*Indian J. Weed Sci.* **42** (1 & 2) : 23-29 (2010)

# Weed Management in Rice-Wheat Cropping System under Conservation Tillage

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## ABSTRACT

A field experiment was conducted at Varanasi during 2005-06 and 2006-07 to find out the most sustainable and economically feasible weed management technologies for realizing high yield of direct seeded rice (*Oryza sativa* L.)-zero till wheat (*Triticum aestivum* L. emend. Fiori & Paol.) system. The treatments comprised five different weed management practices for rice (anilophos 500 g/ha, wheat straw mulch 2 t/ha, eucalyptus leaf leachate spray 3% at 30 days after sowing (DAS), stale seed bed and weedy check) and wheat (mechanical weeding at 15 and 30 DAS, rice straw mulch 2 t/ha, neem oil spray 3% at 30 DAS, sulfosulfuron 25 g/ha at 30 DAS and weedy check) under same rates of seed (75, 100, 125 and 150 kg seeds/ha). In rice crop, the seed rate of 100 kg/ha caused the highest decrease in weed dry matter accumulation and led significantly higher rice yield and NPK uptake over other seed rates. Application of anilophos at 500 g/ha recorded significantly lower dry matter accumulation of weeds, and in turn increased rice yield and NPK uptake than the other weed management practices. This treatment gave 45.4% increase in rice grain yield over weedy check. In case of wheat grown after rice, 125 kg seed/ha reduced dry matter accumulation of weeds, and resulted in the highest wheat yield and NPK uptake which was similar to 100 kg seed/ha, but was significantly superior to 75 and 150 kg seeds/ha. Mechanical weeding done twice at 15 and 30 days stage was found most effective in reducing weed dry matter accumulation, and maximizing wheat yield and NPK uptake which was at par with sulfosulfuron 25 g/ha at 30 DAS. Mechanical weeding at 15 and 30 DAS registered 31.4% increase in wheat grain yield over weedy check. Net return and benefit : cost ratio in rice-wheat system were the highest (Rs. 41347/ha and 2.66) with 100 kg seed/ha to both the crops and in weed management treatments, maximum net return and benefit : cost ratio Rs.13310/ha and 0.87 were recorded with anilophos 500 g/ha in rice, and Rs.29922/ha and 1.82 with sulfosulfuron 25 g/ha in wheat. For realizing higher yield, economic gain and effective weed management in direct seeded rice and zero-till wheat system, 100 kg seed/ha of rice and wheat should be applied with anilophos at 500 g/ ha to rice crop and 125 kg seed/ha alongwith sulfosulfuron 25 g/ha at 30 DAS to the succeeding wheat crop.

**Key words :** Seed rate, weed management, system productivity, direct seeding, zero tillage

## INTRODUCTION

Rice-wheat is the predominant cropping system in India, with an estimated area of 10.5 million ha which contributes more than one-fourth to total food grain production. Though this system has sustained over years, productivity of the cropping system is declining or stagnating (Bajpai and Tripathi, 2000). This stagnation in productivity of the rice-wheat system can be attributed mainly to various factors. Conservation tillage has emerged as efficient tool to tackle some of these problems. But weeds are becoming a menace in conservation tillage system more so with direct sowing and zero-tillage. Therefore, weeds have become one of the most important factors responsible for low yields of both direct seeded rice and zero-tilled wheat crops, and need immediate attention. Weeds in rice-wheat system are generally controlled with manual and cultural manipulations. Now-a-days, herbicide use for weed control in rice and wheat is becoming increasingly popular. Among field crops herbicide use in India is maximum in rice (Raju and Gangwar, 2004) and 57% area of wheat is under herbicide use in Punjab, Harayana, western Uttar Pradesh and Uttarakhand (Anonymous,

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2007). Indiscriminate use of herbicides has posed soil and environmental pollution problems. Alternatively, cultural practices such as higher seed rate, mechanical weeding, smother crops, etc. as a component of integrated weed management programme will play a significant role in weed suppression, besides being economical and eco-friendly. The complexity of these situations has resulted in a need to develop a holistic weed control programme throughout cropping period, which is sustainable in terms of enhanced productivity without eroding the resource base. Weed density and dry matter are supposed to be suppressed substantially through increasing plant populations by manipulation of seed rate. Keeping these facts in view, a study was undertaken to investigate the comparative performance of different weed management practices in rice and wheat under varying seed rates.

