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Influence of intercropping on seed and yield of cotton at Tandojam

Mahmooda Buriro[1], Wajid Hussain Mirjat[1], Khalid Hussain Dhiloo*[2], Ghous Bakhsh Buriro[3], Aziz Laghari[1], Reema Vistro[1], Sanam Kunmbhar[1], Sumbel Mureed Mastoi[2], Ali Akbar Lashari[2], Paras Mureed Mastoi[4]

[1]*Department of Agronomy, Sindh Agriculture University, Tandojam, Sindh, Pakistan*

[2]*Department of Entomology, Sindh Agriculture University, Tandojam, Sindh, Pakistan*

[3]*Department of Energy and Environment, Sindh Agriculture University, Tandojam, Sindh, Pakistan*

[4]*Department of Plant Protection, Sindh Agriculture University, Tandojam, Sindh, Pakistan*

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Abstract

The results revealed that all the growth and cotton seed were significantly ($P<0.05$) affected by cotton + mungbean and cotton + cowpea intercropping systems. The cotton crop planted as sole crop ranked first with 93.67cm plant height, 2.67 monopodial branches plant^{-1}, 18 sympodial branches plant^{-1}, 48.44 bolls plant^{-1}, 41.66 opened bolls plant^{-1}, 349.92g 100 bolls weight, 45.49g seed cotton weight plant^{-1} and 3252.54kg ha^{-1} seed cotton yield. However, cotton + mungbean intercropping system ranked 2nd with 84.78cm plant height, 2.00 monopodial branches plant^{-1}, 15.78 sympodial branches plant^{-1}, 42.22 bolls plant^{-1}, 36.31 opened bolls plant^{-1}, 342.63g 100 bolls weight, 36.75g seed cotton weight plant^{-1} and 2627.39kg ha^{-1} seed cotton yield. Whereas, cotton + cowpea intercropped ranked 3rd with 74.22cm plant height, 1.22 monopodial branches plant^{-1}, 14.44 sympodial branches plant^{-1}, 38.33 bolls plant^{-1}, 32.97 opened bolls plant^{-1}, 333.89g 100 bolls weight, 33.17g seed cotton weight plant^{-1} and 2371.66kg ha^{-1} seed cotton yield. In cotton sole cropping, the seed cotton yield was 3252.54kg ha^{-1}, while 2627.39kg and 2371.66kg ha^{-1} when mungbean and cowpea were intercropped with cotton, respectively. Additional yields of 1087.47kg and 1621.84kg were observed when mungbean and cowpea when intercropped with cotton as compared to 2135.05kg and 3131.48kg ha^{-1} under sole cropping. The statistical results revealed that all the growth and seed cotton yield attributes were significantly affected under cotton + mungbean or cotton + cowpea intercropping systems at ($P<0.05$) levels.

***Corresponding Author:** Khalid Hussain Dhiloo ✉ khdhiloo@sau.edu.pk

Introduction

Recently farmers are developing different crop production systems to increase productivity and sustainability since ancient times including crop rotation, relay cropping and intercropping of major crops with other crops. However, several factors like cultivar selection, seeding ratios, planting pattern and other agronomic practices affect the growth of plants in intercropping (Carr *et al.*, 2004). Many combinations of crops are grown under mixed or relay intercropping systems; which include sunflower cultivation with lentils, cotton with sesame, cotton with mungbean, cotton with pigeon pea and cow pea, wheat with flax and maize with cotton, cucumber and soybean in China; rice and corn in Indonesia, corn and peanut, sorghum and millet, and pigeon and sorghum in various parts of the tropical world (Wolfe, 1993; ICIPE, 2003).

