GROWTH AND ECONOMIC ASSESSMENT OF MULCHES IN AEROBIC RICE (ORYZA SATIVA L.)

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ABSTRACT

A study was conducted in year 2010 at University of Agriculture, Faisalabad, Pakistan to evaluate effect of mulches in aerobic rice on various agronomic aspects. Transplanted rice (TpR) is water and labour intensive with higher production costs. Keeping in view water crisis, it demands research on new technology to increase water use efficiency and reducing rice cultivation cost. Direct seeded rice (DSR) has low-input demand and may be adopted by farmers if weeds are properly managed. Mulch has the potential to discourage weeds and conserve soil moisture to facilitate direct seeding of rice. Super Basmati was used for direct seeding as a test crop in RCBD to test five mulch materials [maize straw (MMaize), plastic sheet (MPlastic), wheat straw (MWheat), sunflower straw (MSunflower) and berseem (MBerseem) @ 5 t/ha] against non-mulched (M0) control and conventionally transplanted rice. The results indicate TpR significantly lowered total weeds and weeds dry weight compared with DSR (no mulch) while plastic mulch among other mulch treatments had lowered total weeds and weeds dry weight. However, rice yield parameter such as plant height, fertile tillers, panicle length, number of grains per panicle, 1000-grain weight and total grain yield were significantly higher in TpR than DSR (no mulch) while plastic mulch had higher yield attributes than other mulch treatments. Transplanted rice and other mulch materials had significant effect on quality parameters such as opaque kernel, chalky kernel, normal kernel while non-significant effect on abortive kernel and sterile spikelets. Transplanted rice and DSR (sunflower mulch) showed maximum net returns and benefit cost ratio than other treatments.

KEYWORDS: Oryza sativa; direct seeding rice; mulches; weeds density; grain yield; cost benefit analysis; Pakistan.

INTRODUCTION

The rice is one of the most important food crop in the world. In Pakistan, rice is the second major grain crop and major export item (1). It is the highest
water consuming among all the crops and consumes about 75% of the total available water resources in the world (22). Water is the major limiting factor for crop production in many parts of the world. Even in areas where water for irrigation is currently plentiful, concerns are increasing about its future availability (12). Thus, water scarcity threatens the sustainability of irrigated rice ecosystems since it may no longer be feasible for farmers to undertake wet cultivation and flood fields to ensure good crop establishment and control weeds (16). Rice is generally grown under puddled conditions mainly to reduce percolation losses and control weeds (20).

To avoid puddling, various resource conservation technologies for rice are being developed and used in different areas of the world. Direct seeded rice (DSR) under un-puddled conditions is one such technique which is more water efficient (24), apart from being labor and cost-effective (28). DSR consumes less irrigation water than puddled transplanted rice (7). So as conventional transplanting, require more quantity of water and this method has been replaced by direct seeding, mainly due to higher cost of transplanting and shortage of required labor (8). If weed infestation in direct seeded rice is properly controlled it may yield equally good as compared to transplanted rice (23).

Several methods are used, for the control of weeds. The current trend in agriculture focuses on reducing the use of pesticides due to their adverse effects on environment. Therefore, an alternative method should be explored. One of the alternative methods for the control of weeds is use of mulches (9). Effect of mulching on conserving moisture and increasing productivity of crops has been reported in rice crop by Kar and Singh (17). Applying mulch on the soil surface to reduce evaporation rate and discourage weeds is another water conservation practice in India (4). The combination of mulching with tillage conserves soil moisture and improves water use efficiency and grain yield (10). In non-flooded rice cultivation, plastic film mulching is considered as a novel water-saving technique and has been practiced in many areas in China since 1990s (29). Mulch has the potential to control weed growth (11). Organic mulches are also commonly applied to soil surface to suppress weeds, conserve soil moisture, moderate soil temperatures and suppress plant diseases (14). Crop residues such as mulch, which may selectively provide weed suppression through their physical presence on the soil surface, should be part of integrated weed management programme in an agro-ecosystem (35). Mulching with wheat residue has been shown to increase yield in water limiting situations (39). The objective of present study was to evaluate the effect of different mulches
in direct seeded rice on total weed density and dry weight; growth, yield and quality of rice against their parameters in transplanted rice under semi-arid climate.

