BIOECONOMIC INTERACTION OF SINGLE SCATTERED TREES ON FARMLANDS

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ABSTRACT

Tree-crop interaction of Single Scattered Trees under arid and semi-arid (rainfed and irrigated) areas are discussed in bio-economics terms. The result suggests crop supplementarity with *Prosopis cineraria* associated with wheat and chick peas. However, the opportunity cost of keeping trees of *Acacia nilotica* and *Zizyphus mauritiana* are more than the value foregone for growing wheat and chick peas. A strong biological and financial competition exist between trees of *Acacia* and *Zizyphus* and agricultural crops of wheat and chick pea.

INTRODUCTION

Farmlands in Pakistan possess substantial tree growth both in linear and scattered arrangements. Growing of single scattered trees is the predominant agroforestry system in rainfed(barani) areas of the country. These trees are mainly the remnants of once existing tropical thorn forest, their seedlings naturally regenerated or planted by farmers. The co-existence of trees and agricultural crops is acceptable by farmers due to the many uses of trees in their subsistence way of life such as food, animal fodder, constructional materials and shade. Ber (*Zyziphus mauritiana* 31%), kikar (*Acacia nilotica* 19%) and Jhand (*Prosopis cineraria* 4%) constitutes more than 50% of tree stock in such areas(Amjad, 1991 and 1992).

As a consequence of high population density subsistence farming is practiced on the available land. The size of land holding is small in general. The most common agricultural crops grown are wheat (*Triticum aestivum* / *T. vulgare* / *T. sativum*), gram (chick peas or garbanzo or *Cicer arietinum*), maize (*Zea maize*), mustard (*Brassica compestris*) and guar (cluster beans or *Cyamopsis tetragonoloba*).

Trees have been reported to provide beneficial effects to agricultural crops grown in association with it as well as to the sustainability of agroecosystem as a whole through soil fertility enhancement, moisture conservation, and erosion control(Vityakon et al,1993). However, the effects of trees on reducing agricultural crop productivity through shading and nutrient and moisture competition are seen as an obstacle for agroforestry promotion. Therefore, the effect of *Acacia*, *Zizyphus* and *Prosopis* on crop yield is worth exploring and quantification of such interaction needs to be researched.

The present study provides bioeconomic interaction of single scattered trees grown on farmlands under arid conditions in D.I.Khan/Bhakkar agroecological zone in the central arid region of Pakistan.

METHODOLOGY

The only feasible approach to assess the effects of single scattered trees on agricultural crops grown beneath them in farmer's field was to select series of plots in at least four directions. For this purpose only those farms were selected for the study where crop of wheat and chick pea was ready for harvest and the trees of *Acacia*, *Zizyphus* and *Prosopis* were standing single in the field and away from the border.

Regular transacts around each single tree were laid out in all the four direction: east, west, north and south. Four 1m^2 plots at 2m, 1/2 of tree height, equal to tree height and twice the tree height in meter were harvested. Data regarding number of plants/number of tillers, number of ears/pod and number of seed per ear/pod was recorded under both barani(rainfed) and canal/tubewell irrigation system. Similar observation were also recorded for control plots away from tree influence. Beside that owner/cultivators were informally interviewed to get their view regarding tree growth on farmlands.

Biological comparison included analysis of grain yield, harvest index, crop yield ratio and grain index. For financial analysis, technique of " *Equal Annual Income* (EAI)" was used because investment horizon for trees and crops are different. EAI is defined as the net future value converted to an annual value paid at the end of each full period for the life of the investment, with interest at the selected analysis rate. Since the growth rate of trees in barani(rainfed) and irrigated areas cannot be the same, a 15 years rotation in barani areas was assumed to be equal to 10 years rotation in the irrigated areas.

RESULTS AND DISCUSSION

The study results are discussed separately for biological effects and financial implications.

BIOLOGICAL

EFFECT OF DIRECTION:

Table 1 shows average grain yield/m^2 in all the four directions for different crop combinations under rainfed and irrigated conditions. In almost all cases, excepting prosopis-chick pea combination under rainfed condition, grain yield on southern side is more than east, west and north sides. Production on south and east under acacia-chick pea with irrigation is more than north and west.

