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EFFECTS OF HERBICIDES ON WEED SUPPRESSION AND RICE YIELD IN TRANSPLANTED WETLAND RICE

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ABSTRACT

Eight herbicides, i.e. oxadiazone, butachlor, pretilachlor and anilphos from pre-, and MCPA, ethoxysulfuran, pyrazosulfuran Ethyl and oxadiarzil from post-emergence category were applied at recommended rates in transplanted wetland rice during aman (autumn), aus (summer) and boro (winter) growing seasons at Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh (BSMRAU) during 2007-08 to study their effects on weed control and rice yield. Results revealed variations in the performance of herbicides in different seasons. Pre-emergence herbicides performed better regarding weed control efficiency and rice yield. Based on the initial performance, butachlor and MCPA were further applied at concentrations ranging from 50% to 150% of the recommended rates in transplanted aus rice in 2009. Data indicated that butachlor provided better weed control efficiency and contributed to better crop growth and grain yield compared to MCPA irrespective of concentration. It might be due to that pre-emergence application of Butachlor provided effective early season weed control, which MCPA could not since apply as post-emergence. The highest grain yield of 4.18 t ha^{-1} was contributed by weed free treatment, while the least (2.44 t ha^{-1}) was by weedy check. Among the herbicide treatments, the highest grain yield of 4.08 t ha^{-1} was obtained from butachlor, while the lowest (2.83 t ha^{-1}) grain production was harvested in the plots receiving MCPA @ 125% of the recommended rate. Results further revealed a positive relationship between butachlor rate and grain yield, although a declining trend was apparent at higher than the recommended rates, while a negative relationship was found in MCPA treatments.

Key words: Pre-emergence herbicides, post-emergence herbicides, *Oryza sativa*, chemical control.

INTRODUCTION

In rice cultivation a considerable portion of production cost is involved in weed control. Hand weeding and other traditional control

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methods are time consuming and involve high labour cost. In Bangladesh, severe weed infestation reduces the grain yield by 70-80% in Aus rice (early summer), 30-40% for transplanted Aman rice (Late summer) and 22-36% for modern boro rice (winter rice) cultivation (Mamun, 1990). According to Willocquet *et al*., (1998), the losses due to infestation of weeds are greater than the combined losses caused by insect, pest and diseases in rice. Mamun, *et al.* (1993) reported that weed growth reduced the grain yield by 68-100% for direct seeded *aus* rice, 22-36% for modern *boro* rice and 16-48% for transplanted *aman* rice. This loss is, therefore, a serious threat for the food deficit countries like Bangladesh and necessitates proper weed management for rice production. Herbicidal weed control methods offer an advantage to save labour and money, as a result, regarded as cost effective (Ahmed *et al.*, 2000). Chemical weed control has become popular in Bangladesh mainly due to scarcity of labour during peak growing season, and lower weeding cost. In Bangladesh the annual consumption of herbicides grew over 4000 metric tons in 2008 (BCPA, 2010) compared to only 108 tons during 1986-87 (BBS, 1991), and the growth is almost exponential. Although, herbicide use was confined in tea cultivation at early stages, it is now being overwhelmingly used in rice cultivation as well. Oxadiazone, pretilachlor, butachlor, ethoxysulfuran, pyrazosulfuran ethyl, oxadiarzil, anilphos, 2,4-D, etc. are the commonly used herbicides in rice cultivation in Bangladesh.

In modern, intensive and complex crop production practices application of fertilizers, insecticides, herbicides and fungicides are common. The so-called “Green Revolution” during the 1960s facilitated the use of agro-chemicals, particularly chemical fertilizers and insecticides in the country. Indiscriminate use of Herbicide has resulted in the devopment of weed resistance and environmental degradation. So, herbicides may also become a burden if appropriate measures are not taken at early stages regarding safe use of safe herbicides for sustaining farm productivity as well as protecting environment (Singh *et al.,* 2005). Therefore, the present study was undertaken to fulfill the following objectives:

(a) to see the performance of selected herbicides used at recommended rates on weed suppression and yield performance of transplanted wetland rice
(b) to see the effects of herbicides at variable rates on weed suppression as well as growth and yield of transplanted wetland rice, and
(c) to determine the effects of herbicides on soil organic matter content and soil biomass carbon content.

