

Original Research Article

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Herbicides Weed Management Effect on Weed Dynamics, Crop Growth and Yield in Rice

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ABSTRACT

Effect of herbicide and their combinations on crop growth, weed suppression and rice yield were evaluated at agronomic research farm of Rajendra Agricultural University, Bihar (Pusa) during *Kharif* season of 2009-10. Results revealed that weed control measures had a significant effects on weed population/m². At 20 DAT minimum weed population/m² was recorded with Butachlor @ 1.5 kg a.i/ha (PE) which was significantly superior to weedy check (no weeding) and hand weeding at 25 and 50 DAT and statistically at par with Butachlor @ 1.5 kg a.i/ha (PE) + Pyrazosulfuron@ 40g a.i/ha (PoE), Pretilachlor @ 0.5 kg a.i/ha (PE) and Pretilachlor @ 0.5 kg a.i/ha (PE) + Pyrazosulfuron (10WP) @ 40 gm a.i/ha (PoE). At 40 DAT lowest weed population/m² was recorded with hand weeding at 25 and 50 DAT which was highly significant to weedy check and significantly superior to Butachlor @ 1.5 kg a.i/ha (PE) and Pretilachlor @ 0.5 kg a.i/ha (PE) but statistically at par with Butachlor @ 1.5 kg a.i/ha (PE) + Pyrazosulfuron@ 40g a.i/ha (PoE) and Pretilachlor @ 0.5 kg a.i/ha (PE) + Pyrazosulfuron (10 WP) @ 40 gm a.i/ha (PoE). At 60 DAT, minimum weed population/m² was recorded with hand weeding at 25 and 50 DAT which was highly significant to weedy check but significantly superior to Butachlor @ 1.5 kg a.i/ha (PE), Butachlor @ 1.5 kg a.i/ha (PE) + Pyrazosulfuron@ 40g a.i/ha (PoE), Pretilachlor @ 0.5 kg a.i/ha (PE) and Pretilachlor @ 0.5 kg a.i/ha (PE) + Pyrazosulfuron (10 WP) @ 40 gm a.i/ha (PoE). A similar trend was observed at harvest. Response of weed control measures on weed control efficiency was found to be significant at all the stages of growth. At 40 DAT maximum weed control efficiency was recorded with hand weeding at 25 and 50 DAT (91.61%) which was significantly superior to Butachlor @ 1.5 kg a.i/ha (PE) (82.00%), Butachlor @ 1.5 kg a.i/ha (PE) + Pyrazosulfuron@ 40g a.i/ha (PoE), Pretilachlor @ 0.5 kg a.i/ha (PE) (89.11), Pretilachlor @ 0.5 kg a.i/ha (PE) (82.77%) and Pretilachlor @ 0.5 kg a.i/ha (PE) + Pyrazosulfuron (10 WP) @ 40 gm a.i/ha (PoE) (88.22%). A similar trend was observed at 60 DAT and at harvest. The crop growth parameters, yield attributes and grain yield were recorded highest in spacing 15 x 15 cm over 20 x 15 cm and 20 x 20 cm in respect of number of tillers/m², dry weight of plant (g/m²), LAI, CGR (g/day/m²), weed population/m², weed dry weight (g/m²) and number of panicle/m² but was found at par in case of weed control efficiency (%) and 1000-grain weight. The spacing 15 x 15 cm also showed superiority over 20 x 15 cm and 20 x 20 cm in respect of grain and straw yield (q/ha) and grain : straw ratio but influence of population density on HI was found to be non-significant. Simultaneously, closer plant spacing recorded significantly highest gross and net return as well as B : C ratio than wider spacing. The treatment weedy check (no weeding) recorded significantly higher plant height but achieved significantly poor growth parameters, yield attributing characters, yield and economics. Results revealed that among various weed control measures, hand weeding and chemical weedicides recorded significantly higher number of tillers/m², dry weight (g/m²), LAI, CGR (g/day/m²), weed parameters, number of tillers/m², length of panicle (cm), number of grains/panicle, 1000-grain weight (g), grain and straw yield (q/ha) and harvest index than weedy check treatment with at par response among themselves. However, chemical weed control practices fetched significantly higher yield and at par net return and B : C ratio as compared to hand weeding (twice) treatment in the experimentation

