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Effect of different herbicides on weed and crop performance in transplanted basmati rice (*Oryza sativa* L.)

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Abstract
Weeds are the cause of serious concern on yield reduction in rice production worldwide, depending on the predominant weed flora and on the control methods practiced by farmers. Keeping view in mind a field trial was conducted during kharif season 2021 on sandy loam soil to study weed and crop performance as influenced by different herbicides in transplanted basmati rice at research station Galgotias University Greater Noida, Uttar Pradesh. The experiment was conducted in R.B.D with three replications comprising 10 treatments of weed management. The results indicated that chemical methods of weed control reduced the \ weed population and weed dry weight, while increased weed control efficiency over weedy check. The highest number of tillers at harvest, filled grains panicle-1, unfilled grains panicle-1, grain yield, biological yield and harvest index were recorded with the application of Pretilachlor @ 750 g a.i./ha, which showed its superiority over rest of the herbicides in puddled and unpuddled conditions. The nitrogen, phosphorous and potassium content and uptake in grain and straw by rice crop was also highest under Pretilachlor @ 750 g a.i./ha in puddled and unpuddled conditions. Besides it had highest net return and B: C ratio was obtained under the treatment receiving Pretilachlor @ 750 g a.i./ha in puddled and unpuddled conditions, respectively. Thus, application of Pretilachlor @ 750 g a.i./ha proved better to obtained higher yield and also fetches more profit, besides suppressing weed in transplanted basmati rice.

Keywords: Basmati, performance, herbicides, profitability, weed dynamics and yield

Introduction

The word Basmati is derived from two Sanskrit words (Vas- aroma, Mati-present from beginning). Generally, pronounced as Vasmati but now Basmati. The main varieties of basmati rice as notified under Seed Act 1966 are Basmati 386, Basmati 370, Basmati 217, Pusa Basmati 1, Pusa Basmati 1121 and Punjab Mehak. The world's total production of basmati rice is 70% in India and the rest of it is produced in Pakistan. In India, Punjab, Haryana, U. P., Uttarakhand and J & K are major states of basmati production. Now, Madhya Pradesh, Telangana and Andhra Pradesh states have also started cultivation of basmati. The area under cultivation and production in India was 27 lakh hectares and 81 lakh tonnes, respectively (Kumar *et al.*, 2012) [11]. Scented rice (*Oryza sativa* L.) cultivation is emerging as a new economic pursuit for the paddy growers in some localities of Uttar Pradesh. Being a relatively recent introduction into Western Uttar Pradesh, adequate information on the population and weed management aspects of this crop are not locally available. Furthermore, weed competition is severe under scented rice because of early slow growth rates (Chander and Pandey, 2001) [3]. Unlike other cereals crops, rice suffers more from weed competition. The degree of competition and extend of yield loss very with rice culture. It is maximum in direct seeded rice while minimum in transplanted rice. On an average 15 to 20 percent yield is reduced due to weeds in transplanted rice while 30 to 35 percent in direct seeded rice under puddled condition. India's rice demand is estimated to rise to 122 million tons in 2020, which is equivalent to an overall increase of 22% in the next 10 years. Moreover, an idea of the dimensions of the problem about 10 million tonnes (Mt) of rice are lost annually due to weed competition; such a quantity of rice is sufficient to feed at least 56 million people for 1 year. Weeds are the major biotic stress in rice production and account for 30 to 40 percent of yield losses (Abeysekera, 2001) [1].

Although, many pre-emergence herbicides are available for controlling weeds in transplanted rice, but for efficacy of pre-emergence herbicides, there is need for continuous stagnation of water in the field. Hence, here is need for post-emergence herbicides to destroy weeds emerged during later stages of crop growth.

Hence, here is a need for high efficacy herbicides and sequential application of herbicide to control weeds in transplanted basmati rice (Gnanavel and Anbhazhagan, 2010) [7].

In order to formulate an effective schedule for controlling the weeds in rice crop an understanding of nature and magnitude of competition and their effect on various factors of crop growth becomes an essential pre-requisite. Characterization of critical period of crop weed competition (the period during which the crop is subjected to greatest stress for factors of its growth) is therefore necessary. As already discussed for control of weeds the age-old practices are time consuming and costly. So the only alternative left with us to control weeds is the chemical weed control. The effectiveness of herbicides depends upon the water management of rice fields. Standing water in transplanted rice fields helps to suppress germination and growth of weeds. Therefore, the present study was carried out to investigate performance and profitability as influenced by different herbicides in transplanted basmati rice vis-à-vis sustainability of Basmati rice (Malik *et al.*, 2011) [12].

