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Yield and Yield Components of Mungbean as Affected by Various Weed Control Methods under Rain-fed Conditions of Pakistan

MUHAMMAD RIAZ CHATTHA, MUHAMMAD JAMIL[1] AND TAHIRA ZAFAR MAHMOOD
Weed Management Program and Sugar Crops Research Program, NARC, Islamabad–Pakistan
[1]Correspoden author's email: jamil_narc@yahoo.com

ABSTRACT

A field study was conducted at National Agricultural Research Centre (NARC), Islamabad during two crop years (2003 - 04) to determine the effect of different weed control methods on the yield and yield components of mungbean (*Vigna radiata* L.). In this study different weed control methods (chemical, mechanical, hand-weeding & their integration) were compared for their efficiency to control various weed species under rain-fed conditions of Pakistan. Among different weed control methods, use of herbicide tribunal 70 WP (methabenzthiazuron) @ 2 kg ha^{-1} at 2 - 3 leaf stage of weeds + hand-weeding at 50 DAS gave promising results in terms of weed reduction. This was closely followed by mechanical weeding after 20 days of crop sowing with a follow-up hand-weeding after 50 days of crop sowing and/or two hand-weeding after 20 and 40 days of crop sowing. Maximum reduction in density and biomass of the weeds was observed by chemical-weeding at 2 - 3 leaf stage of weeds + hand-weeding at 50 DAS. There was a significant increase (50%) in grain yield of mungbean due to chemical-weeding at 2 - 3 leaf stage of weeds + hand-weeding at 50 DAS. Similarly, this treatment out yielded other treatments in terms of number of pods per plant, number of seeds per pod, 1000 grain weight, grain yield and net benefits. The economic analysis of these weed control methods also showed better performance of chemical-weeding at 2 - 3 leaf stage of weeds + hand-weeding at 50 DAS as compared to rest of the treatments.

Key Words: Mungbean; Weeds; Integrated weed control; Yield components

INTRODUCTION

Mungbean (*Vigna radiata* L.) is an important grain legume and is grown on 225 thousand hectares with total production of 130 thousand tonnes and average yield of 577 kg ha^{-1} in Pakistan (Government of Pakistan, 2005). The magnitude of yield losses in mungbean caused by weeds depends mainly upon the weed species and their densities. Research workers have reported different levels of yield losses ranging from 30 to 85% (Sandhu *et al.*, 1980; Singh *et al.*, 1984; Singh, 1987; PARC, 1988). Weed competition with mungbean decreased grain yield by 81% and performance of triflualin (0.75 kg ha^{-1}), linuron (0.75 kg ha^{-1}) and acetachlor (1.0 kg ha^{-1}) each integrated with one hand-weeding at 30 DAS was superior to their alone application against weeds in mungbean (Malik *et al*., 2000). According to Pandey and Mishra (2003) the decrease in mungbean productivity due to weed competition was 45.6%. Chemical + cultural, hand-weeding and chemical treatments significantly suppressed mungbean weeds and caused a marked increase in grain yield. Seed yield of mungbean was maximum (2108 kg ha^{-1}) in the weed free treatment and decreased by 29.5%, 23.5% and 45.8% with 160 plants m^{-2} of *Trianthema portulacastrum, Echinochloa colona* and *Cyperus rotundus*, respectively (Punia *et al*., 2004). About 69% reduction in mungbean grain yield due to weeds was estimated by Yadav and Sing (2005). According to Raman and Krishnamoorthy (2005) presence of weeds reduced the seed yield of mungbean by 35%. Integration of one herbicide with one hand-weeding provided better growth, yield attributes and consequently higher yield.

Many efforts have been made to find out an economical weed control technology, where pulses are grown on larger areas. According to Cheema *et al.* (2001) an inhibition of 44, 28 and 44% in total weed dry weight was noticed by three sorgaab sprays, one hand-weeding and pendimethalin treatment, respectively. More over three sorgaab sprays enhanced grain yield of mungbean by 18%, while hand-weeding and pendimethalin treatments increased grain yield by 10 and 13%, respectively. Various weed control practices such as hand-weeding at 35 days after sowing, chemical treatment (pendimethalin @ 0.75 kg ha^{-1}), cultural treatment and chemical + cultural treatments were studied in mungbean (Pandey & Mishra, 2002). Khaliq *et al.* (2002) investigated efficacy of different weed management strategies in mungbean. The treatments consisted of 2 sprays of sorgaab (10 L ha^{-1}) at 15 and 30 days after sowing (DAS); S. metolachlor at 2.3 kg a.i. ha^{-1} as pre-emergence spray; pendimethalin @ 330 g a.i. ha^{-1}, S. metolachlor at 1.15 kg a.i. ha^{-1} + sorgaab; pendimethalin @ 165 g a.i. ha^{-1} + sorgaab; and two hand-weeding at 15 and 30 DAS. Hoeing treatments resulted in lowest weed dry

