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RESEARCH PAPER

Quality characteristics of rice grains as influenced by varying irrigation regimes in furrow and bed transplanted rice (*Oryza sativa* L.)

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Abstract : A field investigation was carried out in Punjab Agriculture University, Ludhiana during the *Kharif* season 2005 to evaluate the effect of varying irrigation management practices on crop growth and grain quality characters in bed and furrow transplanted rice. Data on the brown, milled and head rice recovery indicated that the effect of different treatments on crop grain milling characters was non-significant. With reference to physico-chemical properties, all the treatments showed soft gel consistency *i.e.* gel consistency values varied from 87.7 to 97.0. Different treatments recorded low in gelatinization temperature (55-69^{o}C). Protein content in grains was also not significantly affected. Grain yield reduced significantly in bed and furrow transplanted rice under all the irrigation methods in comparison to recommended practice. The magnitude of reduction was highest (37-38%) in 'F' irrigation method followed by 22.1 to 24 per cent in 'Inun. B+F' and 9.1 to 14.3 per cent in 'Inun. B' over recommended practice-[Flat (BM)].

Key Words : Brown, Milled and head rice recovery, Gel consistency, Gelatinization temperature

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INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food of more than 60 per cent of the world's population. About 90 per cent of all rice is grown in the world is produced and consumed in the Asian region. Rice occupies a pivotal place in Indian agriculture and is staple food for more than 70 per cent of population and a source of livelihood for about 120-150 million rural households. Rice is primarily a high energy/ high calorie food. The protein content of milled rice is usually 6 to 7 per cent. The biological value of protein is high. The fat content of rice is low (2.0 to 2.5 %) and much of fat is lost during milling. Milled rice loses valuable proteins, vitamins and minerals in the milling process during which the embryo and the aleurone layer are removed.

Rice cultivation requires large quantity of water. This causes over-exploitation of the ground water, resulting into decline in water table at an alarming rate Therefore, it is of prime importance to save water, enhance crop water productivity and maintain its quality characters. Thus, the concept of reduced water supply per irrigation through furrow irrigated rows and bed or furrow transplanted rice was evaluated for its effect on rice productivity and quality of grain. These studies revealed 30 to 40 per cent saving in irrigation water when the irrigation water was applied in furrows as compared to flat borders. Paddy yields were either statistically same or slightly reduced particularly in years when the rains were about 50 % below normal (Mahey *et al.*, 2003; Kaur, 2004). However, in these studies the authors reported severe problem of weeds when irrigation water was applied in furrow and rice was transplanted in furrows or bed because of comparatively unsaturated conditions on the raised portion of beds where even if herbicide is applied, its activity is reduced and also

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prevalence of oxygenated conditions favored the growth of both narrow and broadleaf weeds. Thus, once again the physiological basis of *Echinochloa* seed germination and its control with herbicides' use under just saturation conditions were thought of, as has been the case in flat puddled transplanted rice (Gill *et al.*, 1988; Sandhu *et al.*, 1992) with the hypothesis that even if some water saving is sacrificed to maintain the saturated conditions on the raised portion of bed by just inundating them while applying irrigation water during the first two weeks after transplanting to get optimum control of weeds through herbicide even then a saving of about 50-60 cm (20-25%) in irrigation water can be achieved by furrow/bed transplanting system over conventional method. So, there is need to develop the agronomic practices to sustain its yield, conservation of resource base and also maintain its quality characters. Thus, the present investigation was undertaken to evaluate the effect of furrow and bed transplanting and varying irrigation management on crop yield and crop grain quality characters in rice.