MATERIALS AND METHODS

Experiment-1. Comparative performance of herbicides on weed suppression and yield of transplanted wetland rice.

Eight commonly available herbicides, of which four were from pre-emergence and the rest from the post-emergence category were collected from the local markets. All herbicides were applied at recommended rates in transplanted wetland rice during three consecutive growing seasons under wetland condition. Besides, one control (weedy check) treatment, one weed free treatment and one manual weeding at 25, 35 and 45 days after transplanting (DAT) were also included. The experiment was conducted in the experimental farm of the BSMRAU during 2007 and 2008 in RCB design with 3 replications. Transplanted *Aman* (cv. BR39), *Boro* (cv. BR28) and *Aus* (cv. BR26) rice were used as test crop. The treatments were applied as follows:

Treatments:

T1: Oxadiazone @ 2000 ml ha^{-1} (pre-emergence at 7 DAT).
T2: Butachlor @ 1875 ml ha^{-1} (pre-emergence at 7 DAT).
T3: Pretilachlor @ 1000 ml/ha (applied pre-emergence at 7 DAT).
T4: Anilphos @ 1300 ml ha^{-1} (pre-emergence at 7 DAT).
T5: MCPA @ 1000 ml ha^{-1} (post-emergence at 25 DAT).
T6: Ethoxysulfuran @ 100 g ha^{-1} (post-emergence at 20 DAT).
T7: Pyrazosulfuran Ethyl @ 150 g ha^{-1} (post-emergence at 20 DAT).
T8: Oxadiarzil @ 1875 ml ha^{-1} (post-emergence at 20 DAT).
T9: Manual weeding at 20, 35 and 50 DAT (standard for MV rice).
T10: Weed free (weeded at 7 days interval after transplanting upto flowering).
T11: Unweeded (control)

Parameters studied:

Weed biomass, weed control efficiency (WCE); grain yield and straw yield.

Experiment-2. Effects of herbicides application rates on the performance of transplanted *aus* rice.

Based on performance of the herbicides in terms of weed control efficiency as well as rice grain yield under experiment-1 two better performing herbicides were further tested at variable rates in *aus* rice (cv. BR26) in 2009 at the same location in the split-plot design in RCBD with 3 replications. The herbicides butachlor and MCPA were in the mainplots while the herbicide rates *viz.* 50, 75, 100, 125 and 150% of the recommended rates, were assigned to the sub-plots. Weed free and weedy check were also included in the trial.

Parameters studied:

Weed control efficiency (WCE); plant height, tiller dynamics, phenology, yield components, soil organic matter content, soil biomass carbon content.

Crop Management Practices:

Standard management practices for MV rice were followed in both the experiments.

Weed control efficiency (WCE):

WCE was calculated by using the following formula:

$$WCE = \frac{DMC - DMT}{DMC} \times 100$$

Where, DMC = Weed dry matter in unweeded treatment and DMT = Weed dry matter in weed control treatment. The data recoded for the individual traits was subjected to the ANOVA technique and the significant means were separated by LSD test (Steel *et al.*, 1997).

RESULTS AND DISCUSSION

Experiment-1. Comparative performance of herbicides on weed suppression and yield of transplanted wetland rice.

