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PERFORMANCE OF MUNGBEAN UNDER HERBICIDE APPLICATION AND INTERCROPPING WITH MAIZE

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Abstract

Intercropping is an economically beneficial and a favorable measure for the fertility restoration of agricultural lands. A two year study on herbicide application and legume maize intercropping was undertakenat the New Developmental Farm of the University of Agriculture Peshawar, Pakistanduring maize-mungbean growing seasons of 2014 and 2015. The experiments were laid out in a split plot design with herbicide use as factor A and intercropping as factor B. The maize crop was sown in June and harvested in September. The results revealed that the herbicide application (factor A) and the intercropping treatments (factor B) both significantly affected the weed density (m^{-2}), fresh biomass of weeds, yield and yield components of mungbean. The application of herbicide improved the No. of grains pod^{-1}, 1000 grains weight (g), the biological and grain yields of mungbean as compared to the no herbicide use plots; while no herbicide treatment increased weeds density m^{-2} and fresh weeds biomass. In terms of intercropping, overall sole mungbean performed well as compared to the intercropping treatments. However, among the intercropping treatments, intercropping method of ten rows of mungbeancrop with sixrows of maize crop resulted in significantly higher biological and grain yields as compared to the yields in the treatment of five rows ofmungbeancrop intercropped with sixrows of maize crop. In conclusion, the application of herbicide pendimethalin1.5 kg a.i. $ha^{-1}$is recommended for the desirable weed control in mungbean crop intercropped with maize crop in order to achieve best yields. Further, the intercropping of mungbean with maize at the combination of 10mungbean rows intercropped with 6 maize rows with a ratio of 2:1 is better for achieving good yield of mungbean crop in maize-mungbean intercropping system. For the interaction of pendimethalin application in the intercropping of mungbean with maize by sowing two mungbean rows between each two adjacent maize rows is the best choice.

Key words: Intercropping, Maize, Mungbean, Pendimethalin, Yield.

Introduction

Mungbean (*Vigna radiate* L.) is a traditional pulse crop of Pakistan. At national level, the Punjab province alone contributes up to 85% of the total mungbean production and 88% of the total area in the country (Anon., 2016). In the Indo-Pak subcontinent, this crop is mainly grown as a short duration crop sown in between the two other principal crops (Anon., 2016). Afzal *et al*., (2008) have reported 24-26% proteins, 51% carbohydrates, 4% minerals, and 3% vitamins in mungbean seeds.

By definition, the intercropping is a practice of growing more crops, instead of mono-cropping, on the same piece of land with the interest of diverse production and fetching high income (Zhang *et al*., 2007). The exploitation of intercropping method, which is usually practiced by small land holders, is a general practice worldwide for maximum utilization of the available land for higher income (Ofuso-Amin *et al*., 2007). This process started in the ancient civilization, not only in the tropical areas of the world but also in the rainfed areas (Dahmardeh *et al*., 2009; Banik *et al*., 2000; Dhima *et al*., 2007). Intercrops may have productive and protective functions for the associated crops and/or their environments. Mungbean intercropped with other crops especially with cereals like maize have the ability to perform well and is a best match for intercropping systems (Bibi *et al*., 2019). Intercropping of cereals and legumes is far better than cereals in sole cropping. It is also noticeable that cereal legumes intercropping helps in reduction of soil moisture deficiency due to which soil surface remains moist for longer durations. Furthermore, Ghosh *et al*., (2007) also recommended legume cereal intercropping as the best one in terms of resources utilizationand decreasing the risk of crop failure as well (Kamanga *et al*., 2010). Intercropping generates beneficial biological interactions between cropsviz. legume and non-legume intercropping, more efficiently using the available resources, reducing erosion and nutrient leaching and reducing the weed pressure (Kadziuliene *et al*., 2009; Banik *et al*., 2006; Poggio, 2005).

