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Agronomic and Economic Interference Between Cotton *Gossypium hirsutum* L. and Pigeon Pea *Cajanus cajan* L.

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Abstract: The field experiment was conducted to evaluate the agronomic and economic interference between cotton and pigeon pea at Students Farm, Sindh Agriculture University Tandojam, Pakistan. The intercropping pigeon pea with cotton showed adverse effects on all the growth and yield contributing parameters of cotton. In pigeon pea, the taller plants (300 cm), greater number of branches (12.33 plant^{-1}), remarkably higher pods (223.66 plant^{-1}), heavy seed index (103.33 g) and maximum seed yield (2182.33 kg ha^{-1}) were observed in sole cropping system. In cotton, maximum plant height (164.00 cm), more production of bolls plant^{-1} (26.33), higher number of branches plant^{-1} (37.33), greater bolls plant^{-1} (16.66) and satisfactory seed cotton yield (2271 kg ha^{-1}) were recorded when cotton was sown as sole crop. The agronomic parameters ob both intercrops decreased as compared to sole crops. The economic analysis indicated that cotton sole crop on an average recorded cost of production Rs. 31098 ha^{-1} against Rs. 26000 ha^{-1} intercropping of cotton with pigeon pea. The physical productivity study includes the total seed cotton yield of cotton as a sole crop and the total yield of cotton from intercropping with pigeon pea. The cotton sole crop yielded 2271.00 kg ha^{-1} and cotton intercropping with pigeon pea yielded 1120.00 kg ha^{-1}. According to average per hectare revenue, productivity of cotton sole Rs. 56775.00 and intercropping cotton with pigeon pea Rs. 28000 ha^{-1}. The cotton sole crop on average recorded net returns at the rate of Rs.25677 ha^{-1} whereas, cotton with pigeon pea intercropping exhibited the net returns at the rate of Rs. 2000 ha^{-1}, which was very low due to adverse affect of pigeon pea intercropping with cotton. In this study input output ratio were determined to examine economic efficiency of both cotton sole and cotton intercropping with pigeon pea. The results derived from the above analysis reveal that growing cotton sole crop earned input output ratios at the proportion of 1:87 whereas, cotton intercropping with pigeon pea had input output ratio at the proportion 1:07. It was concluded that cotton-pigeon pea intercropping has adverse effects on each other, therefore the crops should be sown as sole crops.

Key words: Cotton, pigeon pea, intercropping, growth, yield, economics

INTRODUCTION

Sustainable agriculture seeks, at least in principle, to use nature as the model for designing agricultural systems. Since nature consistently integrates plants and animals into a diverse landscape, a major tenet of sustainable agriculture is to create and maintain diversity. Intercropping offers farmers the opportunity to engage nature's principle of diversity on their farms. Spatial arrangements of plants, planting rates and maturity dates must be considered when planning intercrops. Intercrops can be more productive than growing pure stands. Many different intercrop systems including mixed intercropping, strip cropping and traditional intercropping arrangements (Preston, 2003).

Intercropping is the cultivation of two or more crops simultaneously on the same field. It also means the growing of two or more crops on the same field with the planting of the second crop after the first one has completed its development. The rationale behind intercropping is that the different crops planted are unlikely to share the same insect pests and diseased-causing pathogens and to conserve the soil. There is a number of intercropping which include: (i) mixed or multiple cropping is the cultivation of two or more crops simultaneously on the same field without a row arrangement, (ii) relay cropping is the growing of two or more crops on the same field with the planting of the second crop after the first one has completed its development, (iii) row intercropping is the cultivation of

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two or more crops simultaneously on the same field with a row arrangement, (iv) strip cropping is the cultivation of different crops in alternate strips of uniform width and on the same field. It has two types; contour strip cropping and field strip cropping. Contour strip cropping follows a layout of a definite rotational sequence and the tillage is held closely to the exact contour of the field. Field strip cropping has strips with uniform width that follows across the general slope of the land (Boller *et al*., 2004).