Weed Control Efficiency

In general, pre-emergence herbicides performed better than the post-emergence herbicides which were exhibited by lower weed biomass as well as higher weed control efficiency in all the growing seasons (Table-1). However, variations existed within treatments. Among the pre-emergence herbicides, the highest WCE was observed in pretilachlor treatments in both *aman* and *aus* season being followed by butachlor. Butachlor, however, showed the highest WCE among the herbicide treatments in *boro* rice. On the other hand, anilphos could not show its worth in WCE except in Aus 2008 season. Manual weeding was found comparable to herbicide treatments, in all the growing seasons. Among the post-emergence herbicides, only MCPA contributed to higher WCE, particularly during *boro* and *aus* season. Data indicated seasonal variations in the efficacy levels of applied herbicides. One of the causes behind lower weed control efficiency during *aman* growing season might be due to interruption by heavy rainfall which might cause dilution as well as leaching and/or seepage loss of herbicides from the treated plots. These inferences are supported with the work of Panwar *et al.* (1992) who obtained varying level of weed control with the use of different herbcides.

Table-1. Weed control efficiency by selected herbicides in transplanted rice at harvest.

Treatment	Aman 2007		Boro 2007		Aus 2008	
	Weed biomass (g m^{-2})	WCE (%)	Weed biomass (g m^{-2})	WCE (%)	Weed biomass (g m^{-2})	WCE (%)
Oxadiazone @2000 ml ha^{-1}	88.44	67.72	177.20	30.49	27.07	84.19
Butachlor @1875 ml ha^{-1}	31.80	88.39	25.73	89.91	21.47	87.46
Pretilachlor @ 1000 ml/ha	20.08	92.67	35.07	86.24	10.40	93.93
Anilphos 1300 ml ha^{-1}	169.40	38.18	210.67	17.37	37.73	77.96
MCPA @ 1000 ml ha^{-1}	135.52	50.54	82.13	67.78	20.53	88.01
Ethoxysulfuran 100 g ha^{-1}	172.00	37.22	259.60	-1.83	22.80	86.68
Pyrazosulfuran Ethyl @ 150 g ha^{-1}	264.68	3.40	224.27	12.02	44.13	74.22
Oxadiarzil @1875 ml ha^{-1}	203.40	25.77	229.33	10.04	189.87	-10.91
Manual weeding	35.12	87.18	17.33	93.20	21.07	87.69
Weed- free	4.05	98.52	3.61	98.58	0.00	100.00
Weedy check	274.00	-	254.93	-	171.20	-

T7: Pyrazosulfuran Ethyl @ 150 g ha^{-1} (post-emergence at 20 DAT).
T8: Oxadiarzil @ 1875 ml ha^{-1}

Rice yield

Herbicide treatments contributed to higher yield performance compared to control in all the growing seasons except Oxadiarzil, which could not show considerable yield increase over control during the growing seasons (Table-2). Even though it was found inferior to unweeded treatment during *aus* 2008 season. Among the herbicide categories, pre-emergence herbicides performed better than post-emergence ones, particularly during *boro* and *aus* growing seasons. Among the pre-emergence herbicides, the highest yield was contributed by butachlor treated plots in *aman* and *aus* growing seasons, although oxadiazone superseded butachlor in *boro* growing season. Among the post-emergence types, the highest yield was obtained from MCPA treated plots in all of the three growing seasons (Table-2). The previous work of Ali *et al.* (2010) also agrees with our findings who also obtained increased yield with the use of different hebicides.

Table-2. Performance of herbicides in terms of rice grain yield in three growing seasons.

Treatment	Aman 2007		Boro 2007		Aus 2008	
	Yield (t ha^{-1})	Yield increase over control (%)	Yield (t ha^{-1})	Yield increase over control (%)	Yield (t ha^{-1})	Yield increase over control (%)
Oxadiazone	3.68	30.96	4.01	157.05	4.43	71.04
Butachlor	3.94	40.21	3.68	135.90	4.68	80.69
Pretilachlor	3.76	33.81	3.52	125.64	4.07	57.14
Anilphos	3.93	39.86	2.35	50.64	4.37	68.73
MCPA	4.05	44.13	2.92	87.18	4.13	59.45
Ethoxysulfuran	3.86	37.37	2.23	42.95	3.70	42.86
Pyrazosulfuran Ethyl	3.72	32.38	2.34	50.00	3.89	50.19
Oxadiarzil	3.80	35.23	1.79	14.74	1.73	-33.20
Manual weeding	3.75	33.45	3.54	126.92	3.99	54.05
Weed free	3.47	23.49	3.57	128.85	4.02	55.21
Control	2.81		1.56		2.59	
$LSD_{0.05}$	NS*		0.8133		1.293	
CV (%)	9.82		16.51		19.64	

* N.S= Non-significant ($p>0.05$ in F-test)

Experiment-2. Effects of herbicides rates of application on the performance of transplanted *aus* rice.

