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IMPACT OF MAIZE-LEGUME INTERCROPPING ON WEEDS AND MAIZE CROP

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ABSTRACT

To evaluate the influence of cereal-legume intercropping on weeds growth and maize yield (variety Azam), an experiment was carried out during summer 2011 at Agricultural Research Farm, Khyber Pakhtunkhwa Agricultural University Peshawar, Pakistan. The experiment was laid out in a randomized complete block design keeping three replications, comprising of eleven treatments viz, intercrop maize + 1 row of soybean simultaneously seeded, intercrop maize + 2 rows of soybean simultaneously seeded, intercrop maize + 1 row of soybean delay seeded by 3 weeks, intercrop maize + 2 rows of soybean delay seeded by 3 weeks, intercrop maize + 1 row of mungbean simultaneously seeded, intercrop maize + 2 rows of mungbean simultaneously seeded, intercrop maize + 1 row of mungbean delay seeded by 3 weeks, intercrop maize + 2 rows of mungbean delay seeded by 3 weeks, sole maize (weedy check), and sole maize (hand weeded). All the treatments significantly affected the parameters of weed density m^{-2}, maize leaf area (cm^2), thousand grain weight (g), number of grains ear^{-1}, biological yield (kg ha^{-1}) and grain yield of maize. Highest weed density of 230 plants m^{-2} was found in the sole maize (weedy check). Hand weeding and maize soybean intercropping resulted in the highest thousand grain weights (261.5 and 275.3 g), biological yields (11566 and 11370 kg ha^{-1}), grain yields (4954 and 4784 kg ha^{-1}) and leaf area of maize (4143 and 4343 cm^2). In conclusion, the hand weeding and maize intercropping with soybean treatments were the most effective treatments in terms of weeds suppression and grain yield enhancement of maize crop.

Key words: Intercropping, legume, maize, weeds, yield.

INTRODUCTION

Maize is a major food crop after wheat and rice in Pakistan. Being multipurpose crop it provides raw material to industry and feed to live stock and poultry farms as well. It contributes for more than 10% of all agricultural production and 15% of agricultural employment in the country (Khaliq *et al*., 2004). During the year 2009, the small land holding farmers contributed more than 30% of the country's maize; whereas commercial farmers played a significant role in the contribution of commercial maize (MINFA, 2010). Because of the

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importance of maize to food security, the government and agricultural research scientists are taking keen interest in increasing maize production and introducing high yielding varieties and best management practices such as efficient weeds control and soil fertility management (Khaliq *et al*., 2004). Among the major reasons of low maize yields in Pakistan, soil fertility, prices of chemical fertilizers, and weeds infestation are the most important yield affecting factors.

Cereal legume intercropping presents solution to obtain higher yields per unit area, diversified food and reduced risk of crop failure under rainfed conditions. Intercropping, the growing of more than one species simultaneously in the same field is a cropping strategy, which causes more stable yields, often results in a more efficient utilization of resources; and a method to reduce weeds related problems, minimize nitrogen losses and lessen plant pathogens pressure. Cereal-legume intercropping systems play significant role in efficient utilization of the available resources. The main theme of intercropping is to augment the total productivity per unit area and time, besides judicious and equitable utilization of land resources and farming inputs including labour etc. (Marer *et al.,* 2007).

Intercropping being an agricultural practice can be used for decreasing the dependency on chemical herbicides in weed control (Banik *et al*., 2006) and defined as the growing of two or more crop species simultaneously in the same field during a growing season (Ofori and Stern, 1987). Intercropping generates beneficial biological interactions between crops, increases grain yield and stability, helps use the available resources more efficiently and reduces the weed pressure (Jensen, 2007).

Many authors like Amanullah *et al*. (2006) and Banik *et al*. (2006) indicated the limiting effect of intercropping on the number and biomass of weeds. There are two possible reasons for the reduction of weeds biomass in intercropping systems. Some intercrop species release allelopathic compounds which limit the occurrence of weeds (Olufemi *et al.*, 2001), intercropping also encourages efficient utilization of the environmental resources (Egbe and Adeyemo, 2007); thus, the growth of weeds is decreased, depending on the availability of environmental resources. If the crops grown together differ in the way they utilize environmental resources, they can complement each other and make better combined use of resources than when they are grown separately (Ghanbari-Bonjar, 2000). Weed suppression in intercropping through more efficient use of environmental resources by component crops has also been reported (Mashingaizde *et al*., 2000).

The objectives of this study kept in mind were to determine the impact of maize legume intercropping on weeds' growth and to find out how intercropping influences maize yield and yield components.

