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Research Paper

Productivity and profitability of legumes as influenced by integrated nutrient management with fruit crops under hot arid ecology

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ABSTRACT

A field study was conducted during the rainy seasons of 2008 to 2010 at Bhuj, Gujarat, to assess the possibilities of utilizing the inter-row spaces of fruit orchards of aonla (*Embelica officinalis*), ber (*Ziziphus mauritiana* Lam.) and pomegranate (*Punica granatum* L.) for growing legumes such as clusterbean [*Cyamopsis tetragonoloba* (L.) Taub.], cowpea [*Vigna unguiculata* (L.) Walp.] and mothbean [*Vigna aconitifolia* (Jacq.) Marechal] to serve as an additional source of income. The soil was sandy loam with low organic carbon. Among the 3 legumes evaluated, clusterbean performed well with orchards and gave 304, 399 and 315 kg/ha yields under aonla, ber and pomegranate respectively. Highest benefit: cost ratio of 1.83 was obtained with ber + clusterbean system followed by ber + mothbean (1.65). The experiment on nutrient management for the fruit–legume alley cropping system showed that application of 50% recommended dose of fertilizer (RDF) and zinc sulphate @ 20 kg/ha with biofertilisers resulted in the highest net returns (13,273/ha) and benefit: cost ratio (2.15) in cowpea. Clusterbean as an intercrop with ber gave the highest net returns with RDF which was at par with application of 50% RDF with biofertilizer and zinc sulphate @ 20 kg/ha. The study revealed that the inter-row space in fruit crops may effectively be utilized for getting additional income for better livelihood of small and marginal farmers in hot arid region of Gujarat.

***Key words*:** Alternate land-use systems, Arid legumes, Economics, Integrated nutrient management

Arid legumes, i.e. clusterbean, mothbean, cowpea and horse gram, are generally grown in fragile hot arid regions of India. The hot arid region covers an area of 31.7 million ha in India spread over 7 states, viz. Rajasthan, Gujarat, Punjab, Haryana, Andhra Pradesh, Karnataka and Maharashtra (Dayal *et al.*, 2009a). Horticultural crops form an important component of arid ecosystems owing to their capability to withstand adverse environmental conditions (Bhati *et al.*, 2009). In the arid Kachchh region of Gujarat more than 20,000 ha area is under fruit crops. Ber, pomegranate and aonla are important horticultural crops of the region with Kachchh district as first in pomegranate area and production in Gujarat (Directorate of Economics and Statistics, 2011). Ber is grown in an area of 38 ha with a production of 2,434 tonnes; pomegranate in 1,205 ha area with a production of 19,135 tonnes and aonla in 5 ha with 65 tonnes production (Directorate of Economics and Statistics, 2011). Intercropping trees, in an agri-horti system combine agriculture and horticulture enterprizes together for the best utilization of land and other resources. Under harsh environmental conditions intercrops serve as an insurance against total crop failure. This land-management system aims at production of both agricultural crops and fruits. This practice can be adopted till 5–6 years or till canopy of trees becomes fully closed or later as per the tree-canopy management. If the fruit trees are widely spaced, agricultural crops can be simultaneously grown. The practice is highly beneficial in fruit trees like ber which require pruning (Dayal *et al.*, 2009b). The crops used in combination are useful in many ways. They serve as a source of additional income, and if the intercrops grown are legumes they can add nitrogen and other nutrients into the soil (Srivastava *et al.*, 2007), apart from improving soil physical properties and hydrological behaviour. The competition for various resources like space, water and nutrients by the intercrops limits the weed infestation (Teasdale *et al.*, 2007). At the same time cultivation of drought hardy legumes such as clusterbean, cowpea, mothbean and greengram are undertaken by

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farmers in the arid region to stabilize production. Inclusion of these legumes as an intercrop in the inter-row spaces will be beneficial to realize higher income along with environmental benefits. However, a meagre information is available on the effect of growing them as intercrops and their agro-techniques for the region. The aim of this study was to assess the productivity and profitability of legumes with tree orchards and to develop suitable nutrient-management practices for the intercrops.