Weed control efficiency

On the basis of WCE as well as grain yield performance in the first experiment butachlor (pre-emergence) and MCPA (post-emergence) were further tested at variable rates in the next aus growing season. Data on weed biomass counted at different time intervals showed that weed infestation was comparatively lower in butachlor treated plots (T1-T5) compared to MCPA treated plots (T6-T10). MCPA being weaker; its treated plots possessed higher weed biomass even higher than the weedy check treatment (Fig. 1). The highest weed biomass was recorded at 75 DAT where MCPA was applied @ 50% of the recommended dose whereas the least was noticed in butachlor treated plot at recommended dose. Consequently, WCE was lower in the MCPA treated plots as compared to butachlor treatments (Fig. 2). The lower weed count in butachlor is due to its higher efficacy to control weeds in rice. Whereas MCPA is a broadleaf killer and it only picked broadleaf weeds, while the grasses escaped its control, hence its overall effect was lesser as compared to butachlor.

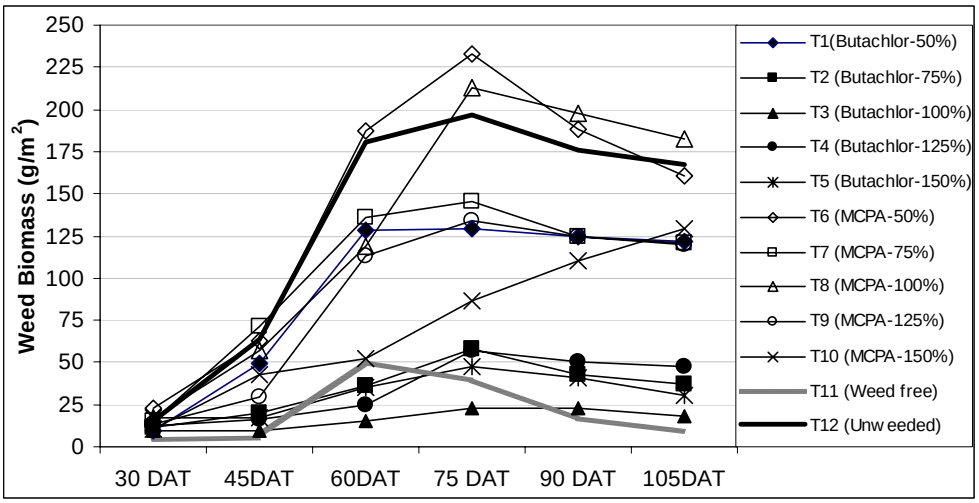

Fig. 1. Weed biomass in transplanted aus rice as affected by concentration of herbicides.