Keywords

Rice, Weed dynamics, Crop growth parameters and yield

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Introduction

Rice and agriculture are still fundamental to the economic development of most of the Asian countries. In much of Asia, rice plays a central role in politics, society and culture, directly or indirectly employs more people than any other sector. A healthy rice industry, especially in Asia's poorer countries, is crucial to the livelihoods of rice producers and consumers alike. Farmers need to achieve good yields without harming the environment so that they can make a good living while providing the rice-eating people with a high-quality, affordable staple. At the current rate of population growth, rice production has to be enhanced to about 125 million tonnes by 2020. Achieving this target is a major challenge as this increase has to be attained with shrinking land and water scarce condition. Therefore, rice farming and the whole rice sector have to be reoriented to face the future challenges and our farmers too have to change their mind set to turn rice into a lucrative economic production rather than a simple food commodity. Full potential of rice could only be achieved with the adoption of proper agronomic management practices.

Plant density plays an important role in maintaining required plant population to achieve optimum yield level and nutrient utilization. The grain and straw yield varied significantly due to plant spacing. The higher grain yield at wider spacing was attributed to superiority of yield attributes such as number of filled grains/panicle, panicle weight and length and fertility per cent and test weight as compared to closer plant density. However, the significantly highest straw yield was recorded with a closer spacing which might be due to appreciable improvement in the growth parameters i.e. plant height, number of tillers/m² due to more number of hills/m², leaf area and dry matter production than the wider spacing (Gautam *et al.*, 2005).

Weed management is an important component of plant protection improving the production potential of crops. It includes management of weeds in a way that the crop sustains its production potential without being harmed by the weeds. Weeds grow in the fields where they compete with crops for water, soil, nutrients, light and space and thus reduce the crop yields. In the high yielding cropping system (Such as rice-wheat) where heavy inputs are utilized for obtaining higher productivity, weed management assumes a much greater importance. Transplanted rice is infested with heterogeneous group of weeds consisting of grassy, broad leaved and sedges. Competition of weeds brought about 15-76 per cent reduction in grain yield of rice (Singh *et al.*, 2004). Effective control of these weeds had increased the grain yield by 85.5 per cent (Mukherjee and Singh 2005). The use of herbicides offers selective and economical control of weeds right from beginning, giving crop an advantage of good start and competitive superiority. For the last many years, several recommended herbicides viz., butachlor, anilofos and pretilachlor are being used by farmers as pre-emergence for effective control of weeds, particularly grassy weed in rice crop. Due to continuous use of these herbicides, there are chances of shift in weed flora in favour of non-grassy weeds and also the evolution of weed resistance. As it was reported in *Phalaris minor* against isoproturon in wheat under rice-wheat system, there is a need of alternate herbicide to combat weed problem in rice. Keeping these facts in view, the present investigation was carried out to study herbicide weed management effects on weed dynamics, crop growth and yield in rice.

Materials and Methods

The experiment was conducted at agronomic research farm of Rajendra Agricultural University, Bihar (Pusa) during *Kharif* season