Cotton (*Gossypium hirsutum* L.) is a major contributor of gross domestic product of Pakistan (1.4%) as it is the main cash crop contributing significantly to the national economy. Furthermore, shortage of fodder and grain legumes is another problem, which demands a simultaneous increase in the production of cotton and legumes to meet the problem. To solve the problem efficiently, cotton-based intercropping seems a promising strategy. Woodhead *et al.* (1994) reported intercropping as a well-established practice with over 12 million hectares in South Asia only. Different cotton based intercropping systems have been reported to increase farm income by 30-40% (Saeed *et al.,* 1999), but magnitude of such agro economic advantages depend upon the type of intercrop (Rao, 1991). Interplant competition usually includes competition for soil, water, nutrients and solar radiation (Buxton and Fales, 1993; Ghosh, 2004; Dhima *et al.*, 2007).

Cowpea, *Vigna unguiculata* is a grain legume mostly grown in tropics. Spreading types are predominant and their leaves, as well as seeds are consumed as an important supplement to the staple diet of maize. Similarly, mungbean (green gram), *Vigna radiate* is an important pulse crop and an important source of easily digestible high quality protein for vegetarians and sick persons. Mungbean is also considered as most suitable legume for intercropping in a variety of major crops. Intercropping of cotton and cowpea is one of the ways to improve food security and soil fertility while generating and maintaining cash income of the rural people. Therefore, the present study was carried out to examine the influence of mungbean and cowpea intercropping on seed cotton yield of newly developed variety Aufaq under Tandojam (Sindh) conditions.

Materials and methods

The study was carried out during 2015-16 at research area, Department of Agronomy, Sindh Agriculture University Tandojam. With randomized complete block design (RCBD), using a plot size of 4m × 6m (24m^2). The seed of newly evolved cotton variety Aufaq, Mungbean variety AEM-96 and local variety of cowpea were used in the respective treatments. The R-R and P-P distance was kept as 60cm and 45cm among cotton, 30cm and 10cm among mungbean and cowpea plants respectively.

The arrangement of rows was maintained as 5 rows in cotton sole, 9 rows in each mungbean and cowpea sole whereas, 5 + 5 (1:1) rows in each cotton + mungbean and cotton + cowpea intercrops. The treatments consisted of T_1 = Cotton Sole, T_2 = Cotton + mungbean intercrop (1:1), T_3 = Mungbean Sole, T_4 = Cotton + cowpea intercrop (1:1), T_5 = Cowpea Sole.

Cultural practices

All the cultural practices like land preparation, fertilizer, irrigation, weed control and crop harvest were applied as per recommendations.

Parameters studied:

A. Cotton (Main crop): Plant height (cm), Monopodial branches plant^{-1}, Sympodial branches plant^{-1}, Bolls plant^{-1}, Opened bolls plant^{-1},100 bolls weight (g), Seed cotton weight plant^{-1} (g), Seed cotton yield (kg ha^{-1}).

B. Mungbean and cowpea (Intercrops): Plant height (cm), Branches plant^{-1}, Pods plant^{-1}, Seeds pod^{-1}, Seed weight plant^{-1} (g), 1000 seed weight (g) , Seed yield (kg ha^{-1}).

Data observation

Plant height (cm): The plant height (cm) was measured after the last picking by measuring tape from bottom to tip of plant in labeled plants in each treatment. Monopodial branches: The monopodial branches in the labeled plants were counted and averaged on per plant basis. Sympodial branches:

The sympodial branches in all the tagged plants were counted and averages were worked out on per plant basis.

Bolls plant^{-1}: The total number of bolls plant^{-1} was counted before each picking and finally the sum of periodical counting was divided with the number of plants to obtain total number of bolls plant^{-1}.

Opened bolls plant^{-1}: The number of opened bolls plant^{-1} was counted before each picking and finally the sum of periodical counting was divided with the number of plants to obtain average number of bolls plant^{-1}. Seed cotton weight plant^{-1}(g): The total seed cotton of labeled plants was picked, weighed and divided with total number of plants examined to obtain yield of cotton plant^{-1} in each treatment. 100 bolls weight (g): One hundred bolls in each plot was collected at random and weighed to record the 100 bolls weight in grams.