Materials and Methods

A field experiment was conducted during *kharif* 2021 at research station Galgotias University Greater Noida, Uttar Pradesh with an elevation of 237 meters above mean sea level. The mean maximum and minimum temperatures of 41^0 to 45^0 and 4.2^0c were recorded in the month of June and January, respectively. The mean annual rainfall during crop period was 815 mm (75-80% of which is received during July to September) and average relative humility varied in between 69 to 83% throughout the year. The experimental field was well drained, sandy loam in texture (46.3% sand, 18.3% silt and 17.4% clay, Bouyoucos hydrometer method) and slightly alkaline in reaction (pH 7.7, Glass electrode pH meter). It was medium in organic carbon (0.48%), available nitrogen (200.6 kg/ha) and available phosphorus (16.0 kg/ha) but high in available potassium (230.0 kg/ha) with an electrical conductivity (1:2, soil: water suspension) and a bulk density of 1.62 dS/m and 1.44 Mg/m^3, respectively. All the physic-chemical properties were analyzed as per the slandered procedures given by Jackson, 1973.

The experiment was laid out in randomized block design under thrice replication. The ten treatments of weed management in the study included (weedy in puddled condition, weed free in puddled condition, Pretilachlor @ 750 g a.i. /ha in puddled condition, Oxyfluorfen @ 200 g a.i./ha in puddled condition, Pyrazosulfuron @ 20 g a.i./ha in puddled condition, weedy in unpuddled condition, weed free in unpuddled condition, Pretilachlor @ 750 g a.i. /ha in unpuddled condition, Oxyfluorfen @ 200 g a.i./ha in unpuddled condition and Pyrazosulfuron @ 20 g a.i./ha in unpuddled condition. A uniform dose of 50 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha as basal through urea, single super phosphate and muriate of potash, respectively and rest of the 50 kg N/ha was top dressed at maximum tillering and panicle initiation in two equal splits through urea. Zinc sulphate was applied at 30 days stage through foliar spray @ 0.5 percent solution with two percent urea. Transplanting was done manually as per treatments using two seedlings $plant^{-1}$. One week after transplanting, gap filling was done from the seedlings of same nursery for maintaining the optimum plant population on 5th July 2021. Uniform irrigation was applied to ensure proper crop establishment. The crop was grown as per recommended package of practices and harvested on 07th November 2021. Observations on the total weed population (m^{-2}) and weed dry weight (gm^{-1}) at 30 DAT and at harvest, number of tillers (m^{-2}) at harvest, filled grains $panicle^{-1}$, unfilled grains $panicle^{-1}$, grain yield (q/ha), biological yield (q/ha) and harvest index (%). The yield was estimated by the produce obtained from net plot area, treatment wise and finally expressed at 14% moisture. Analysis of plant sample at harvest was carried out for their nitrogen, phosphorus and potassium content and uptake in grain and straw by adopting the standard procedures as described by Jackson (1973). The data obtained were subjected to statistical analysis as outlined by Gomez and Gomez (1984). The treatment differences were tested by using "F" test and critical differences (at 5 per cent probability).

Results and Discussion

Effect on weed

Perusal of data revealed that the different chemicals (Pretilachlor @ 750 g a.i./ha, Oxyflorfen @ 200 g a.i./ha and Pyrazosulfuron @ 20 g a.i./ha) control the total weed population and weed dry weight effectively as compared to unweeded check in both condition puddled and unpuddled but puddled condition has better control performance than unpuddled condition (Table-1). Significantly the lowest total weed population and weed dry weight recorded under weed free treatment because weed free treatment was kept free of weeds by hand weeding. Highest total weed population and weed dry weight were recorded in unweeded check plots due to unchecked growth of weeds which compete for all the resources upto maturity with crop. Pretilachlor @ 750 g a.i./ha proved to be the best treatment among the herbicides. Similar finding was also reported by Malik *et al.* 2011 [12]. Among the herbicides the highest weed control efficiency was found with the application of Pretilachlor @ 750 g a.i./ha followed by Oxyflorfen @ 200 g a.i./ha in puddled condition. Simillar trend was also recorded in unpuddled conditions, while in weed free plots it was 100% in both conditions. Similar observations were also recorded by Chopra and Chopra (2003) and Singh *et al.* (2004).

