield (kg ha^{-1})						
T_1 : Sole Cotton	1000	446	722	631	630	553	664
T_2: Sole soybean	0	0	0	0	0	0	0

T_3: Cotton + Soybean (1:1)	536	232	537	356	461	456	430
T_4 : Cotton + Soybean (3:3)	713	246	504	325	366	384	423
	Soybean Straw Yield (kg ha^{-1})						
T_1 : Sole Cotton	-	-	-	-	-	-	-
T_2: Sole soybean	860	663	1785	587	872	751	920
T_3: Cotton + Soybean (1:1)	372	365	944	363	673	535	542
T_4 : Cotton + Soybean (3:3)	458	323	696	297	542	512	471

3.2 Ber yield (kg ha^{-1})

During the years 2016-17, 2020-21 and 2021-22, Ber yield was higher in Ber + sole cotton treatments. During the year 2017-18, Ber yield was higher in treatment of Ber + cotton + soybean (1:1) intercropping system. Treatment of Ber + sole soybean recorded higher yield of Ber during 2018-19 and 2019-20 (Table. 3). Mean data of six year showed that treatment of Ber + sole soybean recorded higher Ber yield and followed by Ber + cotton +soybean (1:1) intercropping system.

Table 3. Ber yield (kg ha^{-1}) as influenced by different treatments

Treatments	Ber yield (kg ha^{-1})						
	2016-17	**2017-18**	**2018-19**	**2019-20**	**2020-21**	**2021-22**	**Mean**
T1 : Sole Cotton	526	77	647	343	387	365	334
T2: Sole soybean	496	71	796	362	302	354	394
T3: Cotton + Soybean (1:1)	458	80	722	329	296	353	379
T4: Cotton + Soybean (3:3)	468	69	611	314	298	349	354

3.3 Ber equivalent Yield (kg ha^{-1})

The data regarding Ber equivalent yield is presented in Table 4. During the year 2016-17, Ber equivalent yield was observed significantly higher in treatment of Ber + Cotton + soybean (3:3) and found at par with Ber + sole cotton (1319 and 1267 kg ha^{-1} respectively). During the year 2017-18, treatment of Ber + sole cotton recorded significantly higher Ber equivalent yield and being at par with treatments of Ber +cotton + soybean (1:1) and Ber + cotton + soybean (3:3) strip intercropping system. Significantly highest Ber equivalent yield (1645 and 915 kg ha^{-1}) was recorded in Ber +cotton + soybean (1:1) intercropping system during 2018-19 and 2019-20. During the year 2020-21, Ber +cotton + soybean (1:1) treatments recorded significantly higher Ber equivalent yield of 880 kg ha-1 and on par with Ber + sole cotton (869 kg ha^{-1}). Treatment of Ber + sole cotton recorded significantly higher Ber equivalent yield (900 kg ha^{-1}) and being at par in the Ber + cotton + soybean (3:3) strip intercropping system than rest of the treatments.

The pooled data of six year for Ber equivalent yield showed that treatment of Ber +cotton + soybean (1:1) recorded significantly highest value (970 kg ha^{-1}) than the other treatments.

Table 4. Ber equivalent yield (kg ha^{-1}) as influenced by various treatments

Treatments	Ber equivalent yield (kg ha^{-1})						
	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	Mean
T1 : Sole Cotton	526	77	647	343	387	365	334
T2: Sole soybean	496	71	796	362	302	354	394
T3: Cotton + Soybean (1:1)	458	80	722	329	296	353	379
T4: Cotton + Soybean (3:3)	468	69	611	314	298	349	354
S.Em. ±	**18.5**	**7.37**	**20.97**	**22.7**	**17.2**	**7.76**	**7.43**
C.D. (*P=0.05*)	**56.1**	**22.4**	**63.6**	**68.8**	**52.1**	**23.5**	**22.55**

3.4 Economics

3.4.1 Gross monetary returns

The data regarding gross monetary and net monetary returns is presented in Table 5. During the year 2016-17, treatment of Ber + cotton + soybean (3:3) strip cropping system recorded significantly higher gross monetary returns (Rs. 94681ha^{-1}) and being at par with Ber + sole cotton (Rs. 91212 ha^{-1}) than other treatments. During the season 2017-18, significantly higher gross monetary returns (Rs. 31259 ha^{-1}) was recorded in Ber + sole cotton and on par with Ber + cotton + soybean (1:1) intercropping system and Ber + cotton + soybean (3:3) strip cropping system. Significantly highest gross monetary returns were recorded in treatment of Ber + cotton + soybean (1:1) intercropping system during the season of 2018-19 and 2019-20. Treatment of Ber + cotton + soybean (1:1) intercropping system recorded higher gross monetary returns (Rs. 63622 ha-1) and being at par with Ber + sole cotton (Rs. 62419 ha^{-1}) during 2020-21. During the season of 2021-22, significantly higher gross monetary returns were recorded with treatment of Ber + cotton + soybean (3:3) and comparable with Ber + sole cotton than other treatments. Pooled mean data showed that the significantly highest gross monetary returns (Rs. 69643 ha^{-1}) was recorded in treatment of Ber + cotton + soybean (1:1) intercropping system

Table 5. Gross monetary returns as influenced by various treatments

Treatments	Gross Monetary Returns (Rs.ha^{-1})						
	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	Pooled mean
T1 : Sole Cotton	91212	31259	85165	59233	62419	64368	61610
T2: Sole soybean	65657	27748	109615	48685	46499	50250	57849
T3:Cotton+Soybean(1:1)	81440	30309	117695	65368	63622	57064	69643
T4:Cotton+Soybean(3:3)	94681	30257	99927	53752	54832	64394	66472
S.Em. ±	**1285**	**523**	**1451**	**1586**	**1240**	**540**	**527**
C.D. (*P=0.05*)	**3898**	**1586**	**4401**	**4812**	**3761**	**1637**	**1599**