## MATERIALS AND METHODS

A field experiment was conducted during 2005-06 and 2006-07 at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (Uttar Pradesh). The soil of the experimental site was sandy clay loam with nearly neutral reaction (pH 7.6) and moderately fertile, being low in organic carbon (0.36%) and available nitrogen (185.2 kg/ha) and medium in available phosphorus (19.8 kg/ha) and potassium (208.6 kg/ha) at 0-30 cm soil depth. The experiment with 20 treatment combinations was laid out in a split plot design, in plots size of 6 x 3 m allocating seed rates to main plots and weed management practices to sub-plots with three replications. Main plot treatments were repeated in the same plots for both the crops of rice and wheat. The experiment with rice (**kharif**) was conducted involving four different seed rates (75, 100, 125 and 150 kg/ha) and five weed management practices viz., anilophos (500 g/ha), wheat straw mulch (2 t/ha), eucalyptus leaf leachate spray (3%) at 30 DAS, stale seed bed and weedy check. The rice experimental field was prepared by minimum tillage operation using only cultivator followed by planking. Pre-germinated seeds of rice variety ‘Swarna’ were direct-sown on 9 and 7 July in 2005 and 2006, respectively, at a row spacing of 15 cm. After the rice harvest, each main plot was further divided into five sub-plots to facilitate wheat (**rabi**) sowing under five weed management practices (mechanical weeding at 15 and 30 DAS, rice straw mulch (2 t/ha), neem oil spray (3%) at 30 DAS, sulfosulfuron (25 g/ha) and weedy check). ‘HUW-234’ variety of wheat was sown with zero-till drill during second week of December 2005 and 2006 at a row spacing of 24 cm. Herbicide (anilophos and sulfosulfuron) was applied 3 DAS in rice and 30 DAS in wheat using spray volume of 600 l/ha with the help of knapsack sprayer fitted with flat-fan nozzle. Recommended dose of fertilizers (120 kg N+26.2 kg P and 50 kg K/ha) was applied through urea, diammonium phosphate and muriate of potash, respectively. Full dose of P and K, and half of N were applied as basal at the time of sowing and remaining N in two equal splits at tillering and panicle initiation stages of both the crops. The residue of both crops left in the field got decomposed automatically. A congenial weather prevailed for proper growth and development for both crops of rice and wheat in each season of the experiment. Data on population and dry matter accumulation of weeds were recorded at 60 DAS with the help of random quadrate (50 x 50 cm) from four places of border row on either side of each plot and subjected to square-root transformation before statistical analysis. The uptake of nitrogen, phosphorus and potassium (NPK) in rice and wheat grain and straw at harvest was estimated as per standard procedure. Comparative economics of various treatments were calculated. The price rates of grain was taken Rs. 6.5/kg for rice and Rs. 8.5/kg for wheat, while that of straw price was Rs. 0.5/kg for rice and Rs. 2.5/kg for wheat, respectively. For determining the significance of difference between the treatments, the data for individual years of rice and wheat were pooled and statistically analysed by applying the standard procedure of analysis of variance.

## RESULTS AND DISCUSSION

The experimental field in rice was mainly infected with *Echinochloa crus-galli* (L.) P. Beauv. (21.6%), *Cynodon dactylon* (L.) Pers.(19.8%) and *Echinochloa colona* (L.) Link. (18.7%) in grasses; *Cyperus rotundus* L. (11.2%) in sedges and *Amaranthus viridis* L. (28.6%) in broad-leaved weeds. *Rumex* spp. (34.3%), *Anagallis arvensis* L. (21.9%) and *Chenopodium album* L. (16.2%) in broad-leaved weeds, *Phalaris minor* Retz. (19.8%) in grasses and *Cyperus rotundus* L. (7.2%) in sedges were the major weeds infecting wheat.