Intercropping in not a new concept but centuries old technique of intensive farming that has been persisted in many areas of the world which efficiently maximizes land and productivity per unit of area per season (Oad *et al*., 2001). Recent world food shortages and prospects of quote supplies in the future have promptly increased the interest in method of increasing food production. Intercropping is providing yield advantages compared to sole cropping. It efficiently uses the space and time of cultivation. It helps to restore soil fertility, utilizes total volume of soil efficiency by utilizing volume of above ground environment embracing incidental heat, CO_2 and rain. The practice of intercropping of turnip with radish and carrot is gaining interest particularly among the farmers having small holdings, who are unable to manage their diversified domestic needs from limited area. The day to day requirement of the growers be modified and reexamined in the light of newly suggested planting system which besides allowing easy and free inter cultivation and provides good chance for kitchen and marketable production (Oad *et al*., 2001). Francis *et al.* (1982) suggested that intercropping should be carefully practiced without damaging to the main crop. Oad *et al.* (2001) were also of the view that intercropping must be practiced intensively and owner can obtain more added benefits with low added costs. Therefore, it is important to investigate the added benefits of intercropping through economic analysis. Preston (2003) concluded that intercropping has a number of advantages, (i) it reduces the insect/mite pest populations because of the diversity of the crops grown. When other crops are present in the field, the insect/mite pests are confused and they need more time to look for their favorite plants; (ii) reduces the plant diseases, (iii) the distance between plants of the same species is increased because other crops (belonging to a different family group) are planted in between, (iv) reduces hillside erosion and protects topsoil, especially the contour strip cropping, (v) attracts more beneficial insects, especially when flowering crops are included in the cropping system, (vi) minimizes labor cost on the control of weeds, (vii) a mixture of various crops gives often a better coverage of the soil leaving less space for the development of weeds, (viii) utilizes the farm area more efficiently, (ix) Results in potential increase for total production and farm profitability than when the same crops are grown separately and (x) provides 2 or more different food crops for the farm family in one cropping season.

Cotton is wider row crop in cropping system and provides better opportunities to grow some legumes or non-legumes as intercrops to produce additional production; those also include cluster bean, sesame, pigeon pea, maize as corn or as fodder produce. Khan *et al.* (2001) intercropped various legume and non-legume crops in cotton variety NIAB-78 including pigeon pea, mung bean, mash bean, *Vigna mungo*, soyabean, *Glycine max*, sesame, maize, sorghum, cowpea and rice bean, *Vigna umbellate* and found that in all the intercropping systems, except cotton + sesame, cotton appeared to be highly dominant for having higher value for relative crowding coefficient than the intercrop. Keeping in view the above facts, the present experiment was conducted to see the nature of interference through intercropping of cotton with pigeon pea on the performance of sole and intercrops.

MATERIALS AND METHODS

The field study was designed to assess agronomic and economic interference through intercropping of cotton with pigeon pea at Students Farm, Sindh Agriculture University Tandojam, Pakistan in randomized complete block design having four replications. The following intercropping combinations were practiced.

T1 Cotton sole
T2 Pigeon pea sole
T3 Cotton-Pigeon pea

Cultural practices

Varieties

Cotton variety = Shahzore
Pigeon pea variety = ICPL-4.

Seed bed preparation: Seed bed was prepared with two dry plowings with mould board plough, followed by cold crushing. The land was also leveled to get fine seed bed and it was divided into unit beds at specified size in all replications.

Sowing: The Cotton was sown by means hand drill at 90 cm row spacing. Alternate rows of cotton and pigeon pea were drilled with single coulter hand drill at 90 cm row to row distance.

Weeding and interculturing: All the weeds were removed with the help of spade, without causing any damage to intercrops. Both weeding and interculturing were done to eradicate weeds and breaking of hard compact surface to make soil porous.

Irrigation and fertilizer applications: The first irrigation was applied after month after the sowing and subsequent irrigations were given as per requirement of intercrops. The full dose of phosphorus in the form of DAP was used at the rate of 75 kg ha^{-1} was applied at the time of sowing. N in the form of urea was split applied during 2nd, 3rd and 5th irrigations.

Statistical analysis: The data were statistically analysed for analysis of variance following the procedures of Gomez and Gomez (1984).

RESULTS

Pigeon pea

Plant height: The taller plants (300 cm) of pigeon pea were recorded in the sole cropping system as compared pigeon-pea-cotton intercropping which exhibited 258.67 cm plant height (Table 1).

Number of branches $plant^{-1}$: The greater number of branches (12.33 $plant^{-1}$) under sole cropping system were noted as compared to 11.00 branches $plant^{-1}$ obtained when pigeon pea was intercropped with cotton (Table 1).

Number of pods $plant^{-1}$: The number of pods $plant^{-1}$ of pigeon pea were remarkably higher (223.66) when pigeon pea was sown in sole cropping system, while the number of pods were reduced to 178.66 when pigeon pea was intercropped with cotton (Table 1).