Seed yield (kg ha^{-1}): The seed cotton yield (kg ha^{-1}) was worked out by using the following formula:

$$\text{Yield plot}^{-1}\text{ (kg) Seed Yield} = \frac{\text{X 10000}}{\text{Plot size (m}^2\text{)}}$$

Statistical analysis

All the data collected were analyzed by using the analysis of variance (ANOVA) on MSTAT-C statistical software package and differences among the treatment means were compared by the least significant difference (LSD) test at 0.05 levels.

Results

The study was carried out during 2015-16to investigate the influence of mungbean and cowpea intercropping on seed cotton yield of cultivar Aufaq. The newly evolved cotton variety Aufaq, Mungbean variety AEM-96 and local variety of cowpea (any local name) were used in the respective treatments. Results have been explained as under. Growth and yield traits of Cotton variety Aufaq as influenced by mungbean and cowpea intercropping

Plant height (cm)

The results for plant height of cotton variety Aufaq as influenced by mungbean and cowpea intercropping are presented in Table 1 and its analysis of variance as Appendix-I. The analysis of variance suggested significant ($P<0.05$) influence of mungbean and cowpea intercropping on the plant height of cotton. The results indicated that the maximum plant height of 93.67 cm was noted in plots where cotton was planted as sole crop, while the plant height was significantly decreased to 84.78cm when mungbean was intercropped with cotton. However, the decrease in the cotton plant height was maximum when cowpea was intercropped with cotton, where the plant height of cotton was 74.22cm. The highest decrease in plant height of cotton under cotton+cowpea intercropping was mainly associated with spreading habit of cowpea which grows meters long and its huge foliage might cause an adverse influence on the cotton plant height. The LSD test suggested that all the treatments differed significantly for cotton plant height between each other.

Monopodial branches plant^{-1}

The monopodial branches in cotton generally are influenced by genetic makeup of varieties and the data on this trait of cotton variety Aufaq as influenced by intercropping of mungbean and cowpea are shown in Table 1. The analysis of variance illustrated that the number of monopodial branches was significantly ($P<0.05$) influenced by mungbean and cowpea intercropping in cotton. The results showed that the maximum monopodial branches of 2.67 plant^{-1} were observed in plots where cotton was planted as sole crop, while the monopodial branches decreased considerably (2.00) when mungbean was intercropped with cotton. However, the monopodial branches plant^{-1} of cotton was lowest (1.22) when cowpea was intercropped with cotton.

The maximum decrease in monopodial branches plant^{-1} of cotton under cotton+cowpea intercropping was mainly associated with sharing considerable space, sunlight, moisture and nutrients by cowpea, because cowpea spreads rapidly with strong competition for inputs with the main crop. The LSD test indicated that all the treatments differed significantly for cotton monopodial branches plant^{-1} when mungbean and cowpea were planted as intercrops.

Sympodial branches plant^{-1}

The results in relation to the number of sympodial branches in cotton variety Aufaq as influenced by intercropping of mungbean and cowpea are presented in Table 1. The analysis of variance demonstrated that the number of sympodial branches was significantly ($P<0.05$) influenced by mungbean and cowpea intercropping in cotton.

The highest number of sympodial branches (18.00) plant^{-1} was recorded in plots where cotton was planted as sole crop, while the sympodial branches decreased considerably to 15.78 plant^{-1} when mungbean was intercropped with cotton. However, sympodial branches plant^{-1}was minimum (14.44) when cowpea was intercropped with cotton. This indicates that cowpea shares moisture and nutrients more than mungbean because of its rapid growing and spreading shrubby habit, while mungbean offers limited competition for the moisture and nutrients.

The LSD test suggested that the differences in the number of sympodial branches plant^{-1} under cotton+mungbean and cotton+cowpea intercropping treatments were non-significant, while significant when compared with cotton sole cropping.

Bolls plant^{-1}

The data pertaining to the number of bolls plant^{-1} in cotton variety Aufaq as affected by intercropping of mungbean and cowpea are given in Table 1. The analysis of variance indicated significant ($P<0.05$) influence of intercropping of various intercropping treatments on the number of bolls plant^{-1} of cotton.