## Rice

**Effect on weeds :** Variation in seed rates significantly influenced weeds population and dry matter accumulation of weeds (Table 1). Increasing rates of seed from 75 to 150 kg/ha significantly reduced weeds population. Similar trend was observed with different seed rates in reduction of dry matter accumulation of weeds. Zimdahl (1980) reported that appropriate plant density would provide more efficient use of available resources and will allow a crop to exert greater inter- and intra-plant competition and reduce losses due to weeds. The highest (56.0 %) weed-control efficiency was observed with 150 kg seed/ha and the lowest (49.8 %) with 75 kg seed/ha. The highest weed-control efficiency may be attributed to lower dry matter accumulation of weeds.

Table 1. Effect of seed rates and weed management practices on weed indices and yield attributes of rice (Pooled data of two years)

| Treatments | Weed population/ $m^2$ | Weed dry matter accumulation ($g/m^2$) | Weed control efficiency (%) | Yield attributes | | |
|---|---|---|---|---|---|---|
| | | | | Panicles/m row length | Grains/ panicle | 1000-grain weight (g) |
| **Seed rates (kg/ha)** | | | | | | |
| 75 | 7.1 (49.5) | 6.7 (44.5) | 49.8 | 56.3 | 93.0 | 22.4 |
| 100 | 6.7 (44.8) | 6.6 (43.2) | 53.1 | 60.5 | 93.4 | 22.5 |
| 125 | 6.5 (41.6) | 6.5 (42.1) | 54.5 | 64.8 | 87.1 | 21.9 |
| 150 | 6.1 (36.7) | 6.5 (41.4) | 56.0 | 68.6 | 80.6 | 21.7 |
| LSD (P=0.05) | 0.02 | 0.02 | | 4.2 | 6.1 | NS |
| **Weed management practice** | | | | | | |
| Anilophos (500 g/ha) | 5.6 (31.2) | 5.8 (32.9) | 55.9 | 72.9 | 99.7 | 23.9 |
| Wheat straw mulch (2 t/ha) | 6.2 (38.4) | 6.0 (35.7) | 52.2 | 62.2 | 93.2 | 22.2 |
| Eucalyptus leaf leachate spray (3%) at 30 DAS | 6.6 (42.7) | 6.1 (36.6) | 51.0 | 57.6 | 79.7 | 21.5 |
| Stale seed bed | 6.5 (35.3) | 5.9 (34.4) | 53.9 | 68.1 | 95.5 | 22.4 |
| Weedy check | 8.3 (68.1) | 8.7 (74.7) | | 53.1 | 74.6 | 20.5 |
| LSD (P=0.05) | 0.01 | 0.02 | | 3.6 | 5.3 | 1.3 |

Figures in parentheses indicate original values. NS–Not Significant.

Weed management treatments significantly decreased weed population and their dry matter accumulation compared with weedy check (Table 2). Anilophos registered the lowest number of weeds population (5.6/$m^2$) and dry matter accumulation of weeds (5.8 $g/m^2$) followed by stale seed bed, wheat straw mulch and eucalyptus leaf leachate treatments, respectively, and led to the highest weed-control efficiency (55.9 %) because it was more effective in controlling the monocotyledon weeds, which mostly infest rice crop.

**Yield and yield attributes :** Increase in number of panicles/m with successive increments of seed rate from 75 to 150 kg/ha was significant, whereas number of grains/panicle was discerned up to 100 kg seed/ha which was at par with 75 kg seed/ha but was significantly superior to rest of the seed rates (Table 1). The higher panicles/m with higher seed rate of 150 kg/ha seem to have caused competition for growth resource thus adversely affecting the growth of individual panicle leading to significant reduction in grains/panicle over that of 125 and 100 kg seed/ha, respectively. No significant variation was seen between different seed rates with respect to 1000-grain weight. Consequent upon bearing more panicles/m and grains/panicle with 100 kg seed/ha, grain yield significantly increased with increase of 17.9 % over 75 kg seed/ha (Table 2). Further, increase in seed rate to 125 and 150 kg/ha was not beneficial. Similar trend was recorded in straw yield as well.