Table 1: Weeds and weed control efficiency as influenced by various treatments

Treatments	Total weeds (m^{-2})		Dry weight of weed (gm^{-2})		WCE (%)
	30 DAT	At harvest	30 DAT	At harvest	
Weedy in puddled condition	15.88(252.17)	14.89(221.33)	7.24(51.96)	13.06(170.10)	0.00
Weed free puddled conditions	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)	100.00
Pretilachlor @ 750 g ai /ha in puddled	7.00(49.00)	6.23(38.33)	3.46(11.36)	5.84(33.60)	80.24
Oxyfluorfen @ 200 g ai/ha in puddled	6.76(45.33)	7.15(50.66)	4.11(16.33)	7.01(48.66)	71.39
Pyrazosulfuron @ 20 gai/ha in puddled	7.47(55.33)	7.73(59.33)	4.48(19.66)	8.00(64.00)	63.08
Weedy in unpuddled condition	16.27(264.00)	16.48(271.33)	8.00(64.10)	13.42(175.62)	0.00
Weedy free in unpuddled condition	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)	100.00
Pretilachlor @ 750 g ai/hain unpuddled	6.38(40.33)	6.75(45.33)	3.75(13.50)	6.39(40.20)	77.07

Oxyfluorfen @ 200 g ai/ha in unpuddled	7.32(52.33)	7.62(57.66)	4.33(18.12)	7.71(58.68)	66.53
Pyrazosulfuron @ 20 g ai/ha in unpuddled	8.00(64.00)	8.61(74.66)	5.00(25.00)	8.49(69.80)	60.18
SEm±	0.11	0.11	0.05	0.14	1.40
CD(P=0.05)	0.34	0.34	0.15	0.41	4.22

Values are square root (X +√0.5) transformed and the actual are given in parenthesis

Effect on yield attributes and yield

Perusal of data presented in Table 2 revealed that weed free plots at all the stages recorded maximum number of tillers m^{-2} followed by application of pretilachlor @ 750 g a.i./ha due to the less completion of crop and weed in herbicides treated plots in both conditions puddled and unpuddled. Similar results were also reported by Malik *et al.* (2011) [12]. Moreover, filled grains/panicle and unfilled grains/panicle, differed significantly due to various weed management practices. The filled grains/panicle and unfilled grains/panicle were also boost up significantly when the crop was treated with Pretilachlor @ 750 g/ha as compared to Oxyflorfen @ 200 g./ha and pyrazosulfuron @ 20 g a.i./ha in both condition puddled and unpuddled. Due to reduced crop-weed competition and better sink capacity increase in the sink capacity of crop was expressed in terms of, filled and unfilled grains.

The yield attributes are decided by genetic makeup of the crop and variety, but the agronomic manipulation also affects them to a great extent. Similar results were also reported by Kathirvelam and Vaiyapuri (2004) [10]. The reproductive growth depends on vegetative growth of plant. More vegetative growth increases the photosynthetic area and supply of photosynthates toward sink which decided the yield attributes and ultimately the yield. The higher values of yield attributes may probably due to increased synthesis and translocation of metabolites for the panicle development and grains formation. Besides, thousand grains weight was also maintained because of high mobilization of photosynthates from source to sink, essential for protein synthesis and carbon assimilation. Similar findings were also reported by Subramanian *et al.* (2006) [14] and Yadav *et al.* (2008) [16].

A cursory glance at the data presented in Table 2 reveals that the maximum grain yield and biological yield was observed in weed free plots and it was 50.34% and 51.8% higher than weedy plots in puddled condition whereas in unpuddled condition the maximum grain yield and biological yield was observed in weed free plots and it was 47.79% and 49.0% higher than weedy plots. Grain yield recorded in weed free plots was found *at par* with the grain yield recorded in Pretilachlor @ 750 g a.i./ha treated plots. This significant increase in grain yield of rice over weedy check was due to reduced crop weed competition and better sinks capacity brought about by controlling the weeds. Such effects of weed management practices on attributes have also been reported by Dubey *et al.* (2005) [6] and Walia *et al.* (2008) [15]. Furthermore, Harvest index is the ratio of grain and biological yield. From the Table 2 it is clear that harvest index of rice crop was significantly influenced by various herbicidal treatments. The highest harvest index (41.03%) was recorded with the application of Pretilachlor @ 750 g a.i./ha followed by weed free (40.66%) and oxyflorfen @ 200 g a.i./ha (40.56%) over weedy check in puddled condition. This significant increase in harvest index of rice over weedy check was due to reduced crop-weed competition, better sink development and more ability of the plant to convert the dry matter into grain yield brought about by controlling the weeds.