Seed index: The seed index values were significantly more (103.33 g) in the pigeon pea crop when sown as sole crop, however, the seed index was found lower (86.667 g) in the plots where pigeon pea was intercropped with cotton (Table 1).

Seed yield: The seed yield of pigeon pea was comparatively maximum (2182.33 kg ha^{-1}) when it was planted in sole cropping system. The minimum seed yield 1939.33 kg ha^{-1} was noted under pigeon pea-cotton intercropping system (Table 1).

Cotton

Plant height (cm): The average plant height of cotton was significantly higher (164.00 cm) when cotton was sown as sole crop, while the plant height was considerably reduced to the level of 127.33 cm when cotton was sown in an intercropping system with pigeon pea (Table 1).

Table 1: Pigeon pea-cotton intercropping parameters

Pigeon pea

Treatments	Plant height (cm)	Branches $plant^{-1}$	Seed index (g)	Seed yield (kg ha^{-1})
Pigeon pea sole	300.00	12.33	103.33	2183.33
Pigeon pea intercrop	258.66	11.00	86.66	1939.33
SE	11.150	0.203	4.509	22.35

Cotton

Treatments	Plant height (cm)	Branches ($plant^{-1}$)	Bolls ($plant^{-1}$)	Open bolls ($plant^{-1}$)	Seed cotton yield (kg ha^{-1})
Cotton sole	164.00	37.33	26.33	16.66	2271.00
Cotton intercrop	127.33	23.33	13.33	7.00	1120.00
SE	6.448	3.00	1.802	1.040	52.886

Number of bolls $plant^{-1}$: The average number of bolls $plant^{-1}$ of cotton were maximum (26.33) when the crop was sown as sole crop. The intercropping system considerably recorded reduced (13.33) number of bolls $plant^{-1}$ (Table 1).

Number of branches $plant^{-1}$: In case of cotton sole, the number of branches $plant^{-1}$ were significantly higher (37.33) as compared to intercropping system, where lower 23.33 branches $plant^{-1}$ were found (Table 1).

Number of open bolls $plant^{-1}$: The results on the number of open bolls $plant^{-1}$ envisaged that the average number of open bolls $plant^{-1}$ of cotton were significantly higher (16.66) when cotton was cultivated in the sole cropping system, while the number of cotton open bolls $plant^{-1}$ considerably reduced (7.00) when it was sown in the intercropping system with pigeon pea (Table 1).

Seed cotton yield kg ha^{-1}: The seed cotton yield kg ha^{-1} was significantly maximum (2271 kg ha^{-1}) when cotton was sown as sole crop, while the seed cotton yield kg ha^{-1} was decreased to the level of 1120 kg ha^{-1} when cotton crop was cultivated in the pigeon pea + cotton intercropping system (Table 1).

Economic analysis

Cost of production: The amount of inputs and their values were determined at prevailing market prices. The analysis showed the consumption of land, labor and capital inputs employed to produce and marketing charges incurred by the farmers to sell the produce. The result indicates that

Table 2: Economic analysis of cotton-pigeon pea intercropping

Cropping system	Physical productivity kg ha^{-1}	Revenue productivity (Rs ha^{-1}) (a)	Cost of production (Rs ha^{-1}) (b)	Added costs Rs (c)	Net returns (Rs ha) (a-b)	Input output ratio	Added benefits Rs. (d)
Cotton sole	2271.00	56775.00	31098	-	24234.95	1:1.82	-
Cotton+pigeon pea	1120.00	28000.00*	26000	5098	2000	1:07	2000
Pigeon pea sole	2182.33	32734.95**	8500	-	256.77	1:3.80	-

* Price of cotton per kg = 25, ** Price of pigeon pea per kg = 25

cotton sole crop on an average recorded cost of production Rs. 31098 ha^{-1} against Rs. 26000 ha^{-1} intercropping of cotton with pigeon pea (Table 2).

Physical productivity: The physically productivity generally expressed in terms of unit weight of product obtain from a particular crop. It was revealed that cotton sole crop yielded 2271.00 kg ha^{-1} and cotton intercropping with pigeon pea yielded 1120.00 kg ha^{-1} (Table 2).