MATERIALS AND METHODS

The proposed study was conducted at University of Agriculture, Faisalabad, during 2010 (latitude 31°26'N and 73°06'E, altitude 185 m), Pakistan. The climate of region is sub-tropical semi-arid with annual average rainfall of 490±5 mm of which 70% of the rainfall occurs during June–September. Mean monthly minimum temperature is 13°C in January and maximum temperature is 45°C in July. The soil is Hafizabad series (fine-loamy, mixed, hyperthermic, Typic Calciargids) and the soil texture is sandy clay loam. Selected field had sand, silt and clay 53, 20 and 27%, respectively. It contains N, available soil P, exchangeable potassium and organic matter 0.04%, 62 mg/kg, 83 mg/kg and 0.73%, respectively having pH 7.7±0.1 and EC 2.82±0.3 dS m⁻¹.

The experiment was laid out in RCBD having three replications with net plot size of 2.6 m × 5.0 m. Super Basmati was used as a test crop with five mulch materials [maize straw (M_Maize), plastic sheet (M_Plastic), wheat straw (M_Wheat), sunflower straw (M_Sunflower) and berseem (M_Berseem) @ 5 t/ha] to be assessed in DSR against a non-mulched control and conventionally transplanted rice for comparison. Sources of different crop mulches were chopped with the help of chopper and then applied between rows after sowing of the rice crop. The crop was sown on June 18, 2010 and was harvested on November 4, 2010. Recommended seed rate of 75 kg per hectare was used. In case of transplanting, nursery was raised using a seed rate of 40 g per m². The direct seeded crop was sown with the help of single row hand drill at optimum moisture conditions in 20 cm apart rows. However, in case of transplanting, the crop was planted in the pattern of 20 × 20 cm with manual labor. Nitrogen, phosphorus and potash fertilizers were applied @143, 88 and 68 kg per hectare, respectively. A full rate of phosphorus and potash and 1/3rd of N were applied at planting. Remaining nitrogen was applied in two doses at tillering and panicle initiation stage. For all mulched treatments 3 inches deep irrigation was applied every time to the known area of each plot measured by a cut-throat flume (90 cm × 20 cm). Total 20 irrigations were applied during crop growth period. The same practice was adopted for transplanted rice. Weed control practices were applied as per treatments. There was no significant infestation of insect pest or diseases.

Abortive, opaque, chalky and normal kernels were counted from randomly selected 20 panicles of primary tillers from each plot. The whole panicles

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were carefully sketched to differentiate between sterile spikelets, abortive, opaque and normal kernels as mentioned by Nagato and Chaudhry (26). Abortive kernels are those in which fertilization does take place but kernels do not attain full size as they stop growing during early stage of development. Opaque kernels are those which attain full size but do not become translucent due to lack of carbohydrates.

To study chalkiness of grains samples were hulled using a Satake Rice Machine (Model THU-35A) and McGill Polisher No. 3. After dehulling, the samples were sorted out by using a seed working board and table lamp. The chalky kernels were visually separated from normal kernels on the basis of chalky area present in different parts of kernel with the help of a high power magnifying glass. Sterile spikelets are those in which fertilization does not take place. Normal kernels are those that attain full size, translucent, show normal starch compaction.

Data were analyzed statistically using SAS (3). The effects of transplanted rice and mulch practices in direct seeded rice were evaluated by the least significant difference (LSD) test at \( P < 0.05 \) unless otherwise mentioned.

**RESULTS AND DISCUSSION**

**Mulch effects on total weeds density and weeds dry weight**

Mulch treatment in transplanted rice (TpR) and mulch treatment in direct seeded rice (DSR) had significant effect on total weed density and dry weight (Fig. 1 and 2). TpR lowered significantly total weed density by 86% followed by plastic mulch (81%) as compared to DSR mulch treatments (Fig. 1).

![Graph showing total weed density](image-url)
Weeds dry weight was significantly lower (80%) in TpR and plastic mulch than other treatments (Fig. 2). Significantly low total weeds density in TpR was due to continuous flooded conditions that suppress the weeds growth (28). Maximum weed density was noted in DSR (no mulch) and was less in DSR (plastic mulch) than the other mulch treatments. Plastic mulch covered the rows and created unfavorable conditions (light and temperature) for growth (33). Weed dry weight was significantly lower in puddled conditions due to less number of total weeds, which ultimately gave minimum weeds dry weight (6). Significantly, less weed dry weight per unit area in plastic mulch was due to low weed density and greater weed control efficiency (31).