MATERIALS AND METHODS

To study the beneficial effect of legume-cereal intercropping on weeds and yield of maize crop, an experiment was conducted at Agricultural Research Farm, Khyber Pakhtunkhwa Agricultural University Peshawar during summer 2011. The experiment consisted of different intercropping combinations of maize with soybean and mungbean in one and two rows. Treatments were in this sequence; intercrop maize + 1 row of soybean simultaneously seeded, intercrop maize + 2 rows of soybean simultaneously seeded, intercrop maize + 1 row of soybean delay seeded by 3 weeks, intercrop maize + 2 rows of soybean delay seeded by 3 weeks, intercrop maize + 1 row of mungbean simultaneously seeded, intercrop maize + 2 rows of mungbean simultaneously seeded, intercrop maize + 1 row of mungbean delay seeded by 3 weeks, intercrop maize + 2 rows of mungbean delay seeded by 3 weeks, sole maize (weedy check), and sole maize (hand weeded).

The experiment was laid out in a randomized complete block design having three replications. The crop was grown on well prepared soil which was ploughed twice and then planked twice for levelling at proper moisture. Maize variety 'Azam' was planted at the rate of 30 kg ha^{-1} with drill method. Nitrogen and phosphorus at the rate of 100 kg and 60 kg ha^{-1} were constantly applied, respectively to each treatment. Full dose of P and half N was applied at time of planting whereas the remaining half of N was applied at after emergence of the legume crops. Intercropped treatments did not receive extra fertilizer dose due to the fact that leguminous crops produce enough nitrogen to compensate its requirement. The treatment size was 4 x 5 m i.e. each plot consisted of four maize rows, 0.75 m apart and 5 m long. The plant population of maize was maintained at 60,000 plants ha^{-1} by thinning. In the hand weeded control (MHand), hand weeding was done weekly. Plots were irrigated as per requirements. Data were recorded on weed density (plants m^{-2}), Seeds cob^{-1}, 500-seed weight (g), leaf area at silking (cm^2), biological yield (kg ha^{-1}) and grain yield (kg ha^{-1}) were measured. A quadrate having a size 50 x 50 cm was placed randomly in each treatment and the weeds inside were identified and finally were harvested to get weed density data. Five cobs were randomly selected from each treatment and number of seeds was recorded and finally averages were calculated. Similarly, three random samples of 500-seeds were collected from each treatment and their weight was measured. Leaf area at silking was recorded by taking samples of 5 representative plants from each plot. Leaves were separated and average leaf area $plant^{-1}$ was worked out with the help of a leaf area measuring machine (LI-CAR-Model A-3000). To record biological and grain yield data, two central rows were harvested in each treatment, bundled, sun dried and weighed. The data were then converted to kg ha^{-1} by using the following formula,

$$\text{Biological yield (kg ha}^{-1}) = \frac{\text{Weight of sample (kg) x 10000}}{\text{Area harvested (m}^2)}$$

Similarly, the grain yield was recorded after threshing cobs of each treatment separately and the values were converted to kg ha^{-1} by using the following formula,

$$\text{Grain yield (kg ha}^{-1}) = \frac{\text{Weight of sample (kg) x 10000}}{\text{Area harvested (m}^2)}$$

Statistical analysis

Data collected were analyzed statistically according to the procedures relevant to RCB design with split plot arrangement. Upon significant results, least significance difference (LSD) test was used for means comparisons to identify the significant components of the treatment means (Jan *et al*., 2009).

RESULTS AND DISCUSSION

Weeds density m^{-2}

Data regarding weeds density m^{-2} are presented in Table-1. Perusal of data indicated that weed density was significantly lower in all treatments over control (weed check). Lowest weed population (50 m^{-2}) was recorded in plots where hand wedding was practiced, followed by plots where maize was intercropped with one row of soybean delay seeded by three weeks (50 m^{-2}) which was however at par with maize mungbean single row intercropped delayed seeded by three weeks. Weedy check plots resulted in higher weeds density (230 weeds m^{-2}). Timely weeding and proper weed control practices in hand weeding plots resulted in lower weeds population in these plots. Regarding weeds infestation and mortality percentage of weeds, the best performance was observed in hand weeded plots where more than 100% reduction was reported in weeds population as compared to control. Our results are confirmed by the finding of Ali *et al*. (2011) who reported that hand weeding was the most effective way to control weeds population in maize crop. Weeds population in intercropped plots was less as compared to sole crop plots and it might be attributed to efficient resource utilization in intercropped plots. Weed suppression in intercropping through more efficient use of environmental resources by component crops has been reported by (Mashingaizde *et al*., 2000; Poggio, 2005).