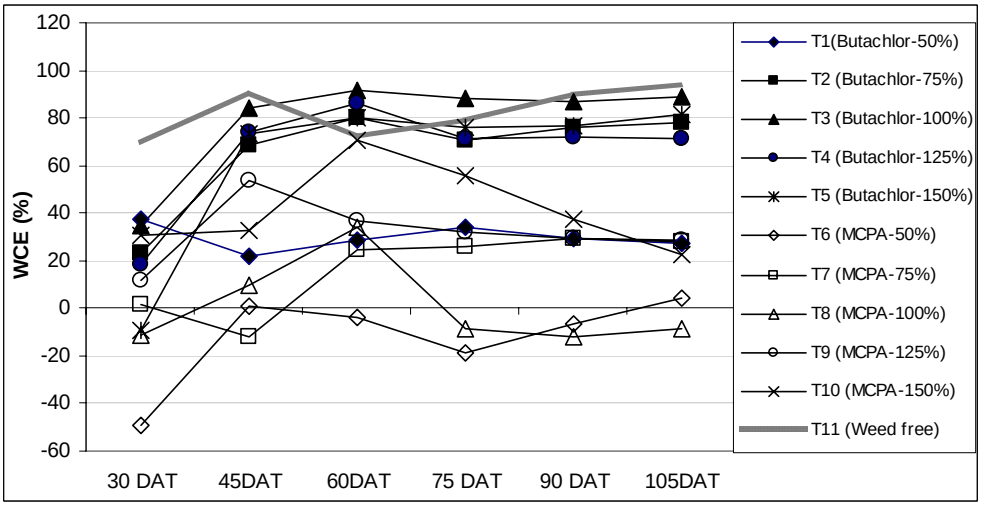

Fig. 2. Weed control efficiency (WCE) of herbicides as affected by concentration.

Performance of rice

Plant Height

Results on plant height as affected by herbicide rates has been shown in Fig. 3. Data indicated that butachlor (T1-T5) application

irrespective of rates contributed to taller plants as compared to MCPA treated plots (T6-T10). Plant height increased in butachlor treated plots even better than in weed free plots. It might be due to the fact that butachlor treatment at early crop growth stages suppressed weed population effectively which resulted in higher vigour and growth of rice plants.

Tillers Dynamics

Data on tiller production over time indicated that tiller number increased up to 75 DAT in herbicide treated plots compared to weed free plots where tiller increase continued up to 90 DAT (Fig. 4). Among the tested herbicides butachlor application contributed to higher number of tillers per unit area compared to MCPA treatment as a whole. Among the butachlor treatments, its application @ 125% of the recommended rate contributed to the highest number of tillers at 75 DAT, however, next to weed free treatment.

Phenology

First flowering was noticed to be induced slightly earlier in MCPA treated plots (T6-T10) as compared to butachlor treated plots (T1-T5) as evident in Table-3. Similar trend was noticed in case of days to 50% flowering. However, the difference was not considerable with weed free as well as unweeded treatments. Maturity, however, came slightly earlier in butachlor treated plots compared to MCPA treated ones. However, the differences among the treatments were non-significant.

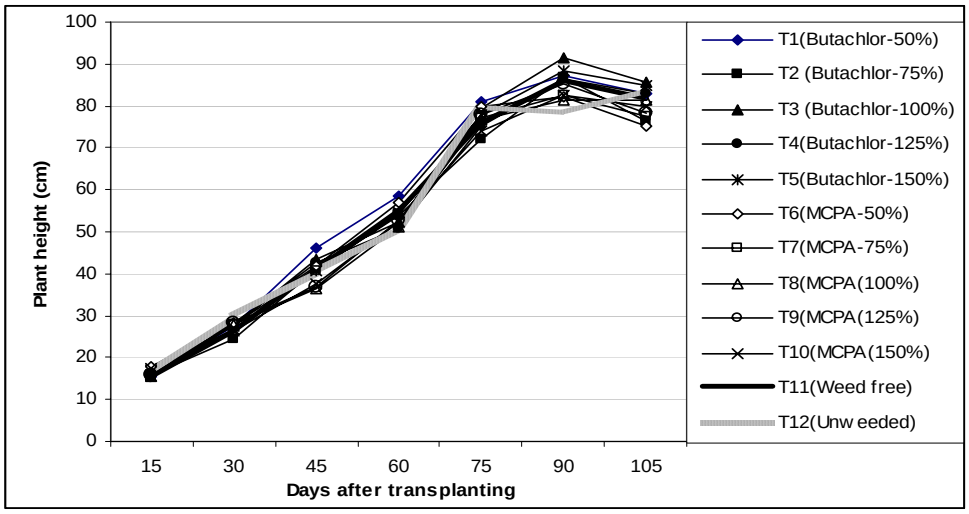

Fig. 3. Plant height as affected by concentrations of butachlor and MCPA.