of 2009. The plot has fairly uniform topography and soil was deep and well drained. It has been sub-tropical and sub-humid monsoon climate with an average rainfall 1276.1 mm out of which nearly 1060 mm is received during the monsoon between June to September. The experiment was conducted in split plot design with three replications by using three plant density viz. (15 × 15 cm (P₁), 20 × 15 cm (P₂) and 20 × 20 cm (P₃) and six weed control measures (weedy check, W₀; hand weeding, (25 and 50 DAT) W₁; butachlor @ 1.5kg ai./ha (PE) W₂; butachlor @ 1.5 kg ai./ha (PE) + pyrazosulfuron @ 40g ai./ha (PoE) W₃; pretilachlor @ 0.5 kg ai./ha (PE) W₄ and pretilachlor @ 0.5 kg a.i./ha (PE) + pyrazosulfuron @ g a.i./ha (PoE) W₅. The soil analysis indicated the pH (8.3), available N (250 kg/ ha), available P₂O₅ (19.6 kg/ha) and available K₂O (130 kg/ha) with silty clay calciorthent taxonomy. Full amount of phosphorous, potassium and 1/2 of nitrogen was given as basal dose through DAP, MOP and Urea respectively as per treatment combination. Rest 1/2 nitrogen was top dressed at 27 and 51 DAT. A uniform recommended dose of 80 N kg/ha, 40 P₂O₅ kg/ha and 20 K₂O kg/ha was applied to all the treatment in the experimentation.

Results and Discussion

Weed flora

Weed flora of experimental plots were comprised of weeds like *Echinochloa crusigalli*, *Echinochloa colonum*, *Eclipta alba*, *Cyperus rotundus*, *Cyperus irria*, *Cyperus diformis*, *Cynodondactylon* and *Caesulina sp.* etc. The efficiency is first reflected in the primary vegetative growth parameters of plant which are manifested in the plant height, leaf emergence, those collectively determine the size of photosynthetic structure (source). Which in

turn determine the dry matter production and its consequent distribution and the ultimately productivity of rice. This is so because physical inputs sustain growth but their biological regulation govern the pattern of its utilization and ultimate expression in economic yield under the influence of variable factors. The pattern of rice growth also varied markedly. Growth in rice has two aspects (a) dry matter production (quantitative change) (b) phasal development (qualitative change).

Crop growth parameters

Plant height is an important vegetative character as it is an index of plant growth and vigour which is ultimately reflected in its productivity. Data on plant height revealed that the effect of plant density on plant height was found to be non-significant at 20, 40 and 60 days after transplanting (Table-1). Shivay and Singh (2003) and Chopra and Chopra (2004) were also noticed that the density did not influence the plant height of rice crop significantly due to different plant geometry. However at harvest the maximum plant height was recorded with wider spacing 20 x 20 cm (83.01 cm) which was significantly superior to 15 x 15 cm (78.71 cm) and 20 x 15 cm (79.93 cm). Khanam *et al.*, (2001) also reported similar findings that higher plant height at harvest was recorded with wider spacing. This might be due to the facts that availability of sufficient space, moisture, air, light and low competition within the plant population and accumulation of frequent photosynthates during the final crop growth. Weed control measures response was found to be positive in respect of plant height at all the stages of growth except 20 DAT. This may be due to the fact that in initial stage of growth low crop weed competition prevailed. The maximum plant height was recorded with weedy check which was significantly higher to all other weed control treatments. This

might be due to more crops weed competition in weedy check in which individual plant from the plots with highest weed population did not get opportunity to proliferate laterally due to less lateral space. Hence, plants were compelled to grow more in upward direction for fulfillment of light requirement for photosynthesis.

The number of tillers/m² is also one of the important yield attributing characters. The periodical observation on the number of tillers/m² revealed that number of tillers/m² increased up to 60 DAT and there after a declining trend was observed irrespective of treatments. This might be due to the mutual competition among the tillers for light, nutrients, space, water and other growth factors resulting in mortality of tillers after 60 days of transplanting. The maximum number of tillers/m² was recorded with closer spacing 15 x 15 cm which was significantly higher than wider spacing 20 x 15 cm and 20 x 20 cm at all the stages of growth. This might be due to more number of hills per unit area under closer plant spacing which resulted in more number of plant population (density). This finding is in close conformity with the result obtained by Kumar *et al.*, (2002). Obulamma and Reddeppa (2002) also reported significantly higher productive tillers/m² with closer spacing of 15 x 10 cm against wider spacing of 20 x 10 cm, 15 x 15 cm and 20 x 15 cm. At 20 DAT, number of tillers/m² was not influenced by weed control measures. After that weed control treatments played a significant role on number of tillers/m². At 40 and 60 DAT all weed control treatments showed significantly superior performance than weedy check and was comparable to each other (weed control treatments) but at harvest two hand weeding was found the best from weedy check and pre-emergence herbicide treatments, viz. butachlor @ 1.5 kg a.i./ha (PE), pretilachlor @ 0.5 kg a.i./ha (PE) and statistically