Number of kernels cob^{-1}

Kernels cob^{-1} of maize is an important yield component which directly affects the grain yield of maize. The treatments such as maize-soybean intercropping, maize-mung bean intercropping and hand weeding had a considerable variation in kernelscob^{-1}of maize (Table-1). Higher kernels cob^{-1} (793) were recorded in cobs collected from hand weeded plots which was statistically similar with maize intercropping with one and two rows of soybean simultaneously seeded and maize mungbean two rows simultaneously seeded. Weed checked plots resulted in lower kernels cob^{-1} (492) which was at par with sole maize plots (501). A possible reason for increased kernels cob^{-1} in hand weeded plots might be less competition for nutrients and other available resources due to low weeds population. There has been a linear increase in kernels cob^{-1} as weeds population decreased. Fertilizer use efficiency could be improved and maize kernels cob^{-1} can be positively increased by controlling weeds population (Ali *et al*., 2011). Nitrogen uptake by grains of intercropped maize and mungbean was greater than that of the sole cultivation of both crops. Higher number of grains cob^{-1} in case of intercropping of maize with mungbean could be attributed to higher N uptake and conversion efficiency in this system (Moses *et al.,* 2000).

Leaf area (cm^2)

Leaf area measures the photosynthetic efficiency of a crop. Leaf area of maize was significantly affected by the intercropping treatments (Table-1). Higher leaf area (4343 cm^2) was observed in plots where maize was intercropped with one row of soybean delay seeded by three weeks, which was however at par with intercropping of maize with two rows of mungbean simultaneously seeded (4293 cm^2) and intercropping of maize with two rows of mungbean delay seeded by three weeks (4243 cm^2). Maize un-weeded plots resulted in lowest leaf area of maize (3483 cm^2). The best possible reason for the significant variation in leaf area of maize between the sole and intercropped maize with soybean and mungbean in various row ratios might be due to maintenance of soil fertility and fixation of atmospheric nitrogen by the intercropped legume crops. Mungbean being a short stature crop with tap root system did not compete with tall maize for growth resources such as nutrients, light and moisture etc. It was confirmed by the increase in leaf area of maize in all intercrop treatment as compared to sole maize crop (Wani *et al*., 1995). Lower leaf area in weedy check plots might be attributed to higher weeds population in theses plots which competed for the available resources. These results confirmed the findings of Ali *et al*. (2011) that maize leaf area decreased as weeds infestation increased. Lawson *et al*. (2006) reported that in maize-legume intercropping legume crops are generally suppressed by weeds and shade effect by the corresponding maize crop which cause difference in photosynthetic efficiency of the two intercropped crops. However, due to its geometry maize leaf area increased in intercropping with legume as compared to respective legume crop.

Thousand kernel weight (g)

Thousand kernel weight as affected by maize-mungbean, maize-soybaean intercropping at various ratios and weeds control treatment are presented in Table-2. Mean values of the data showed that various intercropping and weeds control techniques significantly affected thousand grain weight of maize. Heavier grains (275 g) were produced in plots where maize was grown with two rows of soybean seeded simultaneously, which was at par with hand weeded plots and maize sown with two rows of mungbean seeded simultaneously. Lighter grains were obtained from the weed check plots (198 g). Higher N level in the soil, as a result of N fixation by legume, increased grain weight of cereals due to more available N for the optimum plant growth (Mpairwe *et al*., 2002). Timely weeds control and poor weeds population might have reduced the evaporation demand, thus having adequate water for plant root growth and better nutrients uptake by roots to form more assimilates and increase grain size of maize (Carruthers *et al*., 1998). Similar results were reported by Ali *et al*. (2011) who investigated the synergistic effect of the treatments on thousand kernels weight as compared to weedy check.

Biological yield (kg ha^{-1})

Biological yield is the ultimate product of all photosynthetic activities occurring inside a crop. Data regarding biological yield are presented in Table-2. Statistical analysis of the data revealed that biological yield was significantly affected by intercropping maize with mungbean and soybean seeded simultaneously and delayed sowing by three weeks. Higher biological yield (11570 kg ha^{-1}) was produced by plots where hand weeding was practiced, however it was found at par with plots where maize was intercropped with soybean one row simultaneously (11370 kg ha^{-1}) and maize intercropped with two rows of mungbean delayed sowing by three weeks (10890 kg ha^{-1}).

Maize intercrop with two rows of mungbean simultaneously resulted in lower biological yield of maize (9399 kg ha^{-1}). Higher biological yield in hand weeded plots could be attributed to effective weed control and lower weeds population in these plots. As a result of lower weeds density, available resources like nutrient, moisture and space were fully exploited by maize crop which caused significant increase in total dry matter production. Similarly, biological nitrogen fixation by soybean and mungbean might be a reason for higher biological yield in maize-soybean one row simultaneously intercropped plots and intercropping of maize-mungbean two rows with delay sowing by three weeks. Also, the higher biological yield in mungbean intercropped plots could be attributed to lower plant height of mungbean due to which maize plants were capable to utilize solar radiation efficiently.

