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EFFECT OF INTERCROPPING ON BIOMASS OF WEEDS AND THE ASSSOCIATED CROPS

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ABSTRACT

To study the effect of intercropping on biomasses of maize, the intercrops i.e. mungbean, cowpea and sesbania, and weeds. The experiments were conducted at the New Developmental Farm of the University of Agriculture Peshawar. The experiments were laid out in randomized complete block design with split plots arrangements in such a way that the herbicidal and non herbicidal treatments were kept in the main plots; whereas the subplots comprised of 10 treatments of intercropping including 1-row-maize : 1-row-cowpea, 1-row-maize : 1-row-mungbean, 1-row-maize : 1-row-sesbania, 1-row-maize : 2-rows-cowpea, 1-row-maize : 2-rows-sesbania, 1-row-maize : 2-cowpea, sole maize (M), sole cowpea (C), sole sesbania and sole mungbean. The years, herbicide use, intercropping and their interactions all significantly affected the maize biomass, weed fresh biomass, mungbean biomass, sesbania biomass and cowpea biomass (kg ha^{-1}). The mean weed biomass in 2013 was higher than 2012. In contrary, the biomasses of maize, mungbean, cowpea and sesbania were higher in 2012. For the effect of the herbicide use, the weed biomass was lower in the herbicidal treatments during both the years. However, the biomasses of the associated crops were higher in the plots treated with the herbicide pendimethalin as pre-emergence. As far as the intercropping effect is concerned, the weed biomass was highest in the sole crops as compared to the plots where intercropping was done. Minimum weed biomass was obtained in plots where 10 rows of mungbean were intercropped with six rows of maize. The sole treatments had the highest respective crop biomass i.e. maize, mungbean, cowpea and sesbania had their highest biomasses in their sole treatments. In conclusion, the weed biomass is reduced by increasing the crop population and diversity and also by the use of pendimethalin. In addition, the crop biomass is better when the intercropping is done with a ratio of one maize row and one row of the intercrop. Therefore, the integration of the pre-emergence herbicide (pendimethalin) with the intercropping of legumes with maize in a 1:1 will be an effective approach for weed suppression, and higher crop biomass.

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INTRODUCTION

Maize is an important crop which is widely used by the people on large scale in various routine consumptions. It has been under research investigations since long but still the lower yields of the local varieties in the country have never been improved at par with the developed nations. Generally, the increase in production can be achieved by increasing the acreage (also called horizontal increase) or by enhancing the genetic potential (also termed as vertical increase) of the concerned varieties. The increase in acreage is very difficult because of the rapid surge in the annual population, because of spreading of the infrastructure in shape of constructions of buildings, roads, markets, etc.

On the other hand, the increase in the genetic potential is one of the feasible and workable sides to achieve. However, still there is always a big gap between the potential yield and the actual yields of these varieties. Similarly, maize crop is facing the same problem. This gap is created mainly by the weed competition. The weeds are never considered a serious pest of the crops as compared to the insects and pathogens. In fact, weeds cause more losses in crop yields than insects and pathogens, though their effect is invisible in the earlier season and the losses are irreversible when the impact becomes obvious. Insects and pathogens can directly and quickly be dealt with as their impact is on the spur of the moment, however weeds apparently seem friendly with the crop in the earlier season but applying control measures at the time of impact is always too late. This is the reason that weeds are more serious pest to insects and pathogens.

Several control measures are there to be used for weed management including preventive, cultural, mechanical, chemical and biological etc. however using an individual method for weed control will never be a successful measure. Therefore, an integrated approach can provide best results (Bulson *et al.*, 1997). Chemicals have always been a quick method of weed control and the results have always been prompt but the development of resistance and other environmental and health hazards have triggered a worldwide decision for decreasing reliance only on chemical control of weeds in the agricultural crops (Augustin, 2003).

Along with the herbicide use, intercropping could be a better and environmental friendly weed control measure (Amanullah *et al*., 2006; Banik *et al.,* 2006), and is also a fruitful way of getting more and diverse yields from the same piece of land (Augustin, 2003), if used scientifically (Zhang *et al*., 2007). In this connection, using legume crops can help achieve the goals very smoothly, as these crops also restore the soil fertility and organic matter (Kamanga *et al*., 2010; Ghosh *et al*., 2007). Among the legumes, sesbania, cowpea and mungbean are very effective as fodder, green manure and grain crops, respectively. In this connection, an experiment was designed to with the objective to find out the effect of intercropping on biomasses of weeds and the associated crops.