Weed management practices brought about marked increase in panicles/m, grains/panicle and 1000-grain weight compared to weedy check (Table 1). Anilophos recorded the highest number of panicles/m, grains/panicle and 1000-grain weight, which was comparable to stale seed bed. This may be attributed to better crop growth due to decreased weed-crop competition, which in turn might have resulted in greater photosynthesis and hence better translocation of

Table 2. Effect of seed rates and weed management practices on yield and NPK uptake of rice (Pooled data of two years)

| Treatments | Grain yield (kg/ha) | Straw yield (kg/ha) | NPK uptake (kg/ha) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Nitrogen | | Phosphorus | | Potassium | |
| | | | Grain | Straw | Grain | Straw | Grain | Straw |
| **Seed rates (kg/ha)** | | | | | | | | |
| 75 | 3245 | 4911 | 30.7 | 26.4 | 7.6 | 8.3 | 9.7 | 9.5 |
| 100 | 3827 | 5840 | 35.0 | 30.9 | 8.7 | 9.4 | 10.9 | 11.1 |
| 125 | 3421 | 5160 | 29.3 | 25.7 | 7.3 | 7.4 | 9.2 | 9.8 |
| 150 | 3382 | 4960 | 27.6 | 26.2 | 7.0 | 7.1 | 8.9 | 9.1 |
| LSD (P=0.05) | 254.7 | 377.9 | 2.2 | 2.0 | 0.6 | 0.6 | 0.7 | 0.7 |
| **Weed management practices** | | | | | | | | |
| Anilophos (500 g/ha) | 3943 | 6030 | 37.6 | 32.3 | 10.7 | 10.0 | 12.1 | 11.8 |
| Wheat straw mulch (2 t/ha) | 3548 | 5280 | 30.7 | 27.8 | 7.7 | 8.4 | 9.8 | 9.8 |
| Eucalyptus leaf leachate spray (3%) at 30 DAS | 3454 | 5150 | 29.2 | 26.8 | 7.3 | 7.8 | 9.4 | 9.5 |
| Stale seed bed | 3706 | 5510 | 33.1 | 29.0 | 8.0 | 8.6 | 10.2 | 10.4 |
| Weedy check | 2712 | 4120 | 22.6 | 20.6 | 5.2 | 5.4 | 6.8 | 7.0 |
| LSD (P=0.05) | 249.5 | 386.2 | 1.9 | 1.7 | 0.5 | 0.5 | 0.6 | 0.6 |



photosynthates besides larger sink and stronger reproductive phase, as reflected in maximum panicles/m, grains/panicle and 1000-grain weight. This treatment was significantly superior to wheat straw mulch, which in turn was significantly superior to eucalyptus leaf leachate treated plots. The low yield attributing characters with eucalyptus leaf leachate spray could be attributed to its poor performance against prevailing weeds. Similarly, rice grain and straw yields were also influenced significantly by various weed management practices over weedy check (Table 2). Anilophos at 500 g/ha recorded the highest grain and straw yields and were significantly superior to rest of the other weed management treatments. This increase in grain yield was 45.4 % over weedy check. This may be attributed to increase in yield attributes on account of reduced weed biomass, resulting in increased availability of growth resources.

**NPK uptake :** The uptake of NPK in rice grain and straw was significantly influenced by different seed rates and the maximum value accrued with 100 kg seed/ha which was significantly more than all other treatments (Table 2).

All weed management practices significantly helped in higher NPK uptake as compared to weedy check, which recorded the lowest uptake of NPK (Table 2). Maximum amount of NPK uptake was recorded under anilophos treatment which was significantly higher than the other weed management treatments. This was apparently due to the lesser weed competition, and thus better crop growth and higher uptake by the crop.