Table 2: Yield and yield attributes of crop as influenced by various treatments

Treatments	Number of tillers (m^{-2})	Filled Grains $panicle^{-1}$	Unfilled grains $panicle^{-1}$	Grain yield (q/ha)	Biological yield (q/ha)	Harvest index (%)
Weedy in puddled condition	267.7	107.2	33.9	32.2	82.9	38.78
Weed free puddled conditions	318.7	131.5	18.1	48.9	120.5	40.57
Pretilachlor @ 750 g ai /ha in puddled	314.7	127.2	19.8	47.5	116.0	40.93
Oxyfluorfen @ 200 g ai/ha in puddled	311.3	122.9	20.7	44.9	111.1	40.39
Pyrazosulfuron @ 20 gai/ha in puddled	303.7	121.9	21.0	42.2	106.7	39.55
Weedy in unpuddled condition	266.7	105.2	34.9	29.1	73.3	39.73
Weedy free in unpuddled condition	317.8	130.5	19.4	43.6	110.5	39.42
Pretilachlor @ 750 g ai/hain unpuddled	312.7	125.3	20.1	41.7	107.2	38.88
Oxyfluorfen @ 200 g ai/ha in unpuddled	308.0	122.4	21.4	39.8	102.5	38.85
Pyrazosulfuron @ 20 g ai/ha in unpuddled	302.7	120.5	22.0	37.6	98.2	38.27
SEm±	2.41	1.91	0.81	1.27	2.92	0.38
CD(P=0.05)	7.35	5.80	2.45	3.76	8.85	1.16

Effect on plant nutrients

Statistically analyzed data presented in Table 3 revealed that the uptake of nitrogen, phosphorus and potassium in grains and straw is a product of their nitrogen, phosphorus and potassium contents with respective dry matter yield. Significantly higher content and uptake of nitrogen, phosphorus and potassium were recorded with the application of Pretilachlor @ 750 g a.i./ha. The higher content and uptake of nitrogen, phosphorus and potassium with Pretilachlor @ 750 g a.i./ha and weed free treatments might be due to (i) increased supply of most essential nutrients directly to the crop (ii) indirectly through checking the loss of nutrients, and (iii) increasing the nutrient use efficiency. This results in improved growth parameters, more yield and higher nutrient concentration than weedy check. These findings confirm the results of Deepa and Jaykumar (2008) [5] and Barbar and Velayutham (2012) [2].

Table 3: Nutrient content (%) and uptake (kg ha^{-1}) as influenced by different herbicidal treatments

Treatments	Nutrient content (%)						Nutrient uptake (kg ha^{-1})					
	Nitrogen		Phosphorus		Potassium		Nitrogen		Phosphorus		Potassium	
	Grains	Straw	Grains	Straw	Grains	Straw	Grains	Straw	Grains	Straw	Grains	Straw
Weedy in puddled condition	1.156	0.458	0.323	0.130	0.293	1.240	37.18	14.73	10.39	4.18	9.42	39.88
Weed free puddled conditions	1.204	0.623	0.383	0.168	0.338	1.513	58.88	30.46	18.73	8.22	16.53	73.99
Pretilachlor @ 750 g ai /ha in puddled	1.186	0.608	0.371	0.153	0.326	1.500	56.31	28.87	17.62	7.26	15.48	71.22
Oxyfluorfen @ 200 g ai/ha in puddled	1.177	0.598	0.365	0.145	0.313	1.483	52.81	26.83	16.38	6.51	14.04	66.54
Pyrazosulfuron @ 20 gai/ha in puddled	1.174	0.586	0.349	0.140	0.305	1.383	49.54	24.73	14.73	5.91	12.87	58.36
Weedy in unpuddled condition	1.151	0.438	0.305	0.121	0.264	1.191	33.52	12.75	8.88	3.52	7.69	34.68
Weedy free in unpuddled condition	1.197	0.615	0.376	0.160	0.331	1.506	52.14	26.79	16.38	6.97	14.42	65.60
Pretilachlor @ 750 g ai/hain unpuddled	1.182	0.601	0.368	0.149	0.318	1.492	49.25	25.04	15.33	6.21	13.25	62.17
Oxyfluorfen @ 200 g ai/ha in unpuddled	1.175	0.590	0.359	0.142	0.310	1.397	46.79	23.49	14.30	5.65	12.34	55.63
Pyrazosulfuron @ 20 g ai/ha in unpuddled	1.170	0.584	0.341	0.132	0.298	1.334	43.96	21.94	12.81	4.96	11.20	50.12
SEm±	0.006	0.005	0.004	0.003	0.003	0.006	1.46	1.24	0.41	0.38	0.39	2.92
CD(P=0.05)	0.018	0.016	0.011	0.009	0.011	0.02	4.36	3.75	1.23	1.15	1.19	8.71