MATERIAL AND METHODS

The field investigation was carried out at student's farm, Punjab Agricultural University, Ludhiana (30^0 56' N latitude with 75^0 52' E longitude, 247 m mean sea level) during *Kharif*, 2005. The soil of the experimental field was sandy loam, low in organic carbon (0.27 and 0.21 %) and available N (210 and 182 kg ha^{-1}) and medium in available P (18.9 and 17.8 kg ha^{-1}) and K (185 and 140 kg ha^{-1}) in 0-15 and 15-30 cm soil depth, respectively. The soil reaction (pH) and electrical conductivity were in the normal range. Nursery of pre-germinated seed of var. PR 116 was sown on 10/05/2005 to have 30-35 days old seedlings. Uprooted seedlings were transplanted on 15/05/2005 as per treatments keeping the plant population constant *i.e.* 33 hills m^{-2}. The experiment was laid out in a Randomized Block Design with four replications. The experiment comprised of 14 treatment combinations from seven planting methods × (irrigation treatments) *viz*., (i) Transplanting puddled flat × (Border method of irrigation) [Flat (BM)]; (ii) Transplanting 2 rows/ furrow×(Irrigation inundating beds during establishment phase and in furrows thereafter) [2R/F (Inun. B+F)]; (iii) Transplanting 2 rows/bed × (Irrigation inundating beds during establishment phase and in furrows thereafter) [2R/B (Inun. B+F)]; (iv) Transplanting 2 rows/furrow × (Irrigation inundating beds throughout after transplanting) [2R/F (Inun. B)]; (v) Transplanting 2 rows/bed × (Irrigation inundating beds throughout after transplanting) [2R/B (Inun. B)]; (vi) Transplanting 2 rows/furrow × (Irrigation in furrows throughout after transplanting) [2R/F (F)]; (vii) Transplanting 2 rows/bed × (Irrigation in furrows throughout after transplanting) [2R/B (F)] and two weed control treatments *i.e.* (i) Unweeded control [UWC] (ii) Use of pretilachlor @ 0.75 kg ha^{-1} and metsulfuron @ 0.015 kg ha^{-1} [Herbicide]. Pretilachlor was mixed with sand and applied at 2 days after transplanting and metsulfuron was sprayed 22 days after transplanting while nitrogen, phosphorus, potassium at the rate of 125, 30 and 30 kg ha^{-1} were applied through urea, di-ammonium phosphate and murate of potash. Whole of phosphorus, potassium and one-third nitrogen was applied before last puddling. Zinc sulphate was also applied at the time of puddling @ 62.5 kg ha^{-1}. The remaining N was applied in two equal splits at three weeks interval. Irrigation water was applied daily for the initial two weeks after transplanting and subsequent irrigations were applied two days after the pounded water has infiltrated in to the soil. The crop was harvested manually on October 11, 2005 *i.e.* 118 days after transplanting. Thrashing was done by beating the sheaves against hard surface.

To determine milling characters of crop grains, weighed samples (125 g at 14 per cent moisture content) of cleaned paddy were dehusked in a laboratory sheller equipped with rubber roller (Satake Rice Sheller, Satake Engg. Co., Japan). The shelled rice (brown rice) was weighed and expressed as the percentage of rough rice. Brown rice samples were polished in the Mc Gill Miller No. 2 (USA) in such a way to obtained 6 per cent degree of polish in all the samples and expressed as the per cent of rough rice which gives the value of milled rice recovery. The laboratory model Satake Test Rice Grader (Satake Engg. Co. Ltd., Japan) was used to separate the broken rice from the polished rice. The kernels with more than three fourth length were considered as head rice. The head rice recovery and broken rice yields were calculated as the percentage of rough rice. To determine physico-chemical properties of crop grains, the test was

Table A : Characteristics regarding spreading and clearing of rice kernels and corresponding score

Score	Spreading	Clearing
1.	Kernel not affected	Kernel chalky
2.	Kernel swollen	Kernel chalky, collar powdery
3.	Kernel swollen, collar complete or narrow	Kernel chalky, collar cottony or cloudy
4.	Kernel swollen collar complete and wide	Centre cottony, collar cloudy
5.	Kernel splits or segregated, collar complete and wide	Centre cottony, collar clear
6.	Kernel dispersed merging with collar	Centre cloudy, collar clear
7.	Kernel completely dispersed and intermingled	Centre and collar clear

performed with the method described by Little *et al.* (1958) to calculate gelatinization temperature. Six kernels per sample were placed evenly in a Petri dish. Ten ml of KOH (1.7%) solution was added. Petri dishes were kept undisturbed for 23 hours at room temperature (21 – 24^{0}C). Spreading and clearing of rice kernels was observed and score was given according to the scale (Table 1).