Grain yield (kg ha^{-1})

Grain yield is the most important out come of maize crop and it depends on a number of yield components of maize. Maize intercropping with soybean and mungbean in various intensities considerably affected grain yield of maize (Table-2). Higher grain yield (4954 kg ha^{-1}) was recorded in hand weeded plots, which was at par with maize soybean one (4788 kg ha^{-1}) and two rows (4683 kg ha^{-1}) seeded simultaneously and maize mungbean one row delay seeded by three weeks (4514 kg ha^{-1}). Lower weed density and competition for available limited resources could be the possible reason for higher grain yield in handed plots. In the absence of weeds, maize plants utilize the available nutrients and moisture more efficiently as compared to control plots where weeds population was higher and nutrients availability to maize plants were decreased by weeds (Ali *et al*., 2011). Similarly higher yield in maize-bean intercropped plots could be attributed to increased nitrogen use efficiency and fixation of atmospheric nitrogen by mungbean and soybean through Rhizobia-legume symbiotic relationship. Improved maize productivity and resource use efficiency was noted more in maize-bean intercropping systems than respective sole cropping. As for as legume-cereal intercropping pattern is concerned, the combination of maize + mungbean was considered to be highly effective with a minimum competition for nutrients. Similar results were reported by Ullah *et al.* (2007) that maximum maize seed yield (6.7 t ha^{-1}) was recorded in 90 cm spaced double row strips of maize + soybean intercropping. Maize-legume intercropping is advocated because of its beneficial effect on yield increase of maize (Chen *et al.,* 2004), control of weeds and control legume root parasite infections (Fenandez *et al.,* 2007) which ultimately may improve the farmers income and soil fertility.

CONCLUSION

From the results of the present study it is concluded the all the treatments had a convincing affect on the entire weed and crop parameters studied. The number of weeds m^{-2} was drastically reduced as compared to the control plots. Hand weeding and intercropping of maize with one and two rows of soybean resulted in the highest thousand grain weight, biological, and grain yield of maize. Thus, the hand weeding and maize-soybean intercropping treatments were more effective in terms of weeds suppression and maize grain yield enhancement. Therefore, maize legume intercropping should be encouraged in the future weed management strategies.

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Table-1. Weed density (m^{-2}), leaf area and kernel cob^{-1} of maize as affected by maize-legume intercropping.

Treatments	Weed density (m^{-2})	Leaf area (cm^2)	Number of kernels cob^{-1}
Maize	139 a	4070 a-c	701.7 ab
MS1S	166 a	3929 cd	804.3 a
MS2S	164 a	3768 d	801.9a
MS1D	165 a	4343 a	502.9 c
MS2D	159 a	4015 bcd	673.3 ab
MM1S	186 a	3929 cd	700.1 ab
MM2S	154 a	4291 ab	748.9 ab
MM1D	126 ab	3859 cd	638.4 bc
MM2D	126 ab	4246 ab	673.4 ab
M (sole –weedy check)	230 ab	3893 cd	762.7 ab
M (sole – hand weeded	50 c	4131 abc	736.7ab
LSD	28.57	293.3	154.7

Means followed by different letters are different statistically at 5% level of probability.

Table-2. Thousand kernel weight (g), biological yield (kg ha^{-1}) and grain yield (kg ha^{-1}) of maize as affected by maize-legume intercropping.

Treatments	Thousand kernel weight (g)	Biological yield (kg ha^{-1})	Grain yield (kg ha^{-1})
Maize	257.0 abc	10380 b-f	4533.67 abc
MS1S	199.7 d	11370 ab	4787.67 ab
MS2S	275.0 a	9777 bef	4683.00 abc
MS1D	257.3 abc	10702 a-e	4133.33 bc
MS2D	265.3 ab	10822 a-d	4382.00 abc
MM1S	227.3 cd	9711 ef	4530.00 abc
MM2S	252.3 abc	9399 f	4514.00 abc
MM1D	243.0 abc	10177 cdef	4054.33 c
MM2D	229.7 cd	10889 abc	4564.67 abc
M (sole –weedy check)	235.3 bc	10472 b-e	3073.33 d
M (sole – hand weeded	261.3 bc	11566 a	4954.33 a
LSD	33.12	1057.20	713.3

Means followed by different letters are different statistically at 5% level of probability.

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