Effect on economics

Figure 1 and 2 revealed that under weed management practices in puddled as well as unpuddled conditions the highest cost of cultivation was recorded under weed free plot due to higher labour charge, on the other hand the lowest cost of cultivation was observed in weedy check treatment in puddled and unpuddled conditions. However, the highest gross return was recorded in weed free treatment and higher net return was obtained under the treatment receiving Pretilachlor @ 750 g a.i./ha. Similar results were also reported by Deepa and Jaykumar (2008) [5]. Among the weed management practices highest value of B: C ratio was recorded under Pretilachlor @ 750 g a.i./ha due to higher grain and straw yield production under this treatment in puddled and unpuddled conditions.

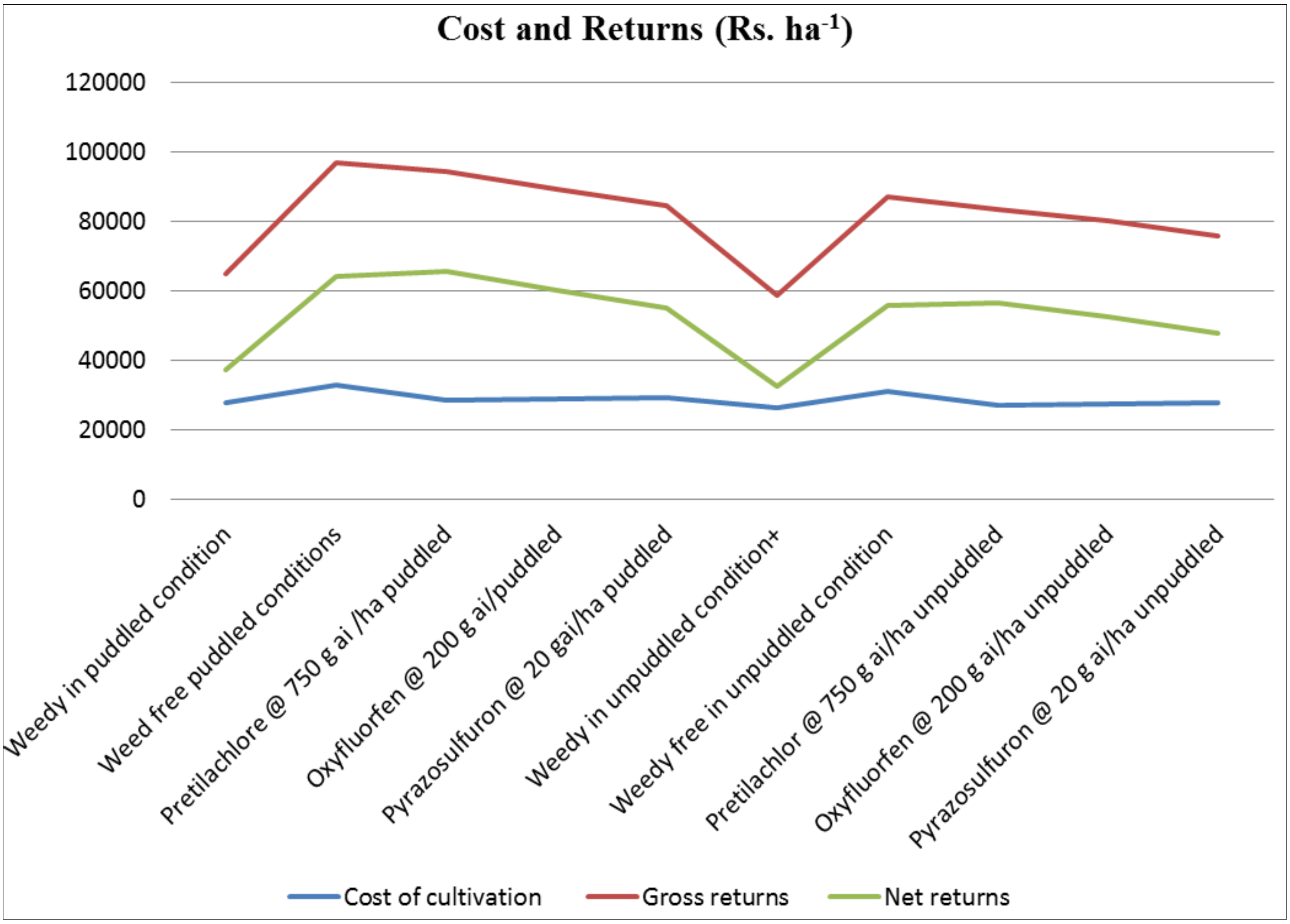

Fig 1: Cost of cultivation, gross returns and net returns as influenced by various treatments