MATERIALS AND METHODS

A field experiment was carried out at the research farm of Central Arid Zone Research Institute, Regional Research Station, Kukma, Bhuj, (23˚12' and 23˚13' N, 69˚47'–69º 48' E) Gujarat during rainy (*kharif*) season of 2008 to 2010. The climate of the region is arid with average annual rainfall of 326 mm only. The total rainfall received during the cropping period (June to October) was 315, 496 and 869 mm in 2008, 2009 and 2010 respectively. The experiment was conducted at 3 different sites of fruit orchard namely, aonla (*Embelica officinalis*) var 'NA 7', ber var 'Seb' and pomegranate var 'Ganesh'. The ber orchard was established in 2001 with a spacing of 6 m × 6 m, aonla in 2004 with 6 m × 6 m spacing and pomegranate in 2004 with 5 m × 5 m spacing. The initial soil-test values of these three experimental sites are provided in Table 1. In 2008 and 2009, 3 legume crops namely clusterbean (*Cyamopsis tetragonoloba* (L.) Taub.) 'Maruguar', cowpea 'GC 3' and mothbean 'CZM 2' were sown as alley crops in the inter-row space of these fruit crops at a spacing of 45 cm × 10 cm. There were 7 rows of legumes between 2 rows of fruit crops. All the agronomic practices for the legume and fruit crops were followed as recommended for the region. The crops were sown in July–August and harvested in October. Based on the results of first 2 years experiment, the best fruit-tree supporting intercropping of arid legume was further experimented to develop proper nutrient-management package for the intercrop. Treatments consisted of 3 legumes grown under ber with 5 integrated nutrient management, namely control, recommended dose of fertilizer (RDF), 50% RDF, 50% RDF + biofertilizer (*Rhizobium*) and 50% RDF + biofertilizer + zinc sulphate @ 20 kg/ha. The RDF for clusterbean, cowpea and mothbean were 20: 40: 40; 20:60:40 and 18:40:40 respectively. The seed was treated with *Rhizobium*, 2 hr before sowing. The economics was calculated on the basis of prevailing market prices of different inputs and outputs. The statistical software package Genstat (v. 14) was used for data analysis. The treatment means were compared at the $P < 0.05$ level using the LSD.

Table 1. Initial soil characteristic of the study area

Soil characteristics	Site 1: Aonla	Site 2: Ber	Site 3: Pomegranate
*p*H (1:2)	8.4	8.1	8.6
EC (1:2) dS/m	0.32	0.54	0.46
Organic carbon (%)	0.29	0.34	0.31
N (kg/ha)	189	206	194
P_2O_5 (kg/ha)	6.5	8.2	5.7
K_2O (kg/ha)	287	359	372
Clay (%)	17.6	21.6	19.2

EC, Electrical conductivity

RESULTS AND DISCUSSION

Performance of legumes under fruit trees

The grain and straw yields of all the 3 legumes were higher under sole cropping than intercropped with fruit trees (Table 2). Under aonla, the yield of clusterbean was reduced by 54%, cowpea by 53% and moth bean by 52.7% when compared to monocropped legumes. The least reduction in the grain yield of all the 3 legumes was noticed under ber (40.3% for clusterbean with yield of 399 kg/ha, 34.3% for cowpea with yield of 391 kg/ha and 33.3% for mothbean with yield of 296 kg/ha). Crops tend to give lower yields when intercropped than grown alone as reported by Meena *et al*. (2008). The yield of clusterbean was 315 kg/ha under pomegranate and it reduced by 52% in comparison to sole cropping. The yields of cowpea and mothbean under pomegranate was 302 and 205 kg/ha respectively. The increased grain yield of legumes under sole cropping was owing to higher plant population (Meena *et al.*, 2009) and less competition for resources. Almost similar trend was observed for straw yield. The straw yield of legumes was 1,321, 1,325 and 736 kg/ha, respectively, for clusterbean, cowpea and mothbean under sole cropping. Under intercropping, the straw yield of clusterbean was reduced by 42.3, 34.6 and 46.5% under aonla, ber and pomegranate respectively. The corresponding straw yield reduction was 43.3, 24.1and 41.8% for cowpea under aonla, ber and pomegranate. The yield of mothbean was reduced by 45% under aonla, 27.8% under ber and 43.7% under pomegranate. The study indicated that all the 3 legumes performed better under ber compared to aonla and pomegranate.

Additional economic benefit consequent to intercropping

Intercropping of legumes in fruit orchard gave additional net returns of 1,613 to 5,655 /ha. The highest net returns were recorded by ber + cowpea, followed by ber + mothbean. The intercrop of clusterbean with ber provided the maximum benefit: cost ratio followed by the intercrop of mothbean with ber. Clusterbean under aonla gave a benefit: cost ratio of 1.49 and of 1.61 under pomegranate.