comparable with butachlor @ 1.5 kg a.i./ha (PE) + pyrazosulfuron @ 40 gm a.i./ha (PoE) and pretilachlor @ 0.5 kg a.i./ha (PE) + pyrazosulfuron @ 40 gm a.i./ha (PoE). Similar view was expressed by Dwivedi *et al.*, (1994) and Tuteja *et al.*, (1995). This might be due to the facts that weed free environment helps the crop for better establishment.

The dry matter production is the cumulative effect of various growth factors viz. plant height, number of tillers and the number of leaves etc. The maximum dry matter accumulation was registered under closer spacing 15 x 15 cm which was significantly higher than the wider spacing 20 x 15 cm and 20 x 20 cm at different growth stage. This might be attributed to the comparatively more number of plant density per unit area. Similar result was also obtained by Obulamma and Reddy (2002). Dry weight of plant was affected non-significantly at initial stage of crop growth through weed control treatments because at this stage less number of weeds was prevailed. After that dry weight of plant was recorded significantly superior in weed control treatments than the weedy check at 40 DAT, at 60 DAT and at harvest. Maximum dry weight of rice plant was recorded with pretilachlor @ 0.5 kg a.i./ha(PE) + Pyrazosulfuron @ 40 gm a.i./ha(PoE) which was statistically comparable with hand weeding (twice) and butachlor @ 1.5 kg a.i./ha (PE) + pyrazosulfuron @ 40 gm a.i./ha (PoE). The interaction effect of plant density and weed control measures on dry weight at 20, 40 DAT and harvest was found to be non-significant but at 60 DAT found significant (Table 8). Perusal of data on P x W revealed that all the three plant density (spacing) showed significant difference among themselves. Maximum plant dry weight recorded with P₁ which was significantly superior than other plant density treatments at various weed management practices. Amongst the weed control measures, the

treatment W_1 , W_2 and W_3 recorded at par plant dry matter which was significantly higher over W_0 , W_2 and W_4 at all the plant density treatments.

Leaf area index (LAI) is one of the yield attributing characters. The periodical observation on the LAI revealed that it was increased upto 40 DAT and after that decreasing trend was observed due to drying of old leaves and starting of commencement of maturity. The leaf area index was found to be maximum at closer spacing 15 x 15 cm which was significantly higher than the wider spacing 20 x 15 cm and 20 x 20 cm. This might be due to higher number of leaves per unit area which simultaneously recorded the maximum LAI with 15 x 15 cm spacing. Amongst the weed control treatments higher LAI was recorded with hand weeding (twice) closely followed by butachlor @ 1.5 kg a.i./ha (PE) + pyrazosulfuron @ 40 gm a.i./ha (PoE), pretilachlor @ 0.5 kg a.i./ha (PE) + pyrazosulfuron @ 40 gm a.i./ha (PoE), butachlor @ 1.5 kg a.i./ha (PE) and pretilachlor @ 0.5 kg a.i./ha (PE) application and these were significantly superior to weedy check. Similar opinion has also been expressed by Dwivedi *et al.*, (1994) and Tuteja *et al.*, (1995). The poor LAI obtained with weedy check (control) might be due to low production of tillers and ultimately the number of leaves per unit area which is resultant of crop weed completion.