In this context, it is also worth mentioning that weeds are a serious threat to such a cropping system. Intercropping cereals-legumes showed no long term effect on suppression of weeds (Kamanga *et al*., 2010). Therefore, the weed control is a key and crucial factor in a profitable cereal legume intercropping. Several methods are available for controlling weeds efficiently depending on the financial status of the farming community. The farmers can manage the weeds by different methods, like the inter- and intra- row cultivation, crop rotation, and irrigation management etc. that are affordable to the farmers more than they can afford the chemical weed control. The herbicides are though not widely or frequently used in the agro-ecological conditions of Peshawar, especially under intercropping practice, even though weeds could be effectively controlled by using the available herbicides. The work done on weed management revealed that using the herbicides in combination with the tillage method is a cheaper and more profitable option for weed control by the small land holding farmers (Ashton & Monaco, 2003). The herbicides thus do increase the smallholder farmers' capability of managing weed infestation, particularly under the critical period of weed competition.

In light of the above review, we are interested to devise weed control through herbicides for the cereal-legume intercropping system with the objective to assess the efficacy of chemical weed control in mungbean-maize intercropping system.

Material and Methods

Description of the experiments site: Two field experiments were undertaken at the research farm of the University of Agriculture, Peshawar, Pakistan in the maize and mungbean growing seasons of 2014and 2015. The location of the experimental site is at east longitude of 71°27/ and 72°47/ and north latitude of 33°40/ and 34°31/; while, the site is at the altitude of 335 m above the sea level. The soil was silty clay loam having8.7% sand, 40% clay, and 51.3% silt. According to Bhatti (2002) and Tariq *et al.*, (2002), the experimental soil was alkaline in reaction, calcareous ($CaCO_3$ = 14.4%) in nature, having an average pH of 8.02 and low in organic matter content0.845 g kg^{-1}.

Detailsof the experiment: There were two types of treatments in the experiments i.e., firstly herbicide used and herbicide not used, and secondly the intercropping treatments. The herbicide was pendimethalin used as pre-emergence (PRE) @ 1.5 kg a.i. ha^{-1}(Stomp 330 E, Syngenta). The intercropping treatments comprised of mungbean mono-cropping, maize mono-cropping, five lines of mungbean intercropped with six lines of maize (abbreviated as 5Mb6M) and 10 lines of mungbean intercropped with six lines of maize (abbreviated as 10Mb6M). The two year research was undertaken using Randomized Complete Block Design with a split-plot arrangement, in such a way that Factor A; the herbicide treatments were placed in main plots, while the Factor B; the mono and intercropping treatments were assigned to the subplots. The experiments were replicated three times.

The maize and mungbean crops were uniformly sown at the recommended seed rates of 40 kg and 25 kg ha^{-1}, respectively. To retain the necessary spaces between the crop plants after their complete emergence, the seedlings were either thinned or re-sown under excessive or reduced emergence, respectively. For re-sowing purpose a separate plot was sown to ensure the availability of seedlings if required. Before the sowing process, the field was ploughed with cultivator, which was followed by a rotavator too, so that a fine seed bed could be prepared. A basal dose 100 kg ha^{-1} was kept for application of P in single super phosphate (SSP) form. The nitrogen fertilizer was applied as Urea. The irrigation type was flood irrigation as per requirement of the crop on quantity and temporal basis. The cultural practices were uniformly carried out in all of the experimental plots.

Statistical analysis

The two year data was analyzed in a combined analysis through the statistical software Statistix 8.1 version using the Split Plot design. The herbicide treatment was placed in the main plots as Factor A, while the intercropping treatment was allotted to the subplots as Factor B. The individual effects of the two factors are presented in tables using their mean values, while the interaction effects are presented in the bar graphs. As the variation among years was non-significant, therefore the two year data was averaged and then analyzed, to avoid redundancy.