Table 2. Grain and straw yield of legumes under different land-use systems (mean value of 3 years)

Treatment	Grain yield (kg/ha)			Stalk yield (kg/ha)		
	Clusterbean	Cowpea	Mothbean	Clusterbean	Cowpea	Mothbean
Sole	669	596	404	1321	1325	736
Aonla	304	278	191	763	752	405
Ber	399	391	269	864	1005	532
Pomegranate	315	302	205	707	771	414
SEm±	6.67	8.5	5.6	20.4	21.8	9.2
CD (P=0.05)	19.7	25.6	16.8	61.2	65.3	27.7

Cowpea recorded benefit: cost ratio of 1.17, 1.59 and 1.34 under aonla, ber and pomegranate respectively. The benefit: cost ratio of mothbean under aonla and pomegranate was 1.32 and 1.36 respectively. Increased monetary benefits by intercropping under ber was reported by Patel *et al.* (2003). Arya *et al.* (2011) also reported higher net returns and benefit: cost ratio under intercropping systems for fruit trees.

Yield and economics of arid legumes under ber with different nutrient management practices

Different nutrient-management treatments significantly affected the yield of all the 3 legumes ($P<0.01$). The highest grain yield of clusterbean was recorded with RDF and it remained on a par with 50% RDF combined with biofertilizer and application of zinc (Fig 1). The lowest yield of clusterbean was recorded with the application of 50% RDF. In case of cowpea and mothbean, the same trend was recorded. The grain yield of cowpea and mothbean with application of RDF was 433 and 274 kg/ha respectively, which was at par with 50% RDF combined with biofertilizer and zinc application (411 and 252 kg/ha) respectively. Under ber + clusterbean, the maximum net return and benefit: cost ratio were recorded with the application of RDF and remained at par with 50% RDF combined with biofertilizer and zinc application. In case of cowpea, the highest net returns and benefit: cost ratio were recorded with 50% RDF combined with biofertilizer and zinc application, followed by RDF. When moth bean was intercropped with ber, the highest net returns were obtained with application of RDF and highest benefit: cost ratio with 50% RDF combined with biofertilizer and zinc application.

It was concluded that growing arid fruits with different legumes was found beneficial for improving productivity/ unit area and profitability of farmers apart from contributing to increased legume production. The results indicated that arid legumes such as clusterbean, cowpea and mothbean can be successfully intercropped with arid fruit crops such as aonla, ber and pomegranate without adverse impact on growth and yield of fruit crops. Among the systems evaluated, ber + clusterbean found to be promising.

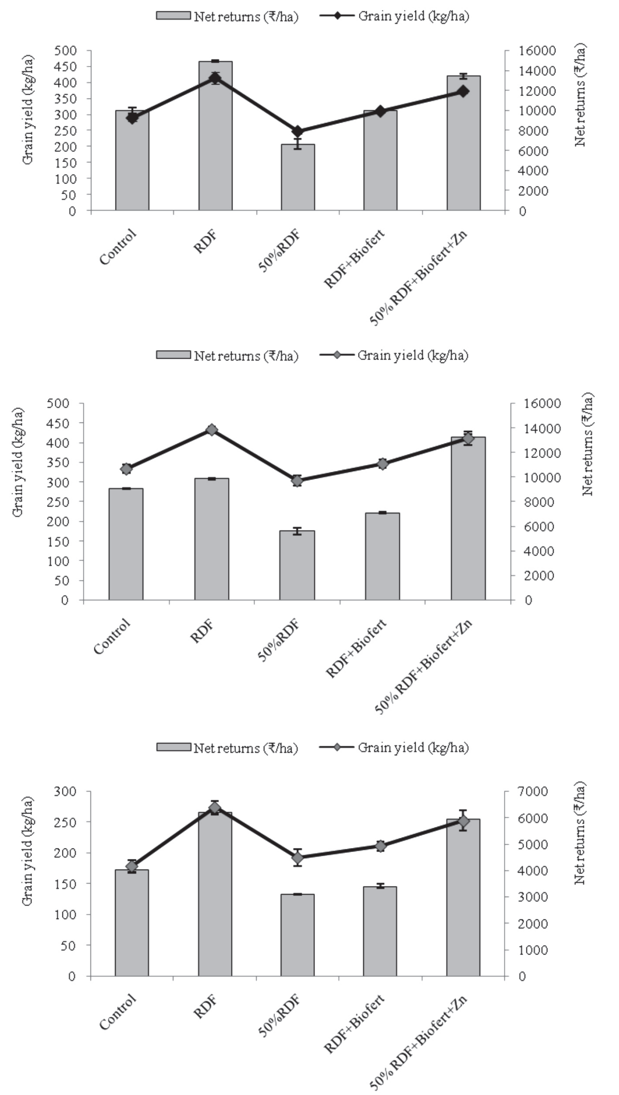

Fig. 1. Yield and economics of arid legumes intercropped with ber under different nutrient management practices. Top, ber + clusterbean; middle, ber + cowpea; and bottom, ber + mothbean.

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