The results in Table 1showed that the highest number of bolls (48.44) plant^{-1} was observed in plots where cotton was planted as sole crop, followed by 42.22 bolls plant^{-1} recorded in cotton when mungbean was intercropped; while the number of bolls plant^{-1} decreased to a minimum level (38.33) when cowpea was intercropped with cotton. The number of bolls plant^{-1} was mainly associated with the number of monopodial and number of sympodial branches plant^{-1}; suggested that mungbean and cowpea intercropping with cotton adversely affected the number of bolls plant^{-1}. However, this negative effect on bolls plant^{-1} was more severe under cotton+cowpea intercropping system. The LSD test indicated that the differences in the number of total bolls plant^{-1} under both the intercropping systems as well as cotton sole cropping were significant ($P<0.05$).

Opened bolls plant^{-1}

The number of open bolls is generally influenced by various biotic and abiotic factors. The results in relation to open bolls plant^{-1} in cotton variety Aufaq as influenced by intercropping of mungbean and cowpea are presented in Table-1. The analysis of variance suggested that the effect of intercropping mungbean and cowpea in on open bolls plant^{-1} of cotton was significant ($P<0.05$). It is evident from the results that the maximum number of open bolls (41.66) plant^{-1} was noted in plots where cotton was sown alone, followed by 36.41 open bolls plant^{-1} recorded under cotton+mungbean intercropping system; while the lowest number of open bolls (32.97) plant^{-1} was recorded under cotton+cow pea intercropping system. The number of open bolls plant^{-1} was mainly associated with the number of total bolls plant^{-1} and it is apparently seen that the number of bolls were mainly associated with the number of monopodial and sympodial branches plant^{-1}. The LSD test showed that the differences in the number of open bolls plant^{-1} under all the intercropping systems and when cotton sown under monocropping were linearly significant ($P<0.05$).

100 bolls weight (g)

The analysis of variance indicated that the influence of various intercropping treatments on 100 bolls weight of cotton was significant ($P<0.05$).

It is apparent from the results (Table 1) that the maximum 100 bolls weight (349.92g) was observed in plots where cotton was sown as sole crop, closely followed by 342.63g 100 bolls weight recorded under cotton + mungbean intercropping system; while the minimum 100 bolls weight of 333.89 g was recorded under cotton + cowpea intercropping system. The 100 bolls weight was mainly associated with the growing health of the crop and under sole cotton cropping, the plants utilized entire available nutrients and moisture; while under intercropping system, the intercrops competed for moisture and nutrients and hence the 100 boll weight adversely affected. Moreover, less adverse effects on boll weight was recorded under cotton + mungbean intercropping due to minimum competition with cotton for nutrients due to nitrogen fixation ability of mungbean. However, cowpea being rapidly growing shrubby plant which resulted more adverse effects on boll weight as compared to mungbean. The LSD test indicated that the differences in 100 bolls weight under cotton as sole cropping and cotton + mungbean intercropping system were non-significant ($P>0.05$) and significant when these treatments were compared with cotton + cowpea intercropping ($P<0.05$).

Seed cotton weight (g) plant^{-1}

The data in relation to seed cotton weight plant^{-1} of cotton variety Aufaq as affected by various intercropping treatments are presented in Table-7. The analysis of variance suggested that the influence of intercropping treatments on seed cotton weight plant^{-1} was significant ($P<0.05$). It can be seen from the data presented in Table 1 that the maximum seed cotton weight (45.49g) plant^{-1} was obtained from the plots where cotton was sown as sole crop, followed by 36.75g plant^{-1} seed cotton weight recorded under cotton + mungbean intercropping system; while the lowest seed cotton weight of 33.17g plant^{-1} was recorded under cotton + cowpea intercropping system. The seed cotton weight plant^{-1} was mainly associated with the number of monopodial and sympodial branches, total and open bolls plant^{-1} and had straight influence on the seed cotton weight plant^{-1}.