Results

Herbicide application: The effect of herbicide application (HA) on various weeds parameters and yield parameters is available in Table 1. The perusal of the collected data showed a significant impact of the herbicide application on all the studied parameters. Weeds density and fresh weed biomass were recorded higher in the plots where no herbicide was applied as compared to herbicide treated plots. It is also clear from the data in Table 1 that the herbicide application indicated a significant effect on the yield and yield components of mungbean crop. For the total and final yield of mungbean, the No. of seeds pod^{-1} is always a key parameter. A higher No. of mung bean seeds pod^{-1} wasobserved in plots of herbicide application as compared to non-herbicide applied plots. Similarly, heavier 1000 grain weight, higher biological and grain yields were recorded in the plots where herbicide was applied while lower values were recorded where no herbicide was used.

Table 1. Weeds parameters, mung-bean yield and yield components as influenced by herbicide application.

Parameters	Herbicide application		
	No herbicide (NH)	**Herbicide used (HU)**	**Significance Level**
Weeds density (m^2)	54.4 a	19.95 b	*
Fresh weed biomass (kg ha^{-1})	3026.6 a	609.3 b	*
Number of seedspod^{-1}	7.89 b	9.94 a	*
1000 grains weight (g)	24.7 b	27.6 a	*
Biological yield (kg ha^{-1})	1048.4 b	1251.1 a	*
Grain yield (kg ha^{-1})	95.28 b	342.56 a	*

*Significant at $p \leq 0.05$

The means having different alphabetical letters are significantly different from each other at 0.05 probability level

Note: The data presented in the table are the average values of the two years 2014 and 2015

Table 2. Weeds parameters, mungbean yield and yield components as influenced by different intercropping treatments.

Parameters	Intercropping treatments			
	Sole 6MB	5Mb6M	10Mb6M	LSD (0.05)
Weeds density	39.06 a	35.21 b	35.06 b	2.03
Fresh weeds biomass (kg ha^{-1})	2033.6 a	1674.6 b	1522.1 c	57.93
Number of seedspod^{-1}	10.3 a	9.42 b	7.04 c	0.834
1000 grains weight (g)	40.08 a	28.8 b	27.6 b	2.49
Biological yield (kg ha^{-1})	1346.2 a	1019.8 c	1083.1 b	30.54
Grain yield (kg ha^{-1})	399.3 a	252.0 c	305.41 b	9.414

*Significant at $p \leq 0.05$

The means having different alphabetical letters are significantly different from each other at 0.05 probability level.

Note: The data presented in the table are the average values of the two years 2014 and 2015

Intercropping: Data regarding the effect of intercropping on weeds and yield parameters are presented in Table 2. The intercropping treatments resulted in lower densities of weeds as compared to the sole treatments. The weed density was recorded highest in the sole maize plots followed by treatments of 5mungbean rows intercropped with 6 maize rows, and 10 mungbean rows intercropped with 6 maize rows. The data showed that the intercropping treatment of 5Mb6M exhibited higher weed density as compared to the intercropping treatment of 10Mb6M (Table 1). In terms of fresh weeds biomass, higher biomass was recorded in sole mungbean plots as compared to 5Mb6M) and 10Mb6M treatments. Higher number of seeds pod^{-1} were recorded in sole mung bean followed by plots of 5Mb6M; however, 10Mb6M resulted in lower number of seeds pod^{-1}. 1000 grain weight was also significantly affected by intercropping treatments, thus a higher 1000 grain weight was obtained in the treatments of sole mung bean, followed by 5Mb6Mand the least in t 10Mb6M. Intercropping treatments had a significant effect on biological yield, thus a higher biological yield of mungbean was recorded in sole mungbean plots followed by 10Mb6M; whereas 5MB6M resulted in lowest biological yield. Biological yield also had a substantial effect on grain yield, therefore a higher grain yield was observed in sole mungbean plots, followed by 10Mb6M; whereas 5Mb6M resulted in the lowest grain yield.

The interaction effects were also statistically significant for all the studied parameters. The interactions have been displayed graphically in Figs. 1 to 6. The weed density was highest in sole maize and then sole mungbean plots under no herbicide use while it was lowest in 10Mb6M where the herbicide pendimethalin was used (Fig. 1). A similar trend was there for the interaction of the two factors regarding fresh weed biomass (Fig. 2).