weight. Pendimethalin @ 165 g a.i. ha^{-1} + sorgaab and S. metolachlor at 1.15 kg a.i. ha^{-1} + sorgaab reduced the total weed dry weight by 78 and 75%, respectively. Marginal rates of returns obtained by Pendimethalin + sorgaab and metolachlor + sorgaab were 6891 and 149%, respectively. Weed population and dry mass were significantly reduced with hand-weeding and chemical + cultural treatments in mungbean and significantly increased grain yield. The reduction in grain yield due to weed competition was 46.5%. Efficacy of various weed control strategies in mungbean was investigated by Mansoor *et al*. (2004). The water extract of acacia (*Acacia nilotica*) resulted in highest grain yield followed by the two hand-weeding s and pre-emergence herbicide treatment (pendimethalin). Buttar and Kumar *et al*. (2004) stated that pendimethalin at 1.5 kg ha^{-1} + hand-weeding at 30 DAS resulted in maximum mungbean grain yield as compared to pendimethalin at 1.5 kg ha^{-1} or hand-weeding at 30 DAS alone. Aulakh (2004) reported that 0.5 kg trifluralin ha^{-1} + hoeing at 6 week after sowing resulted in the highest grain yield of mungbean (790 kg ha^{-1}) and lowest weed dry matter (91 kg ha^{-1}). Malik *et al*. (2005) evaluated five weed control methods in mungbean viz. pendamethalin at 1.5 kg ha^{-1} + hoeing at 45 days after sowing DAS (T_1), 2 hoeings at 25 and 45 DAS (T_2), 2 hand-weeding at 25 and 45 DAS (T_3), weedy (T_4) and Weed free (T_5). The maximum reduction in density and dry weight of weeds was achieved in T_3 and T_2 was found inferior to all other treatments. The highest seed yield of mungbean (1947 & 1870 kg ha^{-1}) was attained in T_5, which was statistically at par with T_1 and T_3. Mitra and Bhattacharya (2005) reported that application of butachlor along with one hand-weeding (35 days after sowing) resulted in maximum mungbean biomass, yield attributes, seed yield and water use efficiency of the crop along with effective weed suppression.

In barani areas of Pakistan, mungbean crop forms an important portion of cropping system. The yield of the crop is very low, which could be increased with proper management of production factors especially weeds control. It may be hypothesized that integration of various weed control methods such as chemical, mechanical and hand-weeding may be more effective against weeds of mungbean instead of alone. In fact none of the weed control method is best under all conditions. So, there is a need to make a comparative study of different weed management techniques in mungbean and to develop an integrated approach, which should be cost effective and environmentally safe. Keeping these facts in view, a comprehensive study was planned to integrate different weed control methods in rain-fed mungbean crop to identify cost effective weed control methods in mungbean based cropping patterns in order to achieve sustainable rain-fed mungbean yield.

MATERIALS AND METHODS

The field experiment was conducted under rain-fed conditions for two crop years (2002 - 03 & 2003 - 04) at National Agricultural Research Centre (NARC), Islamabad. Soils of the area are loess in nature, slightly alkaline with pH 8.2 and low in organic matter (0.5%). The mean maximum temperature during the experiment was 40°C, while the mean minimum temperature was 14°C. The mean annual rain-fall, were 840 and 550 mm during 2003 and 2004, respectively.

The experiments were laid out in randomized complete block design (RCBD) with 3 replications. Six weed control methods were included in the study. These were weedy check (WC_1), hand weeding at 20 and 40 DAS (WC_2), mechanical weeding at 20 DAS (WC_3), chemical-weeding (WC_4) at 2 - 3 leaf stage of weeds, mechanical weeding at 20 days after sowing + hand-weeding at 50 DAS (WC_5) and chemical-weeding at 2 - 3 leaf stage of weeds + hand-weeding at 50 DAS (WC_6). Mechanical weeding was carried out by using local implement "Tarphali". Commonly used herbicide Tribunil 70 WP (methabenzthiazuron) was obtained from local market and applied @ 2 kg ha^{-1} at 2 - 3 leaf stage. Volume of spray (300 L ha^{-1}) was determined by calibration as described by Rao (1983). Spraying was done with Knapsack hand sprayer fitted with T-Jet nozzle maintaining a pressure of 207 kp.