MATERIALS AND METHODS

Two field experiments on intercropping in maize were carried out on the same field in years of 2012 and 2013 at the Research Farm of the University of Agriculture Peshawar, Pakistan. Mungbean, sesbania and cowpea were used as the intercrops with maize crop. The maize variety "Azam" was selected for the research project. Split plot design was the statistical design of the experiments keeping two treatments in the main plots (herbicide used and herbicide not used) and 10 treatments were kept in the sub-plots, all replicated three times. The herbicidal treatment in the main plots was of Stomp 330 EC used as pre-emergence. The 10 subplots comprised of sole maize (1 :0), sole mungbean (1:0), sole cowpea (1:0), sole sesbania (1:0), 5-rows of sesbania + 6-rows of maize (1:1), 5-rows of mungbean + 6-rows of maize (1:1), 5-rows of cowpea + 6-rows of maize (1:1), 10-rows of sesbania + 6-rows of maize (2:1), 10-rows of cowpea + 6-rows of maize (2:1), and 10-rows of mungbean + 6-rows of maize (2:1).

The sole treatments of maize, mungbean, cowpea and sesbania had 6, 15, 15, and 15 rows, respectively in the same size of unit plots; whereas the row to row distance was standard as per recommended distance for the individual species. Among the intercrops, sesbania was utilized as a green manure, the cowpea as fodder and mungbean as the grain crop. The size of each experimental unit (sub-plot) was 5m x 4.8m, with 6 rows of maize crop in each unit, each row 5 m long and spaced 0.8 m apart. Measurements were made on individual plants present in the mid two rows of the four row plots. Maize was sown at the rate of 40 kg, Sesbania at 25 kg, cowpea at 60 kg and mungbean at 25 kg ha^{-1}.

Data were collected on weed biomass, maize biomass, biomass of sesbania cowpea, and mungbean (kg ha^{-1}). The biomass values were taken with a digital balance and were converted to kg ha^{-1} with this formula,

$$\text{Biomass (kg ha}^{-1}\text{)} = \frac{\text{Biomass obtained (kg) in the harvested area x 10000}}{\text{Area harvested (m}^2\text{)}}$$

Using the ANOVA procedure, combined analyses were carried out for each parameter of the two year data. Separate yearly analyses were also performed. Statistical analyses were done for both the main and interaction effects using MS Excel in the MS Office 2007 and also using the statistical software Statistix 8.1. The significant means were then separated using Least Significant Difference test (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Weed biomass (kg ha^{-1})

The year effect of the two year study was significant on the weed biomass. The ANOVA of the data also revealed that weed biomass was significantly affected by the herbicide treatments, intercropping treatments and their interactions (Table-1). The weed biomass in 2013 (1995 kg ha^{-1}) was higher than in 2012 (1640 kg ha^{-1}) which could be due to the weather conditions. The ANOVA of the data also revealed that weed biomass was significantly affected by the herbicide treatments, the intercropping treatments and their interactions (Table-1). As the year effect was significant, the year wise data had to be individually displayed in the given Table-1. In this connection, the mean weed biomass was 2752 kg ha^{-1} achieved in plots where no herbicide was used as compared to the plots where herbicide pendimethalin was used as pre-emergence (530 kg ha^{-1}). Regarding the intercropping effect, during the year of 2012, the lowest weed biomass of 1330 kg ha^{-1} was recorded in the intercropping of 10 rows sesbania + 6 rows maize and highest (2389 kg ha^{-1}) in sole maize. The lowest weed biomass value was however at par with the intercropping of 5 rows mungbean + 6 rows maize, 10 rows mungbean + 6 rows maize, and 10 rows cowpea + 6 rows maize, respectively. It clearly indicated that intercropping factor reduced the weed biomass. The sole maize had the highest weed biomass because of sufficient space availability for weeds to germinate and grow higher. The intercropping provided less room to the emerging weeds and the weeds could not establish stronger in between the intercropped rows. The sole legume treatments also resulted in less weed biomass than sole maize. Bilalis *et al.* (2010) reported that maize-legume intercrop resulted in reduction of weed density as compared to sole crops. This could be due to availability of comparatively less space in the legumes as they grow more vigorous and cover more space. Ghosheh *et al*. (2005) clearly demonstrated beneficial effects of maize–legume intercrops on weed suppression and crop growth. It is worth noting that the interaction effect of herbicide and intercropping was also significant. Tripathi and Singh (1983) found that growing one or two rows of soybean (*Glycine max* L.) as an intercrop in maize reduced fresh weed biomass significantly as compared to sole. Similar results also reported by, Ford and Pleasant (1994), who found no differences among plots cultivated with different maize intercropping treatments concerning weed biomass.