However, under cotton+cowpea intercropping system, the seed cotton weight plant^{-1} was more adversely affected as compared to cotton + mungbean intercropping system. Moreover, less adverse effects on seed cotton weight plant^{-1} was recorded under cotton + mungbean intercropping due to minimum competition with cotton for nutrients and due to nitrogen fixation ability of mungbean. The LSD test indicated that the differences in seed cotton weight plant^{-1} under cotton+mungean and cotton + cowpea intercropping systems were non-significant ($P>0.05$) and significant when these treatments were compared with cotton sole cropping ($P<0.05$).

Seed cotton yield (kg) ha^{-1}

The results as regards seed cotton yield ha^{-1} of cotton variety Aufaq under the effect of mungbean and cowpea intercropping with cotton are shown in Table 1. The analysis of variance indicated significant ($P<0.05$) influence of intercropping treatments on seed cotton yield ha^{-1}. The results indicated that the highest seed cotton yield of 3252.54kg ha^{-1} was achieved from the plots where cotton was sown as sole crop, followed by average seed cotton yields of 2627.39kg ha^{-1} achieved from cotton + mungbean intercropping system; while the lowest seed cotton yield of 2371kg ha^{-1} was noted under cotton + cowpea intercropping system. This higher seed cotton yield under sole cotton cropping was mainly associated with increase in monopodial and sympodial branches, total and open bolls plant^{-1}, increased 100 bolls weight and higher seed cotton weight plant^{-1}. The seed cotton yield reduction was higher under cotton+cowpea than cotton + mungbean intercropping systems when compared with sole cotton cropping. The LSD test indicated that the differences in seed cotton yield ha^{-1} under cotton + mungean and cotton + cowpea intercropping systems were non-significant ($P>0.05$) and significant when these treatments were compared with cotton sole cropping ($P<0.05$).

Table 1. Growth and yield traits of Cotton variety Aufaq as influenced by mungbean and cowpea intercropping.

Treatments	Plant height (cm)	Monopodial branches plant^{-1}	Sympodial branches plant^{-1}	Bolls plant^{-1}	Opened bolls plant^{-1}	100 bolls weight (g)	Seed cotton weight (g) plant^{-1}	Seed cotton yield (kg) ha^{-1}
Cotton	93.67a	2.67a	18.00a	48.44a	41.66a	49.92a	45.49a	3252.54 a
Cotton + Mungbean	84.78b	2.00b	15.78b	42.22b	36.31b	33.89a	36.75b	2627.39 b
Cotton + Cowpea	74.22c	1.22c	14.44b	38.33c	32.97c	342.63 b	33.17b	2371.66b
LSD 0.05	2.5231	0.5905	2.1738	2.6547	1.7972	13.730	3.4112	267.61

Growth and seed yield attributes of Mungbean and Cowpea as affected by their intercropping with cotton

Plant height (cm

The results in Table 2 indicated that plant height of mungbean under sole cropping system was relatively higher (43.67cm) as compared to the plant height of 37.78cm recorded under cotton + mungbean intercropping system. Similarly, the plant height of cowpea was comparatively higher (405.11cm) under sole cropping system; which reduced to 318.34cm when cowpea was sown as intercrop with cotton. Apparently, the plant height of mungbean and cowpea was reduced considerably under intercropping system with cotton, but due to higher within treatment variation, the differences were non-significant ($P>0.05$) statistically.