**Fig. 2. Total weeds dry weight as affected by various mulching treatments in aerobic rice**

**Mulch effects on yield parameters of rice**

TpR and different mulch materials in DSR had significant effect on all yield parameters (Table 1). TpR had significantly 17% higher plant height as compared with DSR (no mulch). In case of mulch materials plastic mulch gave significantly higher plants by 3, 5, 6, 8 and 9% as compared to that in Maize, Berseem, Wheat, Sunflower and 0, respectively. Number of fertile tillers was significantly higher (15%) in TpR than direct seeded rice. Plastic mulch produced significantly higher number of fertile tillers (326.5) than those in Maize, Berseem, Wheat, Sunflower and 0 treatments.

Conventional TpR produced significantly higher (17%) panicle length than DSR (no mulch). Among mulch treatments, plastic mulch has significantly higher panicle length (11%) while Wheat, Sunflower, Berseem, Maize and 0
were statistically at par with each other. Number of grains per panicle was significantly higher (15%) in TpR than DSR while, plastic mulch gave 4, 6, 8, 9 and 12% higher number of grains than M\textsubscript{Maize}, M\textsubscript{Berseem}, M\textsubscript{Wheat}, M\textsubscript{Sunflower} and M\textsubscript{0}, respectively. Conventional TpR gave significantly higher 1000-grain weight (15%) than DSR. In case of mulch materials plastic mulch had significantly higher 1000-grain weight by 4, 6, 8, 9 and 12% than M\textsubscript{Maize}, M\textsubscript{Berseem}, M\textsubscript{Wheat}, M\textsubscript{Sunflower} and M\textsubscript{0}, respectively. Significantly, higher total yield (12.3 t/ha) was noted in TpR than DSR (8.3 t/ha). Among mulch treatments, plastic mulch had significantly higher 1000-grain weight by 4, 6, 8, 9 and 24% higher grain yield than M\textsubscript{Maize}, M\textsubscript{Berseem}, M\textsubscript{Wheat}, M\textsubscript{Sunflower} and (M\textsubscript{0}), respectively. Significantly higher total yield (12.3 t/ha) was noted in TpR than DSR (8.3 t/ha). Among mulch treatments, plastic mulch had 9, 11, 16, 18 and 29% higher paddy yield than M\textsubscript{Maize}, M\textsubscript{Berseem}, M\textsubscript{Wheat}, M\textsubscript{Sunflower} and M\textsubscript{0}, respectively. Trend was same in case of grain yield. Significantly, higher grain yield (4.3 t/ha) was recorded in TpR than DSR (no mulch) (3.2 t/ha). Plastic mulch produced significantly 4, 6, 8, 9 and 24% higher grain yield than M\textsubscript{Maize}, M\textsubscript{Berseem}, M\textsubscript{Wheat}, M\textsubscript{Sunflower} and (M\textsubscript{0}), respectively.

Table 1. Effect of mulch materials on plant height, fertile tillers, panicle length, number of grains per panicle, 1000-grain weight and total grain yields of direct seeded rice.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Plant height (cm)</th>
<th>Fertile tillers/m²</th>
<th>Panicle length (cm)</th>
<th>Grains per panicle</th>
<th>1000-grain wt (g)</th>
<th>Total yield (t/ha)</th>
<th>Grain yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transplanted rice</td>
<td>101.3a</td>
<td>335.5a</td>
<td>26.9a</td>
<td>96.7a</td>
<td>19a</td>
<td>12.3a</td>
<td>4.3a</td>
</tr>
<tr>
<td>No mulch (M\textsubscript{0})</td>
<td>83.9e</td>
<td>284.9e</td>
<td>22.3c</td>
<td>82.1e</td>
<td>16.1e</td>
<td>8.3e</td>
<td>3.2e</td>
</tr>
<tr>
<td>Maize straw (M\textsubscript{Maize})</td>
<td>88.7c</td>
<td>311.3c</td>
<td>23.8bc</td>
<td>89.7c</td>
<td>17.6c</td>
<td>10.6c</td>
<td>4c</td>
</tr>
<tr>
<td>Plastic sheet (M\textsubscript{Plastic})</td>
<td>91.9b</td>
<td>326.5b</td>
<td>25.1b</td>
<td>94.1b</td>
<td>18.5b</td>
<td>11.7b</td>
<td>4.2b</td>
</tr>
<tr>
<td>Wheat straw (M\textsubscript{Wheat})</td>
<td>85.9de</td>
<td>399.1d</td>
<td>23.2c</td>
<td>86.2d</td>
<td>16.9d</td>
<td>9.8d</td>
<td>3.9d</td>
</tr>
<tr>
<td>Sunflower straw (M\textsubscript{Sunflower})</td>
<td>84.3de</td>
<td>395.2d</td>
<td>23.2c</td>
<td>85.1d</td>
<td>16.7d</td>
<td>9.5d</td>
<td>3.8d</td>
</tr>
<tr>
<td>Berseem clipping (M\textsubscript{Berseem})</td>
<td>86.7cd</td>
<td>386.9c</td>
<td>23.5bc</td>
<td>88.4c</td>
<td>17.3c</td>
<td>10.3c</td>
<td>4c</td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td>2.74</td>
<td>7.75</td>
<td>1.58</td>
<td>7.75</td>
<td>0.43</td>
<td>0.53</td>
<td>0.09</td>
</tr>
</tbody>
</table>