**Wheat**

**Effect on weeds :** Successive increments of seed rate from 75 to 150 kg/ha significantly reduced the weeds population and dry matter accumulation of weeds (Table 3). Increased plant density per unit area achieved by higher seed rate probably caused smothering of weeds and consequently reduced their dry matter accumulation. Seed rate of 150 kg/ha reduced dry weight of weeds by 5, 11 and 20% over 125, 100 and 75 kg seed/ha, respectively. Because the unsown space was reduced to minimum which did not provide enough sunlight and space for all weed seeds to germinate and checked initial growth of germinated weeds. Blackshaw *et al.* (2005) also reported that higher crop seed rates had a consistently positive effect on reducing weed growth and weed seed bank. The highest weed-control efficiency was under 150 kg seed/ha and the lowest under 75 kg seed/ha.

Weed management practices significantly reduced the weeds population and their dry matter accumulation as compared to weedy check. Amongst weed management practices, sulfosulfuron at 25 g/ha was the most effective in reducing weeds population and was found significantly superior to rest of the weed management treatments (Table 3). However, mechanical weeding twice recorded significantly lower dry weight of weeds compared with other weed management

Table 3. Effect of seed rates and weed management practices on weed indices and yield attributes of wheat (Pooled data of two years)

| Treatments | Weed population/ m² | Weed dry matter accumulation (g/m²) | Weed control efficiency (%) | Yield attributes | | |
|---|---|---|---|---|---|---|
| | | | | Effective tillers/m row length | Grains/ spike | 1000-grain weight (g) |
| **Seed rates (kg/ha)** | | | | | | |
| 75 | 7.2 (51.2) | 6.2 (37.5) | 62.0 | 50.2 | 38.9 | 37.8 |
| 100 | 6.8 (45.8) | 5.9 (34.8) | 65.0 | 54.0 | 38.6 | 37.3 |
| 125 | 6.4 (40.7) | 5.8 (32.9) | 67.0 | 57.2 | 37.4 | 36.0 |
| 150 | 6.0 (35.4) | 5.6 (31.3) | 67.2 | 59.2 | 35.7 | 34.8 |
| LSD (P=0.05) | 0.03 | 0.02 | | NS | NS | NS |
| **Weed management practices** | | | | | | |
| Mechanical weeding at 15 and 30 DAS | 5.5 (29.8) | 4.3 (18.3) | 74.7 | 61.3 | 39.0 | 38.1 |
| Rice straw mulch (2 t/ha) | 6.5 (41.7) | 5.4 (28.3) | 58.4 | 57.5 | 38.0 | 37.0 |
| Neem oil spray (3%) at 30 DAS | 7.2 (51.3) | 5.8 (32.6) | 57.2 | 50.2 | 37.0 | 36.7 |
| Sulfosulfuron (25 g/ha) at 30 DAS | 5.3 (28.0) | 4.4 (18.6) | 74.2 | 58.8 | 38.6 | 37.5 |
| Weedy check | 8.3 (68.2) | 8.5 (72.1) | | 48.0 | 35.6 | 34.1 |
| LSD (P=0.05) | 0.02 | 0.02 | | 4.4 | 2.1 | 2.3 |

Figures in parentheses indicate original values. NS–Not Significant.



treatments and showed the highest weed control efficiency of 74.7 %. This may be probably due to effective control of first flush of weeds from 15 to 30 days and second flushes of weeds from 30 days onwards.