Table 1 Grain yield gms/m^2 as affected by direction

Crop combination	North	East	West	South
Prosopis + Wheat				
Rainfed	65.11	69.2	70.8	73.1
Irrigated	151.0	152.0	157.0	161.0
Zizyphus + Wheat				
Rainfed	59.8	61.0	66.0	68.0
Irrigated	143.0	145.0	146.0	155.0
Acacia + Wheat				
Rainfed	75.0	76.1	82.2	84.0
Irrigated	148.0	157.0	159.0	162.0
Prosopis + Chickpea				
Rainfed	17.4	17.1	16.1	16.8
Irrigated	23.3	30.8	35.6	36.2
Zizyphus + Chickpea				
Rainfed	11.7	11.8	11.8	12.3
Irrigated	23.1	23.9	24.3	24.8
Acacia + Chickpea				
Rainfed	10.5	10.8	12.0	12.6
Irrigated	20.6	22.6	21.2	22.2

EFFECT OF DISTANCES:

Table 2 shows average grain yield/m^2 as affected by distance in multiple of tree height from the base of the tree. The results, though variable, are very interesting. No crops are grown with Zizyphus and Acacia upto half of tree height(h/2) under rainfed condition. The reason is that farmers never plough their fields around trees believing that no crops could be grown with Zizyphus and Acacia. However, this is not the case with Prosopis. Farmers do plough such areas though the yield are lower. Excepting prosopis-chick pea combination, yield is highest at a distance twice the height(2h) of the tree. At a distance of "h/2" to "h" Prosopis and chick peas are complementary to each other. This is in conformity to the farmer's belief that Prosopis does not compete very much with agricultural crops. A strong competition exist between trees and crops at least upto a distance equal to tree height in almost all crop combinations both under rainfed and irrigated conditions.

Table 2. Average grain yield/m^2 from tree base.

Crop combination	2m	h/2	h	2h
Prospis + wheat Rainfed	14.7	74.1	94.3	95.3
Irrigated	39.4	178.0	195.0	209.0
Zizyphus+ Wheat				
Rainfed	-	-	-	-
Irrigated	76.1	165.0	180.0	206.0
Posopis + Chickpea				
Rainfed	12.3	18.0	19.2	17.5
Irrigated	6.7	16.9	30.2	38.4
Acacia + Chickpea				
Rainfed	-	-	-	-
Irrigated	5.1	11.6	28.5	37.9

CROP YIELD RATIO (CYR)

Crop Yield Ratio (CYR) is the ratio of the yield under investigation to that of yield from control. This ratio is higher with all crop combinations with Prosopis(Table 3). In all other cases there is tremendous decrease in yield ranging from 84% to 11%. Zizyphus is more competitive than Acacia with wheat both under rainfed and irrigated conditions. However, with chick pea, Acacia is more competitive than Zizyphus. Moreover, Prosopis-wheat competition is more in irrigated areas than rainfed areas

Table 3. Crop Yield Ratio in relation to Control in percent

Crop Combinations	2m	h2	h	2h
Rainfed				
Prospis + Wheat	16.4	81.9	104.9	105.3
Zizyphus + Wheat	-	-	33.5	99.9
Zcacia + Wheat	-	-	67.9	99.3
Irrigated				
Prospis + Wheat	19.4	87.7	96.1	102.9
Zizyphus + Wheat	41.4	69.5	75.4	100.5
Acacia + Wheat	37.5	81.3	88.7	101.5
Rainfed				
Prosopis + Chickpea	69.1	101.1	107.9	98.5
Zizyphus + Chickpea	-	-	38.2	96.1
Acacia + Chickpea	-	-	35.4	93.8
Irrigated				
Prosopis + Chickpea	62.5	88.7	95.0	102.1
Zizyphus + Chickpea	17.6	44.4	79.3	100.8
Acacia + Chickpea	13.4	30.4	74.8	99.4

HARVEST INDEX (HI):

Harvest Index is the ratio of total grain yield to that total biomass expressed in percentage form. A higher HI will indicate higher grain yield while a lower will mean higher straw yield. The result of harvest index is shown in table 4. These result suggest better HI with prosopis in all crop combinations. Zizyphus-wheat is more competitive than Acacia-wheat but it is otherwise for chick pea with Zizyphus/Acacia.