SM6 (maize monocrop sown in 6 rows), SMb15 (mungbean monocrop sown in 15 rows), 5Mb6M (mungbean 5 rows sown alternately with maize 6 rows), 10Mb6M (mungbean 10 rows sown with maize 6 rows i.e. 2 mb rows after each maize row)

NHU (No Herbicide Use), HU (Herbicide Used),

The effect of herbicide and intercropping interaction was significant for the data onNo. of mungbean seeds pod^{-1}. The number of seeds of mungbean pod^{-1} was higher in the sole mungbean plots while it gradually decreased with rise in the number of crop plants in a unit area (Fig. 3). Similarly, the 1000 grain weight was in line with the trend of the no. of seeds pod^{-1} (Fig. 4).

The interaction of herbicide (factor A) and intercropping (factor B) on mungbean biological and grain yields was statistically higher in the sole mungbean plots under herbicide used treatments followed by the intercropping treatment of 10Mb6M and 5Mb6M, respectively (Figs. 5 and 6).

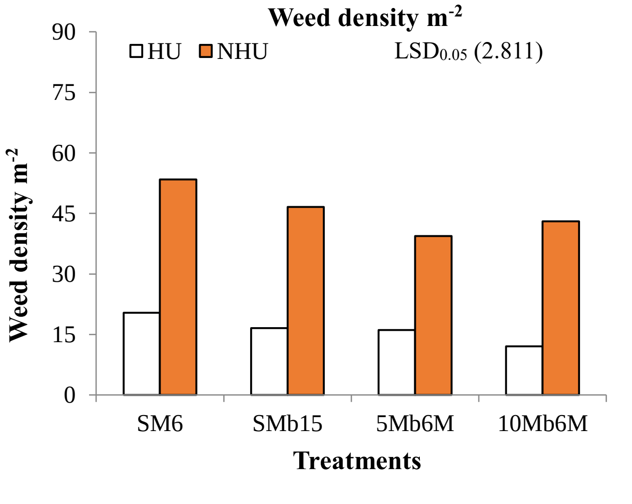

Fig. 1. Interaction of herbicide x intercropping (AxB) on weeds density.

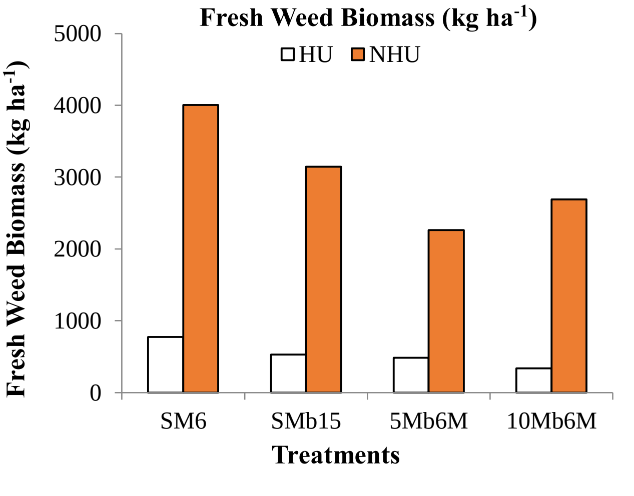

Fig. 2. Interaction of herbicide x intercropping (AxB) on weeds fresh biomass.