Branches plant^{-1}

It is apparent from the data (Table 2) that in mungbean the number of branches plant^{-1} under sole cropping system was comparatively higher (14.67) as compared to 11.33 branches plant^{-1} recorded under cotton + mungbean intercropping system. In case of cowpea, significantly higher number of branches (11.89) plant^{-1} was recorded under sole cropping system; while the lowest cowpea number of branches (8.89) plant^{-1} was observed when cowpea was intercropped in cotton. The number of branches plant^{-1} of mungbean was reduced to some extent, but statistically the differences were non-significant ($P>0.05$) due to higher within treatment variation. However, the differences were significant ($P<0.05$) statistically for branching in cowpea when comparison was made between its sole planting and intercropping in cotton

Pods plant^{-1}

The analysis of variance described that the number of pods plant^{-1} in mungbean and cowpea was significantly ($P<0.05$) influenced when intercropped in cotton. It can be seen from the results (Table 2) that in mungbean the number of pods plant^{-1} under sole cropping system was markedly higher (123.44) as compared to 105.33 pods plant^{-1} when mungbean was intercropped in cotton. In regards to cowpea, the significantly higher number of pods (240.33) plant^{-1} was observed under sole cropping system; while the number of cowpea pods reduced considerably to 202.56 plant^{-1} when cowpea was intercropped in cotton. This indicates that the number of pods plant^{-1} of mungbean and cowpea was adversely affected by the competition of cotton (main crop).

Seeds pod^{-1}

The analysis of variance suggested that the number of seeds pod^{-1} in mungbean and cowpea was significantly ($P<0.05$) influenced due to their intercropping with cotton. It is obvious from the results (Table 2) that in mungbean the number of seeds pod^{-1} was significantly higher (14.45g) under mungbean sole cropping system as compared to 7.89 seeds pod^{-1} when mungbean was intercropped with cotton. The results further showed that in cowpea the number of seeds pod^{-1} (11.11) was highest when sown under sole cropping system; while the cowpea seeds pod^{-1} reduced (7.78) when intercropped with cotton. Regardless the intercropping species, the number of seeds pod^{-1} was negatively affected when intercropped with cotton.

Seed weight (g) plant^{-1}

The results of the analysis of variance demonstrated that the seed weight plant^{-1} in mungbean and cowpea was affected significantly (P<0.05) due to their intercropping with cotton. The results in Table-2 indicated that in mungbean the seed weight plant^{-1} was significantly higher (87.96g) under mungbean sole cropping system as compared to 34.13g seed weight plant^{-1} when mungbean was intercropped with cotton. The results further indicated that in cowpea the seed weight plant^{-1} was highest (394.97g) when sown under sole cropping system; while the cowpea seed weight plant^{-1} reduced to 211.06g when intercropped with cotton. Irrespective of the crops intercropped, the seed weight plant^{-1}mungbean and cowpea substantially reduced when these crops were used as cotton companions.

Seed index (1000 seed weight)

The seed index is considered as grain/seed quality trait. The analysis of variance indicated that seed index of mungbean and cowpea was affected significantly (P<0.05) due to their intercropping with cotton. It is obvious from the results (Table 2) that in mungbean the seed index was markedly highest (49.44g) when it was sown under sole cropping system; while seed index value was lowest (40.00 g) when mungbean was intercropped with cotton. In case of cowpea, the seed index was highest (147.33g) when it was sown under sole cropping system; while the seed index in cowpea was lowest (132.78g) when it was intercropped with cotton. The results suggested that under sole cropping system, both the legumes (mungbean and cowpea) had markedly higher seed index; however due to crop competitions for moisture and inputs, the seed index reduced considerably when intercropped with cotton.

Seed yield (g) ha^{-1}

The results regarding the seed yield ha^{-1} of mungbean and cowpea as affected by their intercropping with cotton are shown in Table 2. The results of the analysis of variance demonstrated that the seed yield ha^{-1} in mungbean and cowpea was affected significantly (P<0.05) due to their intercropping with cotton. It is obvious from the results that in mungbean the seed yield ha^{-1} was significantly maximum (2135.05kg ha^{-1}) under mungbean sole cropping system and seed yield was minimum (1087.47kg ha^{-1}) when mungbean was intercropped with cotton. In case of cowpea, the seed yield ha^{-1} was highest (3131.48 kg) when sown under sole cropping system; while the cowpea seed yield ha^{-1} was lowest (1621.84kg) when cowpea was intercropped with cotton. Apparently, almost 50 percent decrease in yield was observed in case of both the intercrops (mungbean and cowpea) when intercropped with cotton.