The seed of mungbean approved variety NCM-209 was collected from Pulses Research Program, Crop Sciences Institute, NARC, Islamabad. It was planted in 12th July 2003 and 10th July, 2004. Recommended seed rate (25 kg ha^{-1}) was used to plant this crop in 25 cm apart rows. All other agronomic operations except those under study were kept normal and uniform for all the treatments.

Standard procedures were adopted for recording the data on various growth and yield parameters. Species wise weed population was counted at random from an area of one m^2 from each plot. The counted weeds were cut from ground surface, stored in polythene bags and then brought to laboratory for recording their biomass. The dry weight of each weed species was determined after oven-drying at 70^{o}C until constant weight was achieved. The height of ten plants was recorded at random from the ground to the apex of the plants in each plot and then average was taken. Total number of pods from the ten randomly selected plants was counted and average per plant was taken. Ten pods were taken randomly to determine the number of seeds pod^{-1}. Average number of seeds pod^{-1} was calculated. 1000-seeds were taken from each plot and were weighed. Plants in an area of 0.25 square meter was harvested, weighed, oven dried at 65°C for 24 h and dry weight was recorded in grams and then converted into kg ha^{-1}. Two samples of one square meter each were taken from centre of each plot at random. Plants were threshed manually; grain yield of each plot was recorded and converted into kilograms $hectare^{-1}$. Harvest index of mungbean was calculated as ration of grain yield to biological in %. Data collected were statistically analyzed by using the Fisher's Analysis of Variance technique and Duncan`s New Multiple Range (DNMR) test at 0.05 P was

applied to compare the differences among treatments (Steel & Torrie, 1984).

RESULTS

Weed density and dry biomass. *Trianthema monogyna, Cyperus rotundus, Sorghum halepense, Digera arvensis, Echinochloa colona* and *Cynodon dactylon* were the main weed species found in mungbean field. A significant difference between years regarding the density of *Trianthema monogyna, Cyperus rotundus, Sorghum halepense* and *Digera arvensis,* was recorded being minimum during the second year (Table I). This might be due to minimum weed seed bank and complete eradication of weeds during 2nd year. The effect of years on density of *Echinochloa colona* and *Cynodon dactylon* was found to be non-significant (Table I). It is evident from the data that maximum reduction in density of *Trianthema monogyna, Sorghum halepense, Digera arvensis, Echinochloa colona* and *Cynodon dactylon* was observed with the treatment WC_6 followed by WC_5 and WC_2, while WC_5 and WC_4 found more effective against *Cyperus rotundus* density. Comparatively less reduction in weed density was observed with WC_3. Effect of years on density of *Trianthema monogyna, Cyperus rotundus, Sorghum halepense, Digera arvensis, Echinochloa colona* and *Cynodon dactylon,* was found to be non-significant (Table II). Maximum reduction in dry biomass of *Trianthema monogyna, Sorghum halepense, Digera arvensis, Echinochloa colona* and *Cynodon dactylon* occurred with treatment WC_6 followed by WC_2 and WC_5. While *Cyperus rotundus* dry biomass reduced by WC followed by WC_6. Comparatively less reduction in weed density was observed with WC_3 (Table II).

Yield component and yield of mungbean. Data of Table III expresses that promising plant height was obtained in second year, which was a good indicator of better crop stand, because of effective weed eradication. Plant height is a function of the genetic as well as the environmental conditions (Sarwar, 1994), which contributes to biomass production of a crop. All the weed control methods significantly affected plant height of mungbean. Among different weed control methods, WC_6 that was similar to that of WC_5 caused a pronounced affect on plant height of mungbean that showed about 5% and 3%, respectively higher plant height as compared to WC_1 treatment. Similarly, WC_4 caused approximately 3% increase in plant height as compared to WC_1 treatment.