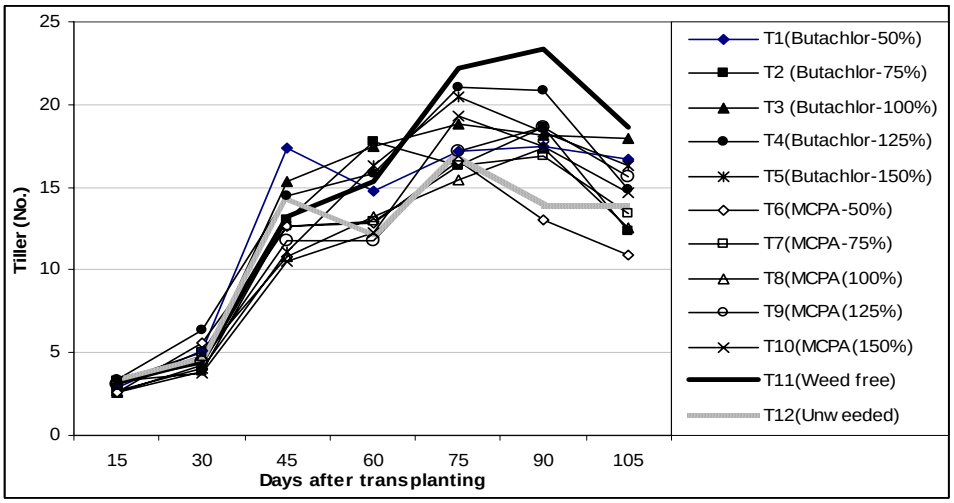

Fig. 4. Tiller development as affected by different concentrations of butachlor and MCPA.

Table-3. Phenological events in transplanted *aus* rice as affected by different concentrations of butachlor and MCPA.

Treatment	Days				
	1st flowering	50% flowering	Difference between 1st & 50% flowering	Maturity	Difference between 1st flowering & maturity
Butachlor (50%)	69.33	74.33	5.00	108.00	38.67
Butachlor (75%)	70.33	75.67	5.33	109.67	39.33
Butachlor (100%)	69.33	74.00	4.67	108.33	39.00
Butachlor (125%)	70.33	75.67	5.33	109.33	39.00
Butachlor (150%)	70.67	75.33	4.67	109.33	38.67
MCPA (50%)	68.00	72.33	4.33	107.67	39.67
MCPA (75%)	68.00	73.00	5.00	108.33	40.33
MCPA (100%)	68.67	73.33	4.67	108.67	40.00
MCPA (125%)	68.33	73.00	4.67	108.33	40.00
MCPA (150%)	69.00	75.00	6.00	110.00	41.00
Weed free	69.33	74.33	5.00	109.00	39.67
Control	68.00	73.00	5.00	109.00	41.00

Rice Yield

Data on grain yield revealed that butachlor application contributed better than MCPA (Table-4). The highest grain yield of 4.18 t ha^{-1} was harvested in the weed free treatment, being followed by 4.08 t ha^{-1} in T2 treatment where butachlor was applied at recommended rate. Among the MCPA treatments, the highest grain yield of 3.76 t ha^{-1} was contributed by MCPA @ 75% of the recommended rate. MCPA treatments contributed to higher grain yields over control plots, however, much lower than the weed free plots. The present findings are corroborated with the previous work of Tapader (2003), Panwar *et al.* (1992), Mondol *et al.* (1995) and *Singh et al.* (2005).