Table 2. Growth and seed yield attributes of Mungbean and Cowpea as affected by their intercropping with cotton.

Treatments	Plant height (cm)	Branches plant^{-1}	Pods plant^{-1}	Seeds Pod^{-1}	Seed weight (g) plant^{-1}	Seed index (1000 seed weight)	Seed yield (kg) ha^{-1}
Mungbean							
Cotton + Mungbean	37.78	11.33a	105.33b	7.89b	34.13b	40.00b	1087.47b
Mungbean sole	43.67	14.67a	123.44a	14.45a	87.96a	49.44a	2135.05a
LSD 0.05	NS	NS	**	**	**	**	**
Cowpea							
Cotton + Cowpea	318.34	8.89b	202.56b	7.78b	211.06b	132.78b	1621.84b
Cowpea sole	405.11	11.89a	240.33a	11.11a	394.97a	147.33a	3131.48a
LSD 0.05	NS	*	*	**	*	**	**

Discussion

Simultaneous cultivation of two or more crops in the same field is regarded as intercropping; it also refers to as planting of the second crop after the first one has completed its development. Generally, there are four types of intercropping which include mixed or multiple cropping, relay cropping, row intercropping and strip cropping (Kumarasinghe *et al.*, 1992).

In order to assess the intercropping consequences, the study was carried out to investigate the growth and yield response of main crop (cotton) and intercrops (mungbean and cowpea) to different intercropping systems.

The findings of the study revealed that under cotton + mungbean or cotton + cowpea intercropping systems, all the growth and seed cotton yield attributes were significantly ($P<0.05$) affected. The cotton crop planted as sole crop ranked first with 93.67cm plant height, 2.67 monopodial branches plant^{-1}, 18.00 sympodial branches plant^{-1}, 48.44 bolls plant^{-1}, 41.66 opened bolls plant^{-1}, 349.92g 100 bolls weight, 45.49g seed cotton weight plant^{-1} and 3252.54kg ha^{-1} seed cotton yield. The cotton under cotton+mungbean intercropping system ranked 2nd with 84.78cm plant height, 2.00 monopodial branches plant^{-1}, 15.78 sympodial branches plant^{-1}, 42.22 bolls plant^{-1}, 36.31 opened bolls plant^{-1}, 342.63g 100 bolls weight, 36.75 g seed cotton weight plant^{-1} and 2627.39kg ha^{-1} seed cotton yield. The cotton under cotton+cow intercropping ranked 3rd with 74.22cm plant height, 1.22 monopodial branches plant^{-1}, 14.44 sympodial branches plant^{-1}, 38.33 bolls plant^{-1}, 32.97 opened bolls plant^{-1}, 333.89g 100 bolls weight, 33.17g seed cotton weight plant^{-1} and 2371.66kg ha^{-1} seed cotton yield. In cotton sole cropping, the seed cotton yield was 3252.54kg ha^{-1}, while 2627.39kg and 2371.66kg ha^{-1} when mungbean and cowpea were intercropped with cotton, respectively. For intercrops, with the exception of plant height of both intercrops and branches plant^{-1} in cowpea, rest all the growth and seed yield attributes of mungbean and cowpea were significantly influenced when intercropped with cotton ($P<0.05$). Additional yield of mungbean and cowpea when intercropped with cotton was 1087.47kg and 1621.84kg against 2135.05kg and 3131.48kg ha^{-1} under sole cropping respectively. Mungbean may preferably be intercropped in cotton because under cotton + mungbean intercropping system, the adverse effects on seed cotton yield were minimum, and maximum when cowpea intercropped with cotton. These results are further supported by Tsubo *et al.* (2005) who reported that in legume crops, mungbean and cowpea are used as intercrops in various fields, particularly in cotton.