Number of pods per plant of mungbean was also variable in first and second years of study being maximum in the second year (Table III). Number of pods plant^{-1} was also significantly affected by different weed control methods in both the years of study. Weed control methods WC_6 followed by WC_5 again remained superior to rest of the treatments in both years of study. The year effect on number of seeds pod^{-1} was significantly higher in second year (Table III). This might be because of better crop stand in this year. Data also revealed that maximum number of seeds pod^{-1} of mungbean was obtained with weed control method WC_6, while rest of the treatments caused similar and significantly better effect than WC_1. Weed control method, WC_6 caused approximately 43% increase in number of grains pod^{-1} as compared to WC_1 treatment. Examination of data in (Table IV) 105 revealed significantly higher 1000-grain weight in second year. The reason might be same as discussed under previous paragraphs. Data regarding 1000-grain weight of mungbean showed that all weed control methods caused a significant effect on 1000-grain weight of mungbean in both years. Among different weed control treatments, WC_6 out yielded (32.33 g), which was about 9% higher as compared to WC_1 treatment. Although, the rest of the treatments performed less comparatively but was statistically better than that of WC_1 in both years. The perusal of Table III indicates a significant difference in plant biomass between study years being maximum during the second year. This might be due to less weed infestation during this year and healthy growth of crop. The effect of different weed control methods on biomass of mungbean is also clear from the data. All the weed control methods increased plant biomass but were significantly better than WC_1. Maximum plant biomass (4.519 tonnes ha^{-1}) was produced by WC_6. On an average, treatment WC_6 caused about 31% increase in plant biomass of mungbean as compared to weedy check treatment.

It is evident from Table III that a significant difference in grain yields of mungbean was observed between the study years, being maximum in second year. This might be due to minimum weed seed bank in the soil and complete eradication of weeds providing healthy environment for crop plants during this year. Examination of data also indicates that all weed control methods caused statistically similar affect on grain yield of mungbean in both study years. Similar trend for grain yield and plant biomass was observed being maximum grain yield of 1.480 tonnes ha^{-1} with WC_6 weed control method.

Data in Table III reveals that harvest index percentage was considerably more in the second year. This was probably, because of better yields obtained during this year. A significant effect of different weed control methods was also observed on the % harvest index of mungbean during both study years. Comparably higher value of harvest index with all weed control methods was obtained than WC_1 during both study years.

All the treatments gave higher net benefit as compared to control (Table IV). Treatments WC_6 (chemical-weeding at 2 - 3 leaf stage of weeds + hand-weeding at 50 DAS) resulted in higher net benefit (Rs. 62400 ha^{-1}). Treatment WC_3 (Mechanical Weeding at 20 DAS) had less net benefits (Rs. 59505 ha^{-1}). But in case of marginal analysis (Table V) mechanical weeding at 20 DAS (WC_3) was found better than all the treatments with maximum marginal rate of return (1988%). The treatments WC_4 (chemical-weeding at

Table I. Effect of various weed control methods on density (m^{-2}) of different weeds of mungbean

Treatments	Trianthema monogyna	Cyperus rotundus	Sorghum halepense	Digera arvensis	Echinochloa colona	Cynodon dactylon
a. Years						
Y_1	15.96a*	14.50a*	31.34a*	14.06a*	29.06NS	37.47NS
Y_2	15.00b	14.31b	30.44b	13.40b	29.76	37.56
			b. Weed Control Methods			
WC_1	63.33a*	24.17a*	150.83a*	43.00a*	31.67 a*	119.67a*
WC_2	7.00e	3.50b	14.17d	5.00c	3.83 c	22.00c
WC_3	16.33c	4.33b	33.00b	8.33b	6.50 b	30.00b
WC_4	16.00b	2.50b	27.17c	6.67bc	6.17 b	33.50b
WC_5	12.00d	2.50b	8.67e	3.50d	3.83 c	20.17c
WC_6	7.17e	2.83b	7.33e	3.50d	2.17 c	17.17d

Y_1=1st year, Y_2=2nd year, WC_1= Weedy Check, WC_2= Hand Weeding at 20 and 40 DAS, WC_3= Mechanical Weeding (Tarphali) at 20 DAS, WC_4= chemical-weeding (Methabenzthiazuron, Tribunil) at 2-3 leaf stage of weeds, WC_5= mechanical-weeding at 20 DAS + hand-weeding at 50 DAS, WC_6= chemical-weeding at 2-3 leaf stage of weeds + hand-weeding at 50 DAS

* Means not sharing a letter in common within treatments differ significantly at 5% probability level,

NS = Non significant

Table II. Effect of various weed control methods on dry biomass (g m^{-2}) of different weeds of mungbean