The crop growth rate was found to be in increasing trend up to 60 DAT, thereafter it decreased. The growth and development of rice crop was more rapid till flowering which was due to faster rate of development and increased photosynthetic efficiency under conducive situation of growth and after wards at a slower pace up to maturity. Closer plant spacing 15 x 15 cm manifested higher CGR and it decreased with subsequent increase in plant spacing and recorded lowest

value at wider plant spacing of 20 x 20 cm at all the crop growth stages. The finding is also supported by Obulamma and Reddy (2002). Higher crop growth rate under closer spacing was mainly be due to higher plant population and better accumulation of plant dry matter. CGR at 20 DAT with all weed control treatments was found superior to weedy check and hand weeding twice. This might be due to almost similar weed dynamics at initial stage of growth in weedy check and hand weeding twice (25 and 50 DAT). At 40 DAT effect of all weed control treatments on CGR was comparably superior to weedy check. Later on maximum CGR was recorded with hand weeding (twice) along with butachlor @ 1.5 kg a.i./ha (PE) + pyrazosulfuron @ 40 gm a.i./ha (PoE) and pretilachlor @ 0.5 kg a.i./ha (PE) + pyrazosulfuron @ 40 gm a.i./ha (PoE) which was significantly superior than weedy check, butachlor @ 1.5 kg a.i./ha (PE) and pretilachlor @ 0.5 kg a.i./ha (PoE).

Yield attributing characters

Growth parameters form the foundation on which development of yield attributing characters stand. The attributing characters investigated were number of panicle/m², number of grains/panicle, length of panicle (cm) and 1000-grain weight (g). Length of panicle and 1000-grain weight in rice are greatly influenced by genetic characters but it is also influenced by external factors (Table-2).

Yield indices also varied due to different plant geometrics. Wider plant spacing 20 x 20 cm registered higher panicle length and number of grains/panicle (Table-2) and it decreased with an increase in plant densities. Gautam *et al.*, (2005) also reported similar results in their experimentation. Maximum 1000-grain weight too was recorded with 20 x 20 cm spacing which was comparable with 20 x 15 cm and 15 x 15 cm.

Table.1 Effect of weed management practices on different growth parameters in rice

Treatments Plant density	Plant height (cm)				Number of tillers/m ²				Plant dry weight (g/m ²)				LAI			
	20 DAT	40 DAT	60 DAT	At harvest	20 DAT	40 DAT	60 DAT	At harvest	20 DAT	40 DAT	60 DAT	At harvest	20 DAT	40 DAT	60 DAT	At harvest
P₁	28.23	43.04	62.85	78.71	186.35	269.41	321.00	287.50	23.73	158.24	409.99	664.55	0.88	4.88	4.67	4.35
P₂	27.88	43.56	62.81	79.93	179.83	257.55	288.78	270.44	20.69	138.04	374.64	586.01	0.85	4.56	4.33	4.12
P₃	27.62	44.08	65.97	83.01	163.78	243.66	268.05	256.94	18.69	124.80	346.47	482.96	0.76	4.06	3.82	3.74
S.Em. ±	0.53	1.23	1.93	0.85	4.96	2.73	4.79	1.35	0.33	1.98	0.56	5.44	0.004	0.019	0.036	0.012
CD (P = 0.05)	NS	NS	NS	3.34	19.50	10.75	18.83	5.31	1.30	7.77	2.20	21.37	0.015	0.076	0.15	0.05
Weed control measures																
W₀	27.27	48.41	68.77	86.56	173.22	213.88	229.77	210.22	20.85	104.22	287.03	381.39	0.82	3.85	3.65	3.35
W₁	28.14	43.37	62.60	79.42	176.66	264.77	310.22	294.22	20.85	146.14	413.17	641.12	0.83	4.71	4.51	4.29
W₂	27.86	41.71	62.51	79.14	176.11	265.33	295.55	268.33	21.11	147.78	362.98	565.85	0.83	4.56	4.36	4.19
W₃	27.69	42.50	63.48	79.19	177.66	265.22	310.22	292.22	21.26	148.78	418.83	634.74	0.84	4.60	4.40	4.18
W₄	27.93	42.42	62.91	79.50	177.56	265.55	298.44	271.00	21.03	147.23	363.02	575.52	0.82	4.56	4.25	4.11
W₅	28.57	42.97	63.00	79.50	178.71	266.49	311.44	293.78	21.14	148.01	417.16	668.41	0.84	4.70	4.48	4.29
S. Em. ±	0.67	1.50	1.75	2.08	6.41	5.36	6.20	3.74	0.89	3.63	1.38	11.73	0.007	0.032	0.050	0.040
CD (P=0.05)	NS	4.33	5.06	6.00	NS	15.48	17.91	10.80	NS	10.49	3.99	33.88	0.02	0.09	0.15	0.12