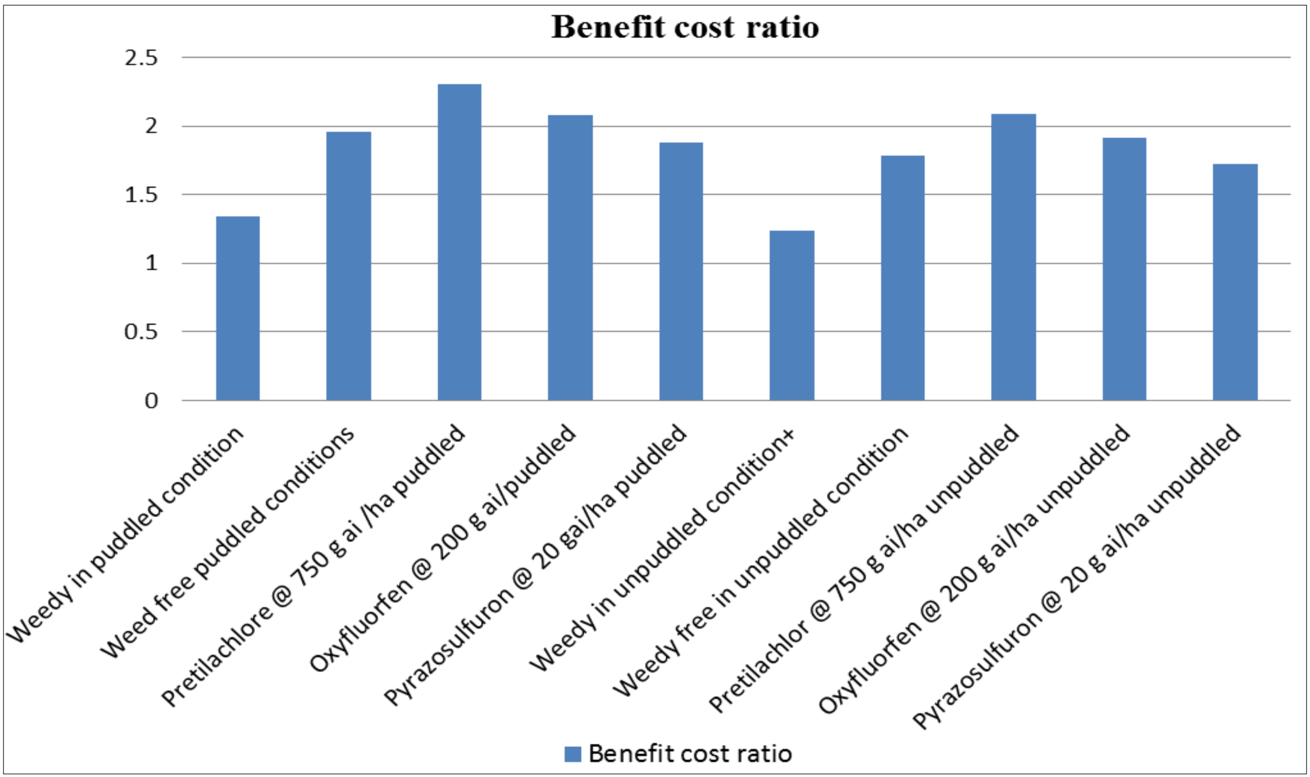

Fig 2: Benefit Cost ratio as influenced by various treatments

Conclusion

Based on finding the application of Pretilachlor @ 750 g a.i./ha proved better to obtained higher yield and also fetches more profit, besides suppressing weed in puddled and unpuddled conditions over all other herbicidal treatments due to its broad spectrum nature of controlling weeds in the sandy loam soil. This study showed that pre-emergence herbicide was an alternative with respect to yield of basmati rice, weed control, as well as benefit: cost ratio to hand weeding.

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