Maize biomass (kg ha^{-1})

Analysis of the data revealed that biomass of maize was significantly affected by years, herbicide treatments, intercropping treatments and their interactions (Table-1). The maize biomass in the year 2012 (9639 kg ha^{-1}) was higher than in 2013 (8762 kg ha^{-1}) which indicated that the weather conditions in the year 2012 were less favorable. The maize biomass was higher in the plots where pendimethalin herbicide was used as pre-emergence as compared to plots where the herbicide was not used. Regarding the intercropping effect, during the year 2013, the lowest maize biomass of 7932 kg ha^{-1} was recorded in the intercropping of 10 rows mungbean + 6 rows maize, whereas highest maize biomass of 9023 kg ha^{-1} was recorded in sole maize. The results are in line with Ennin *et al*. (2002), who intercropped soybean with maize to take advantage of available solar radiation and greater dry matter yields. Higher biomass is an indicator of better crop growth and better weed suppression. Rao (2000) is of the view that one kilogram of weed biomass corresponds to a loss of one kilogram of crop biomass.

Mungbean biomass (kg ha^{-1})

Statistical analysis of the data showed that the effect of herbicides, intercropping and their interaction was significant on the biomass of mungbean crop (Table-1). Analysis of the data revealed that sole mungbean performed better than intercropped mungbean. The year effect of the two year study was also significant on the mungbean biomass. The mungbean biomass in the year, 2012 (1306 kg ha^{-1}) was higher than in 2013 (1195 kg ha^{-1}). Mean value of the data indicated that higher biomass was produced by sole mungbean (1522 kg ha^{-1}), followed by plots where maize was intercropped with ten rows of mungbean (1217 kg ha^{-1}). Higher biomass in sole treatment may be due to the fact that mungbean crop consumed excess amount of solar radiations for efficient photosynthesis resulted in more vegetative growth and plant height which attained more biomass as compared to the sole crop. Minimum biomass of 1023 kg ha^{-1} was obtained in plots where mungbean was intercropped with six rows of maize and five rows of mungbean simultaneously. Low biomass in mungbean might be due to less exposure to sunlight which resulted in less photosynthesis. Results are supported by Evan *et al*. (2001) who reported that when mungbean intercropped with maize, maize performed better then mungbean and utilized all the available resources for the growth and development.

Cowpea biomass (kg ha^{-1})

Data regarding biomass of cowpea is shown in Table-1. Statistical analysis of the data showed that the effect of the years, herbicide use, intercropping and their interactions was significant on the biomass of cowpea. The cowpea biomass in 2012 (5787 kg ha^{-1}) was higher than in 2013 (4452 kg ha^{-1}). Mean values of the data indicated that higher biomass of cowpea was produced in plots of herbicide use with 6212 kg ha^{-1} as compared to the lower biomass of 5362 kg ha^{-1} in non herbicide treatments. Among the intercropping treatments, the sole treatment of cowpea resulted in 7676 and 6540 kg ha^{-1} followed by plots where six maize rows were intercropped with ten rows of cowpea (5382 and 4600 kg ha^{-1}) in 2012 and 2013, respectively. Minimum biomass of 4304 and 3664 kg ha^{-1} were obtained in plots where five cowpea rows were intercropped with six rows of maize in 2012 and 2013, respectively. This greater biomass in sole treatment may be due to the fact that cowpea crop consumed excess amount of nutrients and resulted in more biomass.