**Yield and yield attributes :** Different seed rates did not cause significant variations in effective tillers/m, grains/spike and 1000-grain weight of wheat (Table 3). However, variation in seed rates significantly influenced the grain and straw yields of wheat and recorded the highest value (3724 kg/ha grain yield and 5472 kg/ha straw yield) at 125 kg seed/ha which was significantly superior to rest of other seed rates, but was on a par with 100 kg seed/ha (Table 4). Seed rate of 125 kg/ha gave 2.65% more wheat grain yield than 100 kg seed/ha (3628 kg/ha), which in turn recorded 14.6 and 20.4% more grain yield than 75 and 150 kg seed/ha, respectively. Naik *et al*. (1991) also reported that seed rate of 125 kg/ha produced higher grain and straw yields than other seed rates. Selection of appropriate plant density for higher productivity depends mainly on tillering and lodging. Therefore, higher grain and straw yields at 125 kg seed/ha may be ascribed to increase in effective tillers/running m. High plant density beyond optimum leads to mutual competition among plants due to which it fails to exploit the inputs fully. However, a little lodging and mutual competition among plants at 150 kg seed/ha decreased yield of crop. Similar results were obtained for straw yield.

There was no phytotoxic effect on wheat crop under any weed management treatment. Weed management practices significantly influenced all yield (grain and straw) and their attributes (effective tillers/ m, grains/spike and 1000-grain weight) compared to weedy check. Effective tillers/m, grains/spike and 1000-grain weight were statistically on a par among weed management practices. Grain and straw yields were better under mechanical weeding at 15 and 30 DAS, which was significantly superior to other weed management practices, but was on a par with sulfosulfuron and straw yield of rice straw mulch treated plots (Table 4). The highest increase in grain yield upto 31.4% was recorded under mechanical weeding, followed by sulfosulfuron (29.4 %), rice straw mulch (20.2 %) and neem oil (7.2 %) treatments, respectively. The higher yield under two mechanical weedings may be attributed to lower dry matter accumulation by weeds and decrease in their population that helped in increasing the yield attributes which ultimately led to higher yield.

**NPK uptake :** The uptake of NPK in wheat grain and straw increased with increase in seed rates from 75 to 125 kg/ha but decreased thereafter (Table 4). Higher NPK uptake in 125 kg seed/ha might be due to higher crop biomass production. The nitrogen and phosphorus uptake increased significantly with an increase in seed rate up to 100 kg/ha and potassium uptake up to 125 kg/ha in wheat grain and straw and

Table 4. Effect of seed rates and weed management practices on yield and NPK uptake of wheat (Pooled data of two years)

| Treatments | Grain yield (kg/ha) | Straw yield (kg/ha) | NPK uptake (kg/ha) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Nitrogen | | Phosphorus | | Potassium | |
| | | | Grain | Straw | Grain | Straw | Grain | Straw |
| **Seed rates (kg/ha)** | | | | | | | | |
| 75 | 3250 | 5074 | 74.5 | 32.0 | 11.8 | 7.8 | 25.8 | 72.6 |
| 100 | 3628 | 5411 | 81.4 | 34.5 | 13.3 | 8.5 | 27.2 | 74.2 |
| 125 | 3724 | 5472 | 84.2 | 35.7 | 14.6 | 9.1 | 29.9 | 76.9 |
| 150 | 3094 | 4802 | 76.3 | 33.7 | 14.2 | 9.0 | 29.2 | 75.2 |
| LSD (P=0.05) | 284.5 | 358.4 | 4.4 | 2.4 | 1.3 | 0.7 | 1.3 | 1.3 |
| **Weed management practices** | | | | | | | | |
| Mechanical weeding at 15 and 30 DAS | 3826 | 5535 | 88.2 | 36.8 | 15.1 | 9.7 | 31.4 | 81.3 |
| Rice straw mulch (2 t/ha) | 3499 | 5318 | 81.2 | 35.1 | 13.9 | 9.0 | 28.7 | 72.8 |
| Neem oil spray (3%) at 30 DAS | 3120 | 4882 | 71.8 | 31.5 | 12.6 | 8.2 | 24.9 | 67.9 |
| Sulfosulfuron (25 g/ha) at 30 DAS | 3766 | 5488 | 87.4 | 36.7 | 14.9 | 9.4 | 30.8 | 79.7 |
| Weedy check | 2911 | 4726 | 66.9 | 29.7 | 11.1 | 7.0 | 25.1 | 66.7 |
| LSD (P=0.05) | 281.3 | 347.0 | 3.8 | 2.1 | 0.9 | 0.6 | 1.1 | 0.7 |



thereafter differences among seed rates were non-significant except between 125 and 150 kg seed/ha of nitrogen uptake in grain.