Table.1 Effect of weed management practices on different growth parameters in rice

Treatments	Crop growth rate(g/m ² /day)				Weed population (m ²)				Weed dry weight				Weed control efficiency (%)			
	20 DAT	40 DAT	60 DAT	At harvest	20 DAT	40 DAT	60 DAT	At harvest	20 DAT	40 DAT	60 DAT	At harvest	20 DAT	40 DAT	60 DAT	At harvest
P₁	1.22	6.72	12.60	7.06	40.33	63.88	94.38	120.28	12.58	18.65	29.28	38.04	71.76	72.47	70.41	71.76
P₂	1.03	5.75	11.60	6.51	44.38	70.88	99.50	126.61	13.23	20.41	31.98	39.80	72.37	71.69	69.99	72.37
P₃	0.93	5.30	11.08	4.21	48.44	71.66	106.78	136.22	13.86	20.26	35.04	45.89	72.71	70.33	67.18	72.71
S.Em. ±	0.02	0.09	0.14	0.16	2.13	2.52	2.17	2.82	0.46	0.55	1.29	1.70	0.64	1.73	1.36	0.64
CD (P = 0.05)	0.07	0.33	0.56	0.62	NS	NS	8.54	11.06	NS	NS	5.08	6.68	NS	NS	NS	NS
Weed control measures																
W₀	1.04	4.16	8.72	2.67	73.33	250.22	347.33	404.00	22.83	71.55	113.25	134.74	0	0	0	0
W₁	1.04	6.26	13.35	7.14	73.44	24.44	22.56	43.44	23.20	5.99	5.47	12.81	91.61	95.11	91.07	91.61
W₂	1.05	6.33	10.76	5.46	29.56	39.55	71.22	91.22	7.88	12.77	22.51	30.24	82.00	79.86	76.67	82.00
W₃	1.06	6.37	13.50	7.11	30.11	29.22	46.89	69.56	8.73	7.66	15.39	21.15	89.11	86.20	84.01	89.11
W₄	1.05	6.08	10.78	6.06	30.00	40.44	66.67	90.56	8.59	12.31	21.24	28.35	82.77	81.00	78.44	82.77
W₅	1.12	6.34	13.45	7.11	29.88	29.00	46.66	67.44	8.11	8.36	14.73	20.20	88.22	86.84	85.00	88.22
S. Em. ±	0.03	0.27	0.18	0.19	2.14	2.99	2.10	4.25	0.38	0.84	2.13	1.68	0.54	3.37	2.05	0.54
CD (P=0.05)	0.07	0.76	0.53	0.56	6.20	8.66	6.08	12.28	1.07	2.43	6.16	4.87	1.57	9.74	5.94	1.57

Table.2 Effect of weed management practices on grain yield, its attributes and straw yield and harvest index in rice