Sesbania biomass (kg ha^{-1})

Statistical analysis of the data on sesbania fresh biomass showed that the effect of the years, the herbicide treatment, the intercropping treatments and their interactions was significant (Table-1). The biomass of sesbania in 2012 was 2265 kg ha^{-1} and 1888 kg ha^{-1} in 2013. Mean value of the data indicated that higher biomass of sesbania (2463 and 2052 kg ha^{-1}) was produced in the herbicide treatments in the two respective years. The treatment of sole sesbania resulted in the highest sesbania fresh weight of 2829 and 2357 kg ha^{-1}, followed by plots where six rows of maize were intercropped with ten rows of cowpea (2200 and 1833 kg ha^{-1}). Minimum biomass of 1767 and 1472 kg ha^{-1} were obtained in plots where sesbania was intercropped with six rows of maize and five rows of sesbania. This greater biomass in sole treatment may be due to the fact that sesbania crop utilized excess amount of nutrients and resulted in more biomass as compared with the rest treatments.

CONCLUSION

It can be concluded from the study that herbicide application can affect the biomasses of the weeds and the associated crops. Sufficient weed suppression has been achieved under higher and diverse crop population. The higher crop population or diversity also has a negative effect on their ultimate biomasses. Intercropping of maize with any of the legumes like mungbean, cowpea and sesbania have a good effect on weeds suppression and crop biomass enhancement. To summarize the findings, intercropping is recommended in integration with pendimethalin as a pre-emergence herbicide for weed suppression and higher crop production.

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Table-1. Weed biomass and biomasses of maize, mungbean, cowpea, and sesbania (kg ha^{-1}) as affected by the herbicide use and intercropping treatments during 2012 and 2013 in Peshawar Pakistan

Treatments	Weed biomass (kg ha^{-1})		Maize biomass (kg ha^{-1})		Mungbean biomass (kg ha^{-1})		Cowpea biomass (kg ha^{-1})		Sesbania biomass (kg ha^{-1})	
Factor A and B	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Herbicide treatments means (A)										
Herbicide used	530 b	688 b	9639 a	8762 a	1306 a	1195 a	6212 a	5213 a	2463 a	2052 a
Herbicide not used	2752 a	3301 a	8723 b	7930 b	1201 b	894 b	5362 b	4469 b	2068 b	1723 b
$LSD_{0.05}$	219.48	262.19	564.01	512.91	66.71	34.07	789.9	668.1	89.215	74.28
Intercropping Treatments means (B)										
Sole maize (6 rows)	2389 a	2906 a	9925 a	9023 a	---	---	---	---	---	---
Sole mungbean (15 rows)	1837 c	2231 c	---	---	1522 a	1170 a	---	---	---	---
Sole cowpea (15 rows)	2159 b	2621 b	---	---	---	---	7676 a	6540 a	---	---
Sole sesbania (15 rows)	2056 b	2500 b	---	---	---	---	---	---	2829 a	2357 a
5-row-Sesbania+6-row-maize	1192 g	1455 g	9204 bc	8367 bc	---	---	---	---	1767 c	1472 c
5-row-Mungbean+6-row-maize	1373 ef	1671 ef	9143 bc	8311 bc	1023 c	1016 b	---	---	---	---
5-row-Cowpea+6-row-maize	1101 g	1345 g	9360 b	8509 b	---	---	4304 c	3664 c	---	---
10-row-Sesbania+6-row-maize	1330 f	1619 f	8890 de	8082 de	---	---	---	---	2200 b	1833 b
10-row-Cowpea+6-row-maize	1456 de	1770 de	9021 cd	8201 cd	---	---	5382 b	4600 b	---	---
10-row-Mungbean+6-row-maize	1515 d	1835 d	8726 e	7932 e	1217 b	949 c	---	---	---	---
$LSD_{0.05}$	113.89	138.09	248.03	225.43	31.21	29.87	488.31	417.41	165.92	138.34
Interaction H x IC ($LSD_{0.05}$)	*	*	*	*	*	*	*	*	*	*
Year means	1640 b	1995 a	9181 a	8346 b	1254 a	1045 b	5787 a	4452 b	2265 a	1888 b
$LSD_{0.05}$	110.32		88.59		24.17		321.58		37.45	

Means of the same category followed by different letters are significantly different at $P \leq 0.05$ level using LSD test.
H = Herbicide, IC = Inter-cropping, if the LSD value is given it means the results are significant
*Significant at $P \leq 0.05$

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