Table 4. Harvest Index as affected by distance from the tree.

Crop combination	2m	h/2	h	2h
Rainfed				
Prosopis + wheat	5.8	29.4	37.4	37.8
Zizyphus + wheat	-	-	12.0	38.8
Acacia + wheat	-	-	24.4	38.7
Irrigated				
Prosopis + wheat	8.7	39.3	43.0	46.1
Zizyphus + wheat	18.5	31.1	33.8	45.7
Acacia + wheat	16.8	36.4	39.7	45.5
Rainfed				
Prosopis + Chickpea	29.5	43.3	46.3	42.3
Zizyphus + Chickpea	-	-	16.3	41.2
Acacia + Chickpea	-	-	7.9	38.7
Irrigated				
Prosopis + Chickpea	29.5	41.9	44.9	48.3
Zizyphus + Chickpea	8.4	21.2	37.8	52.9
Acacia + Chickpea	6.3	14.6	35.6	51.9

GRAIN INDEX

Grain Index (1000-grain weight in gm) as affected by different crop combination is shown in Table 5. Grain Index is good indicator to the extent that higher grain index would mean a good size of the grain. Tabulated results are extremely variable but one thing is clear that grain size is affected by distance from tree base at least upto 1h. Prosopis combinations are better than Zizyphus/Acacia with wheat and chick pea.

FINANCIAL ANALYSIS

Trees and agricultural crops have different investment horizon. They need to be brought to one common denominator for comparison. Agricultural crops produces annual income while tree crops produces return at the end of rotation (final harvest). Therefore, the future returns from trees have to be spread out equally over all of the earning period of the rotation for comparison to earning from agricultural crops. This was done through the technique of *Equivalent Annual Income* (Rose et al., 1988). A 10% discount rate was used for comparison.

Table 5. Grain Index (1000 seed weight) for various crop combinations.

Rainfed	2m	h/2	h	2h
Prosopis + Wheat	47.0	47.7	48.9	49.4
Zizyphus + Wheat	-	-	49.7	49.5
Acacia + Wheat	-	-	47.4	49.5
Irrigated				
Prosopis + wheat	48.3	50.0	50.6	51.2
Zizyphus + Wheat	43.0	48.3	48.7	48.8
Acacia + Wheat	40.4	46.7	49.1	50.2
Rainfed				
Prosopis Chickpea	185	207	211	212
Zizyphus + Chickpea	-	-	178	198
Acacia + Chickpea	-	-	178	195
Irrigated				
Prosopis Chickpea	190	208	210	208
Zizyphus + Chickpea	178	206	209	209
Acacia + Chickpea	181	200	204	207

Table 6 shows financial analysis of wheat and chick pea with single scattered trees of Prosopis, Zizyphus and Acacia. Column 1 of the form gives the average area(m^2) not sown by farmer around trees. This area is more for Zizyphus and Acacia in rainfed areas, although it is lesser in irrigated areas.

Column 2, 3 and 4 gives break up of yield decrease in different combinations due to one single tree. This decrease is further sub-divided into decrease due to area not sown around the tree (column 2) and decrease due to competition for light, nutrients and moisture (column 3). Column 4 is summation of column 2 and 3 or the over all decrease in yield. Value of the decrease in monetary terms is depicted in column 5 which is just the multiplication of column 4 value and average selling price of agricultural crops (Rs.3/- and Rs. 5/- per Kg for wheat and chick pea respectively). This is basically the value of income foregone for keeping a single scattered tree on the farm.