Weed management practices significantly increased the NPK uptake by wheat than weedy check (Table 4). The highest uptake of these nutrients was recorded under mechanical weeding which was significantly higher than weed management practices, but was on a par with sulfosulfuron. Pandey *et al.* (2001) also found that weed management treatments significantly increased the uptake of NPK in wheat over weedy check.

## System Productivity

The production of grain from rice-wheat system was significantly higher under the treatments of recommended seed rate of 100 kg/ha to both the crops. The increase in rice grain equivalent yield (RGEY) was 7.9, 14.4 and 15.4% over 125, 75 and 150 kg seed/ha, respectively.

The productivity of rice-wheat system in terms of RGEY was influenced significantly due to different weed management practices (Table 5). Among weed management treatments, the highest RGEY was obtained with use of anilophos in rice and mechanical weeding in wheat rotation. Uncontrolled weeds reduced RGEY by 37.2 %. The lowest RGEY was recorded with eucalyptus leaf leachate spray in rice rotated with neem oil treated plots in wheat because of its ineffectively in rice-wheat system.

## Economics

In rice, the highest net return (Rs.13402/ha) and benefit : cost ratio (0.93) were obtained with seed rate of 100 kg /ha due to the receipt of higher yield in this treatment. The lowest net returns of Rs. 9508/ha were recorded under 75 kg seed/ha, while the benefit : cost ratio of 0.65 with 125 kg seed/ha (Table 5). Weed management treatments had better economics over the weedy check. The highest net return of Rs. 13310/ha and benefit : cost ratio of 0.87 were recorded with anilophos at 500 g/ha, followed by wheat straw mulch (Table 5). Singh *et al.* (2002) reported increase in net profit with the spraying of anilophos.

In wheat, net return and benefit : cost ratio increased with increasing seed rates upto 125 kg/ha which recorded the highest net return (Rs. 29155/ha) and benefit : cost ratio (1.77). Further, increasing in seed rates from 125 to 150 kg/ha caused reduction in net return and benefit : cost ratio owing to higher cost of seed and lower yield (Table 5). All weed management practices gave more net return and benefit : cost ratio than weedy check (Table 5). Among weed management practices, sulfosulfuran at 25 g/ha was found more remunerative, as it fetched the highest net return (Rs. 29922/ha) and benefit : cost ratio (1.82) compared with other weed management practices. The higher cost of weed control is the reason for lower value of net return (Rs. 28507/ha) and benefit : cost ratio (1.53) under mechanical weeding treatment in spite of the highest

Table 5. Effect of seed rates and weed management practices on rice grain-equivalent yield and economics of rice-wheat system (Mean data of two years)

| Treatments: Rice | Treatments: Wheat | Rice grain equivalent yield (kg/ha) | Net return (Rs./ha): Rice | Net return (Rs./ha): Wheat | Net return (Rs./ha): Total | Benefit : cost ratio: Rice | Benefit : cost ratio: Wheat | Benefit : cost ratio: Total |
|---|---|---|---|---|---|---|---|---|
| **Seed rates (kg/ha)** | | | | | | | | |
| 75 | 75 | 7495 | 9508 | 23152 | 32660 | 0.68 | 1.46 | 2.14 |
| 100 | 100 | 8572 | 13402 | 27945 | 41347 | 0.93 | 1.73 | 2.66 |
| 125 | 125 | 7943 | 9793 | 29155 | 38948 | 0.65 | 1.77 | 2.42 |
| 150 | 150 | 7428 | 9770 | 20412 | 30182 | 0.65 | 1.22 | 1.87 |
| LSD (P=0.05) | | 599 | | | | | | |
| **Weed management practices** | | | | | | | | |
| Anilophos (500 g/ha) | Mechanical weeding | 8947 | 13310 | 28507 | 41817 | 0.87 | 1.53 | 2.40 |
| Wheat straw mulch (2 t/ha) | Rice straw mulch | 8124 | 11339 | 24295 | 35634 | 0.78 | 1.36 | 2.14 |
| Eucalyptus leaf leachate spray | Neem oil spray | 7534 | 11035 | 21945 | 32980 | 0.79 | 1.42 | 2.21 |
| Stale seed bed | Sulfosulfuron | 8552 | 11118 | 29922 | 41040 | 0.71 | 1.82 | 2.53 |
| Weedy check | Weedy check | 6519 | 6460 | 19892 | 26352 | 0.49 | 1.32 | 1.81 |
| LSD (P=0.05) | | 365 | | | | | | |