Treatments	Trianthema monogyna	Cyperus rotundus	Sorghum halepense	Digera arvensis	Echinochloa colona	Cynodon dactylon
a. Years						
Y_1	6.78NS	5.13NS	26.42NS	11.31NS	17.02NS	28.99NS
Y_2	6.68	5.06	25.71	10.69	16.88	27.47
			b. Weed Control Methods			
WC_1	21.20a*	8.11a*	109.98a*	33.78a*	18.96a*	65.75a*
WC_2	4.10d	1.10b	13.17c	4.44c	2.01c	14.19c
WC_3	7.68b	1.62b	29.08b	7.78b	4.43b	27.09b
WC_4	7.08b	1.05b	29.25b	6.15b	3.44b	23.54b
WC_5	5.08cd	0.97b	9.25c	3.17c	2.39c	15.94c
WC_6	3.31d	1.02b	7.81d	3.58c	1.55c	12.68c

Y_1=1st year, Y_2=2nd year, WC_1= Weedy Check, WC_2= Hand Weeding at 20 and 40 DAS, WC_3= Mechanical Weeding (Tarphali) at 20 DAS, WC_4= chemical-weeding (Methabenzthiazuron, Tribunil) at 2-3 leaf stage of weeds, WC_5= mechanical-weeding at 20 DAS + hand-weeding at 50 DAS, WC_6= chemical-weeding at 2-3 leaf stage of weeds + hand-weeding at 50 DAS

* Means not sharing a letter in common within treatments differ significantly at 5% probability level,

NS = Non significant

Table III. Effect of various weed control methods on yield and yield components of mungbean

Treatments	Plant height (cm)	No. of pods (Plant^{-1})	No. of seeds (pod^{-1})	1000-grain wt. (g)	Plant biomass (tonnes ha^{-1})	Grain yield (tonnes ha^{-1})	Harvest Index (%)
a. Years							
Y_1	73.94b*	40.72b*	10.06b*	30.89b*	4.072b*	1.303b*	31.91b*
Y_2	74.50a	40.78a	10.28a	31.00a	4.205a	1.353a	32.05a
				b. Weed Control Methods			
WC_1	72.50c*	36.17d*	8.17c*	29.67d*	3.445c*	0.991c*	28.76b*
WC_2	73.50bc	39.67c	10.50b	31.17b	4.089b	1.333b (34.6)[2]	32.60a
WC_3	73.67bc	39.33c	10.17b	30.33cd	4.120b	1.339b (35.3)	32.50a
WC_4	74.67b	40.33c	10.00b	31.00bc	4.278ab	1.393ab (40.7)	32.57a
WC_5	74.83ab	42.83b	10.50b	31.17b	4.378ab	1.435ab (44.9)	32.72a
WC_6	76.17a	46.17a	11.67a	32.33a	4.519a	1.480a (49.5)	32.75a

Y_1=1st year, Y_2=2nd year, WC_1= Weedy Check, WC_2= Hand Weeding at 20 and 40 DAS, WC_3= Mechanical Weeding (Tarphali) at 20 DAS, WC_4= chemical-weeding (Methabenzthiazuron, Tribunil) at 2-3 leaf stage of weeds, WC_5= mechanical-weeding at 20 DAS + hand-weeding at 50 DAS, WC_6= chemical-weeding at 2-3 leaf stage of weeds + hand-weeding at 50 DAS

* Means not sharing a letter in common within treatments differ significantly at 5% probability level,

NS = Non significant

[2]% increase compared with control

2 - 3 leaf stage of weeds) and WC_2 (hand-weeding at 20 & 40 DAS) was dominated due to less net benefit and higher cost that varied, so it was un-economical treatment at the prevailing crop and herbicide prices. On the basis of this study it is suggested that chemical-weeding at 2 - 3 leaf stage of weeds + hand-weeding at 50 DAS or Mechanical Weeding at 20 DAS may be used for controlling weeds in wheat with fairly good economic returns.

DISCUSSION

Chemical-weeding combined with hand-weeding was suggested (Aulakh, 2004) to inhibit weeds growth more than their sole use. This is also true in case of present studies, because application of tribunal + hand-weeding checked weed growth more than hand-weeding and chemical-weeding alone. Combination of these weed