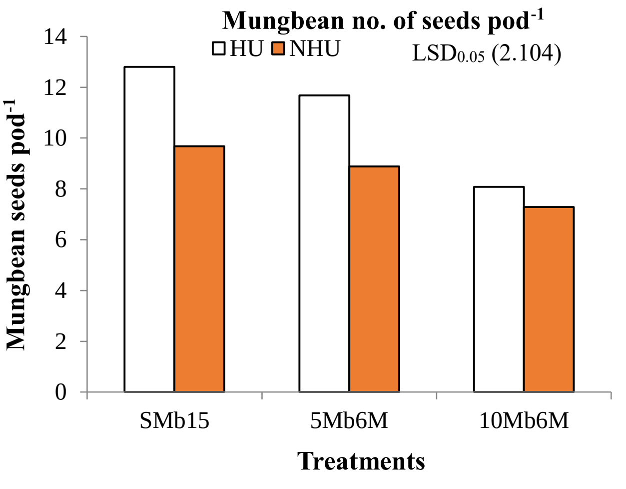

Fig. 3. Interaction of herbicide x intercropping (AxB) for no. of mungbean seeds pod^{-1}

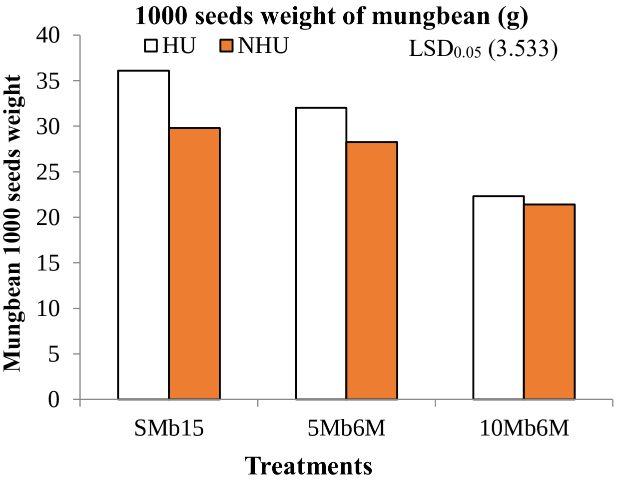

Fig. 4. Interaction of herbicide x intercropping (AxB) forMb1000 seeds weight.

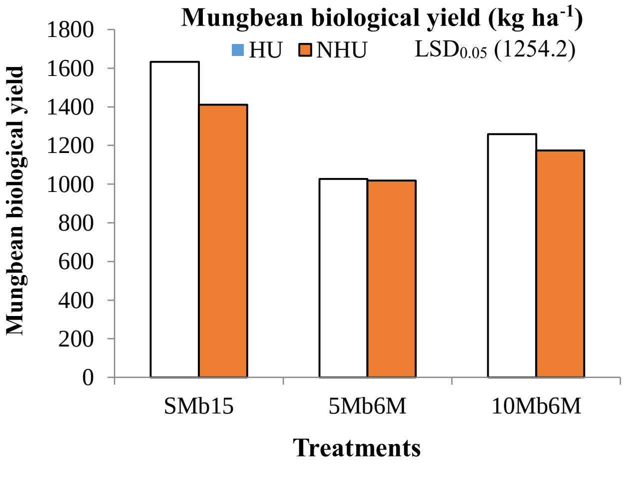

Fig. 5. Interaction of herbicide x intercropping (AxB) for Mb biological yield.

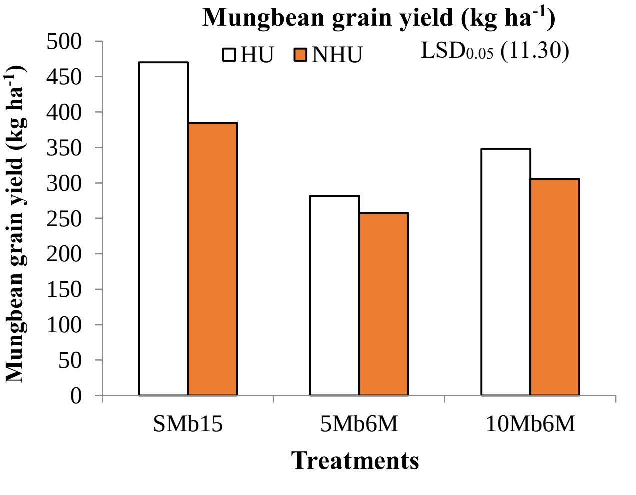

Fig. 6. Interaction of herbicide x intercropping (AxB) for Mb grain yield (kg ha^{-1}).