All yield parameters were significantly higher in TpR compared with DSR. In flooded conditions, soil environment changes as all nutrients are dissolved in water (15). The uptake and availability of essential nutrients was done by the plant roots through mass flow process (6). The availability of nutrients resulted in improvement of plant metabolic process, which had positive effect on crop growth and yield (37). In TpR conditions weed germination and infestations were low due to anaerobic conditions (5). Significantly lower yield parameters in DSR (no mulch) was due to high weeds germination and infestation, which retards the rice growth (25).

Significantly, higher yield attributes were observed in plastic mulch than no mulch and organic mulch materials. Black plastic sheet has greater ability to conserve moisture by reducing the rate of evapotranspiration (21). The availability of soil moisture and thermal conditions favored the early vegetative growth to flowering, which synchronized the crop need for water
and improved the crop growth and yield attributes (30). The lower yield parameters in organic mulches were due to wider C:N ratio as well as high evapotranspiration rate resulted in less soil moisture percentage (38). Organic mulches response on growth and yield attributes was higher from no mulch and not too lower than plastic sheet (34). Organic mulches significantly increased the yield and yield attributes (36). The lower yield in DSR no mulch was due to higher weeds infestation (31).

**Mulch effects on grain quality parameters of rice**

Conventional TpR and different mulch materials under DSR had significant effect on opaque, chalky and normal kernel percentage and non-significant effect on abortive kernel and sterile spikelets percentage (Table 2). The DSR (no mulch) had significantly higher (18%) opaque kernel than TpR. Chalky kernel had significantly higher (23%) in DSR rice compared than TpR. Among mulch materials, no mulch has significantly 2, 3, 5, 7 and 8% higher than M_Wheat, M_Maize, M_Plastic, M_Sunflower, and M_Berseem, respectively. Berseem mulch under DSR had significantly higher normal kernel percentage (3) than TpR. In case of mulch materials, berseem mulch had significantly (2, 4, 5, 6 and 11%) higher normal kernel than M_Sunflower, M_Maize, M_Wheat, M_Plastic and no mulch rice.

There was no significant competition developed among spikelets at the grain filling stage (30). The higher percentage of normal kernels in berseem mulch under DSR might be attributed to better establishment of spikelets because of better resource utilization (36). The non-significant effect of TpR and different mulch materials under DSR on abortive and sterile kernel percentage might be due to optimum number of spikelets per panicle which

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Table 2. Effect of mulch materials on abortive kernels, opaque kernels, chalky kernels, sterile kernels, normal kernels and moisture retention of direct seeded rice.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Abortive kernel (%)</th>
<th>Opaque kernel (%)</th>
<th>Chalky kernel (%)</th>
<th>Sterile spikelets (%)</th>
<th>Normal kernel (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transplanted rice (TpR)</td>
<td>3.58</td>
<td>10.57e</td>
<td>20.87f</td>
<td>6.30</td>
<td>52.68c</td>
</tr>
<tr>
<td>No mulch (M_0)</td>
<td>4.35</td>
<td>12.95a</td>
<td>27.25a</td>
<td>7.25</td>
<td>48.20g</td>
</tr>
<tr>
<td>Maize straw (M_Maize)</td>
<td>3.64</td>
<td>11.10c</td>
<td>26.48b</td>
<td>6.69</td>
<td>52.09d</td>
</tr>
<tr>
<td>Plastic sheet (M_Plastic)</td>
<td>3.61</td>
<td>10.62e</td>
<td>25.86c</td>
<td>6.35</td>
<td>50.56f</td>
</tr>
<tr>
<td>Wheat straw (M_Wheat)</td>
<td>3.89</td>
<td>11.25b</td>
<td>26.55b</td>
<td>6.88</td>
<td>51.43e</td>
</tr>
<tr>
<td>Sunflower straw (M_Sunflower)</td>
<td>3.95</td>
<td>10.85d</td>
<td>25.31d</td>
<td>6.61</td>
<td>53.28b</td>
</tr>
<tr>
<td>Berseem clipping (M_Berseem)</td>
<td>3.75</td>
<td>10.10f</td>
<td>25.20e</td>
<td>6.65</td>
<td>54.30a</td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td>ns</td>
<td>0.14</td>
<td>0.07</td>
<td>ns</td>
<td>0.17</td>
</tr>
</tbody>
</table>