Grain yield of mungbean was reduced by 39% and 51%, respectively, as compared with single cropping. Legume intercropping in cereals and cotton has also been reported beneficial. Mkandawire and Likoswe (2001) found that cotton, cowpea and pigeon pea yields were lower in intercrops than in pure stands; and there is a potential for improving cotton and legume yields through intercropping, but population density levels need to be balanced so that the crops do not suppress each other. In a similar investigation, Chellamuthu and Ramaswami (2001) concluded that when sown simultaneously with cotton, the seed cotton yield was increased by cowpea and black gram. Based on net return and benefit cost ratio, cowpea was found to be the best suited intercrop for MCU. 5 cotton. Moreover, Shah *et al.* (2002) reported that cotton and mungbean interplanted according to 2:1 row arrangements surfaced as the most compatible system by producing combined yield of 4465kg ha^{-1}, which was 18.7% higher than monoculture cotton.

Polthanee and Vidhaya (2003) concluded that grain yield of peanut, soybean and mungbean was reduced by 28%, 39% and 51%, respectively, as compared with single cropping. From another study, Tsubo *et al.* (2003) reported that in maize and bean intercropping systems the total land equivalent ratios for yield and growth ranged between 1.06 to 1.58 and 1.38 to 1.86 respectively, showing yield and growth advantage of intercropping; while Khan and Khaliq (2004) found that higher net field benefit was obtained from cotton + mungbean than sole cropping of cotton. Farmers with small land holdings, seriously constrained by low crop income can adopt the practice of intercropping of mungbean in cotton. Rusinamhodzi *et al.* (2006) concluded that fertilizer equivalency values show substantial benefits and effort should be directed at maximizing the dry matter yield of the legume in the intercrop system while maintaining or improving the economic yield of the companion cash crop. Yilmaz *et al.* (2007) revealed that, compared to solitary planting, the maize-cowpea and maize-common bean intercropping, regardless of planting patterns, at the mix proportions of 67:50 plant density had advantages due to its better yield, land use efficiency, and economics.

The studies of Aasim (2008) concluded that intercropping with cowpea reduced the yield of cotton, however, it seemed more appropriate for intercropping with cotton in both 80 cm and 120/40cm spaced rows; 120/40 cm spaced rows spacing seemed better compared to single row spacing for easy handling of intercrops and sole cotton, therefore, it is recommended for mechanical farming in Pakistan. In a recent study, Rusinamhodzi *et al.* (2009) concluded that highest amount of N released (12.2mg/kg soil) was from soil previously under sole cowpea, while soil from the 1:1 cotton-cowpea intercrop released 9.9 mg/kg soil and soil from sole cotton released 5.9mg/kg soil; while Rusinamhodzi (2010) found that the reduction in cotton yield was less when cowpea was planted 4 weeks after cotton and when the row configuration was 2:1 (cotton:cowpea). Cowpea grain yield across the sites was as follows, sole cowpea Comparable intercrops had higher cowpea grain yields in the simultaneous than in the relay intercrops but cotton lint yields were higher in relay than simultaneously planted intercrops. All the intercrops were productive as compared to the sole cotton.

Conclusion

The present study concluded that under cotton+mungbean or cotton+cowpea intercropping systems, all the growth and seed cotton yield attributes were significantly ($P<0.05$) affected. For intercrops, with the exception of plant height of both intercrops and branches plant^{-1} in cowpea, rest all the growth and seed yield attributes of mungbean and cowpea were significantly influenced when intercropped with cotton ($P<0.05$). In cotton sole cropping, the seed cotton yield was 3252.54kg ha^{-1}, while 2627.39kg and 2371.66kg ha^{-1} when mungbean and cowpea were intercropped with cotton, respectively. Additional yield of mungbean and cowpea when intercropped with cotton was 1087.47kg and 1621.84 kg against 2135.05kg and 3131.48kg ha^{-1} under sole cropping respectively. Mungbean may preferably be intercropped in cotton because under cotton + mungbean intercropping system, the adverse effects on seed cotton yield were minimum, and maximum when cowpea intercropped with cotton.

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