Average selling price for Prosopis, Zizyphus and Acacia is assumed to be R. 400/-, R. 500/- and R. 800/- respectively. This value was estimated through interview with the farmers/cultivators. Rotation for the same tree size was assumed to 15 and 10 years in rainfed and irrigated areas. EAI, the value of Equal Annual Income, from a single scattered tree is given in column 7. The difference of column 5 and 7 is given in column 8 which is in fact the value of net annual benefits/losses for one tree in scattered arrangement.

Prosopis-wheat combinations are more competitive than prosopis-chick pea in biological terms both under rainfed as well as irrigated conditions. However, only Prosopis-wheat under rainfed conditions are competitive financially while Prosopis-chick pea and Prosopis-wheat are supplementary under irrigated condition.

One good reason which goes in favour of *Prosopis cineraria* is that it has a very deep taproot system and hence it does not generally compete for moisture and nutrient with associated crops. It also provide shade to agricultural crops during summer month when temperature is very high.

Zizyphus and Acacia are strongly competitive with wheat and chick pea under all conditions, but the competition is more under rainfed than irrigated condition in bioeconomic terms. This higher yield decrease is due to area not sown for fear of moisture and light competition. This decrease could be lowered if farmers are persuaded to plough land around trees with some root pruning.

Table 6. Financial Analysis of Wheat and Chick Pea with Single Scattered Trees of *Prosopis cineraria*, *Zizyphus mauritiania* and *Acacia nilotica* under arid/semi-arid rainfed and irrigated conditions.

Crops combination	Area not sown (m²)	Yield decrease due to unsown area (Kg/tree)	Yield decrease due to competition (Kg/tree)	Total dereas in yield Kg/tree	Value degree @ Rs. 3.0 Kg (Wheat) Rs. 5.00/Kg Chickpea	Av. Selling price/tree (15x10 yrs rotation)	EAI of tree at 15&10 years rotation (10%)	Net annual benefits/ losses per tree
Prosopis Wheat								
Rainfed	5.2	0.47	4.53	5.0	15.00	400(15)	12.59	-2.41
Irrigated	5.2	1.10	6.9	8.0	24.00	400(10)	25.10	+1.10
Zizyphus wheat								
Rainfed	133	12	6	18.0	54.00	500(15)	15.74	-38.26
Irrigated	24	5	8	13.0	39.00	500(10)	31.37	-7.63
Acacia Wheat								
Rainfed	201	18-1	3.9	22	66.00	800(15)	25.18	-40.82
Irrigated	28	6	13	19	57.00	800(10)	50.20	-7.20
Prosopis chilele pea								
Rainfed	5.2	-	1	1	5.00	400(15)	12.59	+7.59
Irrigated	5.2	-	3	3	15.00	400(10)	25.10	+10.10
Zizyphus Chickpea								
Rainfed	133	7.1	2.4	9.5	47.53	500(15)	15.74	-31.76
Irrigated	24	1.0	6.5	7.5	37.50	500(10)	31.37	-6.13
Acacia chile pea								
Rainfed	201	9.8	3.7	13.5	67.50	800(15)	25.18	-42.32
Irrigated	28	1.1	10.4	11.5	57.50	800(10)	50.20	-7.30

CONCLUSION

The study result suggest that trees and agricultural crops competes with each other both in biological and financial terms. This competition is more under rainfed conditions than irrigated conditions. *Prosopis cineraria* is one promising species because it could supplement farmers income upto some extent without adversely affecting biological yield. Also it appears that farmers are reluctant to plough land at least upto a distant equal to tree height for fear of competition for moisture and light with trees of *Acacia nilotica* and *Zizyphus mauritiana.*

The results are quite indicative and corresponds to the observation elsewhere on crop improvement with *Prosopis cineraria.* Available plant material under this tree is reported to be higher with better growth of crop grown with it.

Farmers in regions know the value of *Prosopis cineraria* and ordinarily will not cut them for fuel. Only lopping for fodder and fuel is being practiced. The only problem with this tree is that it is slow growing. Considering the suitability of this species under arid and semi-arid condition it would be advisable to identify fast growing germ plasm for seed multiplication and field testing.

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