grain and straw yields.

In rice-wheat cropping system, the highest net return (Rs.41347/ha) and benefit : cost ratio (2.66) were recorded with recommended seed rate of 100 kg/ha. This might be due to significantly higher rice grain-equivalent yield under this treatment and relatively low cost of seeds. The lowest net return (Rs.30182/ha) and benefit : cost ratio (1.87) were obtained with the highest seed rate of 150 kg/ha, perhaps due to relatively less addition to yield, while the cost of input increased substantially. Weed management practices recorded higher economics over the weedy check. Among weed management practices, anilophos in rice and mechanical weeding in wheat gave the highest economics in terms of net return and benefit : cost ratio, followed by stale seed bed in rice and sulfosulfuron in wheat rotation. This could be attributed to significantly higher rice grain-equivalent yield with use of anilophos in rice and mechanical weeding in wheat over weedy check and lower cost of treatment.

Thus, it was concluded that for realizing higher yield, economic gain and effective weed management in direct seeded rice and zero-till wheat system, 100 kg seed/ha of rice and wheat crops should be applied with anilophos at 500 g/ha to rice crop and 125 kg seed/ha along with sulfosulfuron 25 g/ha at 30 DAS to the succeeding wheat crop.

## REFERENCES

Anonymous. 2007. *Vision 2025, NRCWS Perspective Plan.* National Research Centre for Weed Science (NRCWS), Jabalpur, Madya Pradesh, India. p. 22.

Bajpai, R. K. and R. P. Tripathi. 2000. Evaluation of non-puddling under shallow water tables and alternatives tillage methods on soil and crop parameters in a rice-wheat system in Uttar Pradesh. *Soil and Tillage Res.* **55** : 99-106

Blackshaw, R. E., H. J. Beckie, L. J. Molnar, T. Entz and J. R. Moyer. 2005. Combining agronomic practices and herbicides improve weed management in wheat-canola rotations within zero tillage production systems. *Weed Sci.* **53** : 528-535

Naik, P. L., B. A. Patel and K. K. Kalaria. 1991. Response of wheat (*Triticum aestivum*) varieties to sowing date and seed rate. *Ind. J. Agron.* **36** : 225-226.

Pandey, I. B., S. L. Sharma, S. Tiwari and V. Bharati. 2001. Nutrient uptake by wheat and associated weeds as influenced by tillage and weed management. *Ind. J. Weed Sci.* **33** : 107-111.

Raju, R. A. and B. Gangwar. 2004. Long-term effects of herbicidal rotation on weed shift, crop productivity and energy efficiency in rice (*Oryza sativa*)-rice system. *Ind. J. Agron*. **49** : 213-217.

Singh, N. P., L. Tangpong and T. Langkumar. 2002. Effect of weed management practices on weed population, weed dry weight, yield and economics of upland direct seeded rice cv. Nagaland local. *Ind. J. Hill Fmg.* **15** : 122-124.

Zimdahl, R. L.1980. *Weed Crop Competition–A Review.* International Plant Protection Centre, Corvallis, Oregon, USA. pp. 195.