TR = Transplanted rice, M_0 = No mulch, M_Maize = Maize straw, M_Plastic = Black plastic sheet, M_Wheat = Wheat straw, M_Sunflower = Sunflower straw, M_Berseem = Berseem clipping. Ns = Non-significant. LSD = Least significant difference = P ≤ 0.05.
had no inter-spikelet competition and resulted in better development of kernels (33).

**Mulch effects on economics of rice**

Economic analysis of various mulch materials under DSR and TpR is given in Table 3. TpR had maximum net income (Rs. 29398/ha) followed by sunflower mulch under DSR (Rs. 26078). Higher net income in TpR was due to higher paddy and straw yield and low cost of production. However, sunflower mulch under DSR gave maximum benefit cost ratio of 1.31 followed by conventional TpR (1.30). Minimum benefit cost ratio of plastic mulch treatment was due to more cost of production. It is clear from data (Table 3) that sunflower mulch and maize mulch under DSR gave higher net returns than DSR (no mulch).

Table 3. Effect of mulch materials on gross income, total cost, variable cost, net return and benefit cost ratio of direct seeded rice.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Gross income (Rs./ha)</th>
<th>Total cost (Rs./ha)</th>
<th>Variable cost (Rs./ha)</th>
<th>Net return (Rs./ha)</th>
<th>BCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transplanted rice</td>
<td>126532</td>
<td>97134</td>
<td>24474</td>
<td>29398</td>
<td>1.30</td>
</tr>
<tr>
<td>No mulch (M0)</td>
<td>92050</td>
<td>81506</td>
<td>10544</td>
<td>29398</td>
<td>1.12</td>
</tr>
<tr>
<td>Maize straw (Mmaize)</td>
<td>116893</td>
<td>94886</td>
<td>22228</td>
<td>22007</td>
<td>1.23</td>
</tr>
<tr>
<td>Plastic sheet (Pplastic)</td>
<td>123095</td>
<td>115946</td>
<td>43288</td>
<td>7149</td>
<td>1.06</td>
</tr>
<tr>
<td>Wheat straw (Mwheat)</td>
<td>111930</td>
<td>96938</td>
<td>24280</td>
<td>14992</td>
<td>1.15</td>
</tr>
<tr>
<td>Sunflower straw (Msunflower)</td>
<td>110376</td>
<td>84298</td>
<td>11640</td>
<td>26078</td>
<td>1.31</td>
</tr>
<tr>
<td>Berseem clipping (Mbasseem)</td>
<td>115318</td>
<td>94746</td>
<td>20572</td>
<td>20572</td>
<td>1.22</td>
</tr>
</tbody>
</table>

BCR = Benefit cost ratio. Paddy price per kg = Rs. 28. Straw price per ton = Rs. 700. Total permanent cost = 72658.

Although paddy yield of plastic mulch was greater than other mulch materials. It was evident (Table 3) that due to more cost of plastic mulch it was not economical as compared to other mulch materials (19).

**CONCLUSION**

The present study revealed that TpR is superior to DSR because TpR gave higher crop growth and yield attributes and lower total weed density than all DSR mulch rice. Black polythene mulch compared with other mulch treatments, showed good potential for total weeds control, higher growth and yield in aerobic rice under the sub-tropical soil and climatic conditions. Quality parameters were significantly affected by TpR and DSR with mulch application while abortive and sterile spikelets were not affected significantly. Maximum net returns were obtained by TpR followed by DSR (sunflower mulch) while maximum benefit cost ratio of 1.31 was obtained in DSR sunflower mulch followed by TpR (1:30). Direct seeded rice offers an alternative way to future rice production under threat of global water scarcity and double labor rates. The extent and nature of weed flora is the main hindrance for the transition of TpR to DSR.

*J. Agric. Res., 2014, 52(3)*
REFERENCES


J. Agric. Res., 2014, 52(3)


25. Maqsood, M. 1998. Growth and Yield of Rice and Wheat as Influenced by Different Planting Methods and Nitrogen Levels in