SMb15 (mungbean monocrop sownin 15 rows), 5Mb6M (mungbean 5 rows sown alternately with maize 6 rows),10Mb6M (mungbean 10 rows sown with maize 6 rows i.e. 2 mb rows after each maize row), NHU (No herbicide use), HU (Herbicide used)

Discussion

The basic objective of intercropping method is that to boostthe gross production in a given area as well as time, in addition to well-balanced and equitable exploitation of soil resources along with the inputs used by the farmers such as labor etc. (Marer *et al*., 2007). Therefore, the use of these available land and water resources in a very efficient way is considered to be the most economical way for higher productivity through intercropping. The intercropping system of mungbean-maize is capable of lessening the quantity of nutrients up-taken from the soil as compared to the mungbean mono-cropping (Tsubo *et al*., 2003). Thus, the intercropping method is less risky (i.e. there is reduction inthebiotic and abiotic risks for the crops when there is increase in the crop diversity and in the suppression of weeds) and more productive in terms of resources and input utilization (Kamanga *et al*., 2010).

Intercropping features can play a role in declining the weed density. In our study, sole cropping of mungbean provided opportunity for high weeds infestation due to free existing spaces for germination (Bilalis *et al*., 2010). Moreover, the studies of Buchler *et al*., (2001) showed that intercropping declined the weed density per unit area which as a result enhanced the crop production and finally the yield is increased by providing extra nutrients. The intercropping process created an inter-specific competition among the plants of the main crop and the intercrop.

The probable rationale for the higher No. of seeds pod^{-1} in mungbean mono-cropping plots might be the sufficient availability of required nutrients due to sufficient empty spaces and due to no competition from maize plants (Oljaca *et al*., 2000). In our study, there was a significant effect of the herbicide application x intercropping treatments (AxB) on 1000 grains weight. This again might be as a result of the higher availability of the resources and reduced intra-specific competition from the maizeplants. These results are in analogy with the findings of Thavaprakaash *et al*., (2005) who had obtained significant results for thousand grains weight in intercropping system. Mungbean is always an important pulse and leguminous crop which has always been impressive in intercropping systems. The grain yield of mung bean was higher in sole mungbean plots in our study. Our finding are supported by the study of

Sunilkumar *et al*., (2005), who reported reduction in grain yield when sown in intercropping system. Greater biological yield of mungbean was noted in the herbicide treated plots. The results of these experiments are strongly backed by the findings of Evan *et al*., (2001). Therefore, the decreased mungbean biological yield was due to the competition as the intercrop with maize crop plants. In support of our results, there were reduced soybean yields in intercropping obtained by Polthanee & Trelo-ges (2003) as compared with the sole cropping of soybean.

The possible reason for the highest weed biomass in sole mungbean plots was that there was no competition from the crop plants and secondly there were sufficient empty spaces for the weeds to occupy. This situation not only increased the weed density but also the weed biomass on the same time. However, the available resources were utilized by the mungbean plants for reproductive growth when sown alone; while the resources were utilized for the vegetative growth when sown in competition with the maize crop plants. The reason for the higher biological and grain yields in 10Mb6M treatments was understandable that the number of mungbean plants was higher than the 5Mb6M due to which the net yields were higher.

Conclusion

In conclusion, the pre-emergence application of the herbicide pendimethalin at a rate of 1.5 kg a.i. $ha^{-1}$is better for achieving optimum weed control in mungbean crop intercropped with maize crop, which resulted in good yield of mungbean crop. The intercropping treatment ofmungbean 10 rows sown with six maize rows resulted in significantly better than the treatment of intercropping fivemungbean rows sown alternately with six maize crop rows in terms of mungbean yield and yield components. Therefore, the intercropping of mungbean with maize at the combination of 10mungbean rows intercropped with 6 maize rows with a ratio of 2:1 is better for achieving better yields of mungbean crop in maize-mungbean intercropping system.

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