Treatments	No. of Panicle/ m ²	Length of Panicle (cm)	No. of grains/ panicle	1000-grain weight	Grain yield (q/ha)	Straw yield (q/ha)	Grain : straw ratio	Harvest index
Plant density								
P ₁	287.50	20.16	91.72	20.51	36.94	47.32	0.78	43.86
P ₂	270.44	20.77	97.28	20.52	32.79	42.64	0.77	43.48
P ₃	256.94	22.46	104.17	20.36	29.54	38.70	0.76	43.29
S.Em. ±	1.35	0.45	1.01	0.50	0.18	0.24	0.002	0.02
CD (P = 0.05)	5.31	1.75	3.97	NS	0.74	1.00	0.007	NS
Weed control measures								
W ₀	210.22	16.18	73.44	20.07	21.97	28.46	0.77	43.54
W ₁	294.22	22.32	103.00	20.51	36.84	47.78	0.76	43.54
W ₂	268.33	21.63	101.78	20.71	33.51	43.42	0.77	43.54
W ₃	292.22	22.64	101.67	20.45	35.79	46.37	0.77	43.54
W ₄	271.00	20.83	101.00	20.51	34.37	44.53	0.77	43.54
W ₅	293.78	22.47	105.44	20.55	36.07	46.73	0.77	43.54
S. Em. ±	3.74	0.89	4.52	1.01	1.09	1.41	0.006	0.005
CD (P+0.05)	10.80	2.60	13.06	NS	3.15	4.09	NS	NS

Table.3 Economic feasibility of different treatments on yield

Treatments	Gross return (₹/ha)	Net return (₹/ha)	B : C ratio
Plant density			
P ₁	41631	24302	1.40
P ₂	36972	19993	1.22
P ₃	33336	16707	1.01
S.Em. ±	219.64	219.89	0.03
CD (P = 0.05)	862.28	863.29	0.11
Weed control measures			
W ₀	24727	9615	0.63
W ₁	41550	20438	1.04
W ₂	37791	21879	1.37
W ₃	40364	23252	1.36
W ₄	38762	23050	1.46
W ₅	40682	23770	1.40
S. Em. ±	1224.45	1224.45	0.08
CD (P = 0.05)	3536.00	3536.01	0.24

Similar result has also been observed by Chopra and Chopra (2004). However, reverse trend was observed for number of panicle/m². This might be due to more plant population in unit area was found in closer spacing. Patra and Nayak (2001) found the fate of maximum tillers due to close plant spacing.

Amongst the weed control treatments, hand weeding twice (25 and 50 DAT) recorded maximum number of panicle/m² followed by pretilachlor @ 0.5 kg a.i./ha + pyrazosulfuron @ 40 gm a.i./ha and butachlor @ 1.5 kg a.i./ha + pyrazosulfuron @ 40 gm a.i./ha. These three treatments had higher number of panicle/m² than the rest of the treatments. This finding is conformity with those of Dhiman and Nandal (1996) as well as Kalia and Bindra (1996).

Length of panicle and number of grains/panicle were higher in all weed control treatments than the weedy check while 1000-grain weight was found to be almost similar in all the treatments. These findings are in accordance with the result of Hasanuzzaman *et al.*, (2007).

Economic feasibility of different herbicides on yield

Net return (Rs/ha) was significantly influenced by various treatments (Table-3). Maximum net return was obtained with closer plant spacing 15 x 15 cm (24302 Rs./ha) which was significantly superior to wider plant spacing 20 x 15 cm (19943.22/ha) and 20 x 20 cm (16707 Rs/ha). In weed control measures, higher net return was obtained with pretilachlor @ 0.5 kg a.i./ha (PE) + pyrazosulfuron @ 40 gm a.i./ha (PoE) (23770 Rs./ha) which was significantly superior to weedy check and hand weeding and at par with other chemical weeding treatments. A similar trend was observed in case of benefit : cost ratio. Under plant density treatment,

closer plant density scored significantly higher B : C ratio and weed control measures, higher B : C ratio was recorded with pretilachlor @ 0.5 kg a.i./ha (PE) which was significantly superior to weedy check but found to be at par with other chemical weed control measures. Hand weeding (twice) fetched comparatively poor B; C ratio due to its high expenditure.

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