Table IV. Economic analysis of various weed control treatments in mungbean

	WC_1	WC_2	WC_3	WC_4	WC_5	WC_6	Remarks
Total mungbaen grain yield for two Year	1982.0	2666.0	2678.0	2786.0	2870.0	2960.0	kg ha^{-1}
10% less (than actual yield)	198.2	266.6	267.8	278.6	287.0	296.0	kg ha^{-1} (to bring it at farmer level)
Adjusted yield	1783.8	2399.4	2410.2	2507.4	2583.0	2664.0	kg ha^{-1}
Gross income (ha^{-1})	44595.0	59985.0	60255.0	62685.0	64575.0	66600.0	Mungbaen grain Price @ 2500/kg
Hand Weeding	0.0	3000.0	0.0	0.0	1500.0	1500.0	Rs.100/man (one man /day/ha).
Mechanical weeding	0.0	0.0	750.0	0.0	750.0	0.0	Rs. 750 ha^{-1}
Cost of herbicide	0.0	0.0	0.0	2400.0	0.0	2400.0	Tribunil Rs.1200/ha. Expenses for two years
Spray application cost	0.0	0.0	0.0	200.0	0.0	200.0	Rs.100 man^{-1} (one man /day/ha)
Spray rent	0.0	0.0	0.0	100.0	0.0	100.0	Rs.50 $spray^{-1}$
Cost that vary	0.0	3000.0	750.0	2700.0	2250.0	4200.0	Rs. ha^{-1}
Net benefit	44595.0	56985.0	59505.0	59985.0	62325.0	62400.0	Rs. ha^{-1}

WC_1= Weedy Check, WC_2= Hand Weeding at 20 and 40 DAS, WC_3= Mechanical Weeding (Tarphali) at 20 DAS, WC_4= Chemical Weeding at 2-3 leaf stage of weeds, WC_5= Mechanical Weeding at 20 DAS + Hand Weeding at 50 DAS, WC_6= Chemical Weeding at 2-3 leaf stage of weeds + Hand Weeding at 50 DAS

Table V. Marginal rates for various weed control treatments in mungbean

Treatments	Total cost that vary[1] (Rs. ha^{-1})	Net benefits[2] (Rs. ha^{-1})	Marginal rate of return[3] (%)
WC_1 (Weedy Check)	0.0	44595.0	
WC_3 (Mechanical Weeding at 20 DAS)	750.0	59505.0	1988.0
WC_5 (Mechanical Weeding at 20 DAS + Hand Weeding at 50 DAS)	2250.0	62325.0	188.0
WC_4 (Chemical Weeding at 2-3 leaf stage of weeds)	2700.0	59985.0	D
WC_2 (Hand Weeding at 20 and 40 DAS)	3000.0	56985.0	D
WC_6 (Chemical Weeding at 2-3 leaf stage of weeds + Hand Weeding at 50 DAS)	4200.0	62400.0	6.3

[1]The sum of all the costs that vary for a particular treatment,
[2]The difference between total costs that vary and the gross benefit for each treatment,
[3]The ratio of marginal net benefits and marginal costs expressed as percentage,
[4]Dominated treatment, the treatment which have higher costs but lower net benefits

control methods decreased more weed biomass suggesting that integrating the weed control strategies enhanced their weed inhibitory capability. The improvement in grain yield under different weed control methods may be attributed to more weed growth reduction, which favoured number of pods $plant^{-1}$, seeds per pod and 1000 grain weight.

A significant difference between years regarding yield and yield component of mungbean was recorded being maximum during the second year. Possibly less weed bank and less competition of mungbean crop for growth resources due to more reduction of weeds during second year may be the possible reason for this improvement of these yield and yield component. These treatments showed about 28% and 18%, respectively more number of pods as compared to weedy check. This might be due to adequate weed control during the cropping period, which provided maximum moisture and nutrients for healthy plant growth and hence pod formation. Similar results have also been discussed by Nawaz *et al.* (1990) and Khan *et al.* (1991a & b). Comparatively less effect of other weed control methods seems due to incomplete weed control that resulted ultimately poor crop stand and less number of pods $plant^{-1}$ in both years of study.

It was quite interesting that combined effects of various weed control strategies were more inhibitory than their sole applications. This supported the concept of combining weed control strategies. This also indicates that weeding at proper time definitely enhances crop yields. These results are supported by the previous findings of Rana and Pal (1997), who found that crops grown with proper weeding could produce higher yields. Similar findings have also been reported by Mathew and Sreenivasan (1998).

On the basis of these results it is concluded that maximum reduction in density and biomass of the weeds was observed by chemical-weeding at 2 - 3 leaf stage of weeds + hand-weeding at 50 DAS (WC_6). There was a significant increase (50%) in grain yield of mungbean in the same treatment. Similarly, this treatment (WC_6) out yielded other treatments in terms of number of pods per plant, number of seeds per pod, 1000 grain weight, grain yield and net benefits.

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