Revenue productivity: It is expressed in terms of money and is calculated by multiplying physical productivity with the prices. Revenue productivity indicates the output in terms of money and its vital importance in examining the efficiency of some farm enterprise. It includes the value of the product offered for the sale in the market as well as the value of farm per requisites. According to average per hectare revenue productivity of cotton sole Rs. 56775.00 ha^{-1} and intercropping cotton with pigeon pea Rs. 28000 ha^{-1} (Table 2).

Net returns: Net returns are considered as the most important criteria to examine the efficiency of farm enterprise. The net returns are calculated by subtracting all farm expenses from gross income. The cotton sole crop on average recorded net returns at the rate of Rs. 25677 ha^{-1} whereas, cotton with pigeon pea intercropping exhibited the net returns at the rate of Rs. 2000 ha^{-1}, which was very low due to adverse affect of pigeon pea intercropping with cotton (Table 2).

Input-output ratio: The results derived from the above analysis reveal that growing cotton sole crop earned input output ratios at the proportion of 1:87 whereas, cotton intercropping with pigeon pea had input output ratio at the proportion 1:07 (Table 2). The input output relationship to the amount and nature of yield or production forthcoming as various quantities of labor, seed, fertilizer or other factors of production are used on the farm (Heady, 1994).

DISCUSSION

Intercropping is the cultivation of two or more crops simultaneously on the same field or growing of two or more crops on the same field with the planting of the second crop after the first one has completed its development. In the present study, intercropping system had significant effect on all the growth and yield contributing parameters of both the crops i.e., cotton and pigeon pea. Gu *et al.* (2000) concluded that multiple cropping systems is most cost effective and the most important considerations for maximizing income from these systems included market analysis to ensure crops are marketable and to determine when maximum market prices are achieved, selecting optimum cropping patterns, incorporating organic matter to increase soil fertility and preserve soil moisture.

Irrespective of reduction in growth and other contributing parameters, there would have been a beneficial effect on the economic parameter, but in the present study no economical effect of intercropping cotton with pigeon pea was recorded. Similarly, the seed cotton yield kg ha^{-1} was significantly maximum (2271 kg ha^{-1}) when cotton was sown as sole crop, while the seed cotton yield kg ha^{-1} decreased to the level of 1120 kg ha^{-1} when cotton crop was cultivated in the pigeon pea+cotton intercropping system. In contrast, Dhoble and Bhosle (1996) studied intercropping of cotton with various crops including pigeon and found better economics of the crop, while Yang (1998) has beneficially practiced intercropping cotton and pigeon pea. Likewise, Chari *et al.* (1998) compared cotton+pigeon pea and other combinations and observed that intercropping cotton with pigeon pea combination was efficient and better. Azevedo *et al.* (1999) reported that land use efficiency was greatest with the highest density of cotton, pigeon pea and cowpeas at any density and all the intercrops gave higher land use efficiencies than sole crops. Gnanasambandan *et al.* (2000) reported that rain fed cotton+pigeon pea, cotton + soybean were the positive crop combinations for better growth and yield contributing parameters and the cost benefit ratio was improved in intercropping system as compared to sole cropping system. Reddy *et al.* (2001) found that there were enhanced crop yields in intercropping systems (cotton+pigeon pea and sorghum+pigeon pea). These studies clearly advocate that cotton+pigeon pea intercropping system was beneficial under improvement management conditions. Supporting this concept, Krishnareddy *et al.* (2001) conducted field experiments

with 12 combinations including cotton+pigeon pea and found that intercropping of pigeon pea+cotton was beneficial than sole cropping of cotton in sense of monetary recoveries. Naganagouda *et al.* (2001) obtained highest pigeon pea seed yield (935 kg ha^{-1}) and proved that cotton+pigeon pea at 2:1 ratio and 100:75% population produced the maximum net monetary returns (Rs. 10704 ha^{-1}). The results of the present investigation deviate from the findings of Blaise *et al.* (2005) that cotton+pigeon pea intercropping was one of the effective crop combinations where mean seed cotton yield was significantly greater (809 kg ha^{-1}). Most of the above findings are in contrast to the results obtained in the present investigation, probably due to different climatic conditions.

CONCLUSIONS

After going through the results of the present investigation, it was concluded that for proper land use efficiency and improved economic parameters, intercropping practice keeps a significant scope for the farmers. A number of minor crops can be intercropped with major crops but the present investigation intercropping cotton with pigeon pea did not prove beneficial and net revenue was better when cotton was sown as sole crop as compared to intercropping pigeon pea with cotton, probably due to the adverse effect in terms of plant competition for light, moisture and nutrients.

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