Data indicated that butachlor treated plots contributed to yield increase ranging from 16.39% to 67.21% with an average value of 50.40% over the weedy check, while the respective increase in yield for MCPA was only 31.56% (Table-4). Data further revealed inclining trends in yield increase with the increase in butachlor rate, although yield was in declining trend when concentration crossed the recommended dose (Fig. 5). In case of treatments receiving MCPA a declining trend was also noticed. Pacanoski and Glatkova (2009) found significant increase in rice grain yield with the use of Mefenacet+ bensulfuron methyl in comparison with untreated control. These findings are further supported with the work of Bhuiyan and Ahmad (2010), who also realized better yields in rice with the mixture of Mefanacet and bensulfuron.

From data presented it might reasonably be argued that pre-emergence herbicides offered early season weed control up to the period of full canopy cover by rice plants, which might also contributed to higher grain yield. Application of MCPA at 25 DAT (as recommended) could not bring the desired benefits as weeds grew luxuriantly and. competed with the crop for resources like nutrients, solar radiation, water and space.

Results so far indicated that herbicide application offered higher weed control efficiency as well as higher rice yield as observed in different growing seasons as well as different situations. However, since herbicide application has been increasing rapidly in the country, impacts of repeated as well as longer term application of herbicides in wetland rice on soil health parameters raise concern as well as deserve attention for further research before reaching any precise conclusion.

Table-4. Yield and yield contributing characters as affected by varying rates of butachlor and MCPA .

Treatment	Filled grains panicle^{-1}	Unfilled grains panicle^{-1}	Grain yield (t ha^{-1})	Yield increase over control (%)	Average yield under herbicide treatments	Yield increase over control (%)
Butachlor (50%)	59.73	7.70	2.84	16.39	3.67	50.40
Butachlor (75%)	61.43	13.90	3.79	55.33		
Butachlor (100%)	72.21	7.30	4.08	67.21		
Butachlor (125%)	62.00	10.93	3.79	55.33		
Butachlor (150%)	61.30	5.83	3.83	56.97		
MCPA (50%)	61.13	5.57	3.60	47.54	3.21	31.56
MCPA (75%)	69.53	5.84	3.76	54.09		
MCPA (100%)	63.83	10.57	2.96	21.31		
MCPA (125%)	55.73	15.40	2.83	15.98		
MCPA (150%)	58.43	20.44	2.91	19.26		
Weed free	72.17	6.43	4.18	71.31		
Weedy check Control	59.07	23.50	2.44	-		
$LSD_{0.05}$	13.32	NS	0.8295			
CV (%)	11.7		14.9			

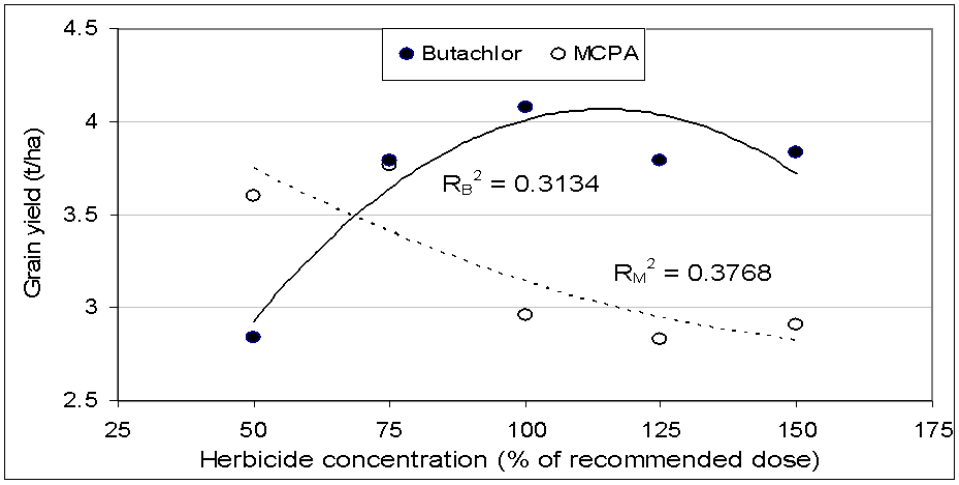

Fig. 5. Relationship between butachlor and MCPA concentrations and rice grain yield.

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