3.4.2 Net monetary returns

During the year 2016-17, treatment of Ber + cotton + soybean (3:3) strip cropping system resulted in significantly higher net monetary returns (Rs. 46809 ha^{-1}) and being at par with Ber + sole cotton (Rs. 45716 ha^{-1}) than other treatments. Treatment of Ber + sole soybean recorded significantly higher net monetary returns of Rs. 70370 ha^{-1} and comparable with Ber + cotton + soybean (1:1) intercropping system than rest of the treatments during the season of 2018-19. During 2019-20, net monetary returns recorded higher in treatment of Ber + cotton + soybean (1:1) system and found at par with Ber + sole cotton than other treatments. Net monetary returns were found significantly higher during 2020-21 in treatment of Ber + sole cotton and found to be comparable with Ber + cotton + soybean (1:1) system than other treatments. During the season 2021-22, treatment of Ber + sole cotton recorded significantly highest net monetary returns of Rs. 20312 ha^{-1} (Table 6). Pooled mean data regarding net monetary returns showed that, significantly highest net monetary returns of Rs. 22106 ha^{-1} was recorded in treatment of Ber + cotton + soybean (1:1) intercropping system.

Table 6. Net monetary returns (Rs. ha^{-1}) as influenced by various treatments

Treatments	Net monetary returns (Rs. ha^{-1})						
	2016-17	**2017-18**	**2018-19**	**2019-20**	**2020-21**	**2021-22**	**Pooled mean**
T1 : Sole Cotton	45716	-11525	41055	15555	18735	20312	17644
T2: Sole soybean	27155	-10484	70370	10432	8189	11931	19250
T3:Cotton+Soybean(1:1)	33311	-15943	68870	17635	15974	10169	22106
T4:Cotton+Soybean(3:3)	46809	-17541	50176	5508	6454	15429	17587
S.Em. ±	**1285**	**523**	**1451**	**1586**	**1240**	**540**	**527**
C.D. (*P=0.05*)	**3898**	**1586**	**4401**	**4812**	**3761**	**1637**	**1599**

3.4.3 B:C ratio

The mean data regarding the benefit cost ratio of six seasons presented in Table 7 and revealed that treatment of Ber + sole soybean recorded maximum value of B:C ratio (1.50) followed by Ber + Cotton + Soybean (1:1) intercropping (1.46) than rest of the treatments.

Table 7. B:C ratio as influenced by various treatments

Treatments	B:C Ratio						
	2016-17	**2017-18**	**2018-19**	**2019-20**	**2020-21**	**2021-22**	**Mean**
T1 : Sole Cotton	2.00	0.73	1.93	1.36	1.43	1.46	1.40
T2 : Sole soybean	1.71	0.73	2.79	1.27	1.21	1.31	1.50
T3 : Cotton + Soybean (1:1)	1.69	0.66	2.41	1.37	1.34	1.22	1.46
T4 : Cotton + Soybean (3:3)	1.98	0.69	2.01	1.11	1.13	1.32	1.36

3.5 Rainwater Use Efficiency (kg $ha^{-1}mm^{-1}$)

The data regarding rainwater use efficiency is given in Table 8. In respect of rainwater use efficiency, treatments of Ber + Cotton + Soybean (3:3) recorded maximum rainwater use efficiency (1.59kg ha-1mm-1) and followed by Ber + sole cotton (1.52kgha-1mm-1) during 2016-17. During 2017-18, rainwater use efficiency was found maximum in treatment of Ber + sole Cotton followed by Ber + Cotton + Soybean (1:1) and similar value observed in Ber + Cotton + Soybean (3:3) strip cropping. Treatment of Ber + Cotton + Soybean (1:1) recorded maximum value of RWUE during 2018-19 and 2019-20. During the year 2020-21, rainwater use efficiency was recorded maximum in Ber + Cotton + Soybean (1:1) and followed by Ber + sole Cotton. Similar value of RWUE (0.83kg ha-1mm-1) was observed in treatment of Ber + sole Cotton and cotton + soybean (3:3) strip cropping. Mean of six-year data showed the higher value of RWUE was recorded in Ber + Cotton + Soybean (1:1) followed by Ber + Cotton + Soybean (1:1) and Ber + sole Cotton

Table 8. Rainwater Use Efficiency (kg $ha^{-1}mm^{-1}$) as influenced by various treatments

	Rainwater Use Efficiency (kg$ha^{-1}mm^{-1}$)						
Treatments	**2016-17**	**2017-18**	**2018-19**	**2019-20**	**2020-21**	**2021-22**	**Mean**
T1: Sole Cotton	1.52	0.83	1.43	0.89	1.13	0.83	1.10
T2: Sole soybean	1.11	0.74	1.84	0.74	0.84	0.65	0.99
T3:Cotton+Soybean (1:1)	1.37	0.81	1.97	0.98	1.14	0.73	1.17
T4:Cotton+Soybean (3:3)	1.59	0.81	1.67	0.81	0.99	0.83	1.11

4. CONCLUSION

It can be concluded that, under Agri-horticultural system of Ber (6x6 m) intercropped with HDPS american cotton (AKH-081) + soybean (1:1) with fertilizer level of (50:55:30 NPK kg ha^{-1}) recorded highest Ber equivalent yield, Gross monetary returns, Net monetary returns and rainwater use under rainfed conditions.

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