A rating of spreading of 1-3 is classified as high (>74^{O}C), 4-5 as intermediate (70^{O}C-74^{O}C) and 6-7 as low (55^{O}C-69^{O}C) gelatinization temperature. Clearing values are usually 1 unit lower than spreading values (Jennings *et al.*, 1979).

Gel consistency is determined by gel consistency test described by Cagampang *et al.* (1973). According to this method, whole grain of milled rice ground to pass through a 100-mesh sieve. Weigh 100 mg of powder in duplicate in culture tubes (100 x12 mm). Add 0.2 ml of 95 % ethanol containing 0.025 % thymol blue. Add 2.0 ml of 0.2 N KOH and mix with a cyclomixer/vortex mixer. Cover the tubes with glass marbles and heat in a vigorously boiling water bath for 8 minutes making sure that the tube contents reach 2/3rd the height of the tube.

Remove from water bath and let them stand for 5 minutes. Then cool in ice water bath for 20 minutes. Lay the tubes horizontally over a graph paper spread on a table. Do not disturb for one hour. Measure the total length of the gel (mm) from the bottom of the tube to the gel front. Gel consistency was characterized as per Table.

Table B : Gel consistency characteristics

Length of gel (mm)	Gel consistency
40 mm or less	Very flaky rice with hard gel consistency
41 – 61 mm	Flaky rice with medium gel consistency
More than 61 mm	Soft rice with soft consistency

To determine protein content, the per cent nitrogen estimated in the milled rice kernels by Kjeldhal's method was multiplied by 5.95 to get per cent crude protein (Bali and Uppal, 1999).

In order to test the significance of results, the data were subjected to statistical analysis of variance according to method given by Cochran and Cox (1967).

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Observations on crop grain quality characters:

Milling characters:

Brown, milled and head rice recovery:

Data on the brown, milled and head rice recovery (Table 1) indicate that neither the combinations of planting technique(irrigation method) nor the weed control levels alone or the interactive effects of the two affected these grain quality characters significantly. All treatments showed

Table 1: Quality of rice grain as influenced by various treatments

Treatments	Brown rice recovery (%)	Milled rice recovery (%)	Head rice recovery (%)	Gel consistency (length mm)	Alkali spreading and clearing value	Crude protein (%)	Grain yield (q/ha)
Unweeded control							
Flat (BM)	80.6	73.4	61.1	92.0	7, 6	8.4	50.3
2R/F (Inun. B+F)	78.8	71.1	60.6	89.5	7, 6	7.9	28.5
2R/B (Inun. B+F)	79.5	71.8	59.5	91.5	7, 6	8.3	26.1
2R/F (Inun. B)	80.2	72.4	59.1	91.0	7, 6	8.2	39.4
2R/B (Inun. B)	80.0	71.3	59.2	89.8	7, 6	8.4	35.8
2R/F (F)	79.0	70.7	57.9	87.7	7, 6	8.4	21.9
2R/B (F)	80.2	72.1	59.4	91.7	7, 6	8.2	21.4
Herbicides							
Flat (BM)	80.7	73.1	62.3	88.0	7, 6	8.2	55.7
2R/F (Inun. B+F)	80.7	72.4	61.5	90.7	7, 6	8.3	54.1
2R/B (Inun. B+F)	80.1	72.6	59.6	87.7	7, 6	8.2	54.5
2R/F (Inun. B)	80.2	72.2	59.2	91.0	7, 6	8.2	56.9
2R/B (Inun. B)	80.3	72.7	61.3	89.8	7, 6	8.1	54.9
2R/F (F)	79.8	72.0	59.9	96.0	7, 6	8.0	45.1
2R/B (F)	80.1	71.9	59.2	97.2	7, 6	8.3	44.7
Interaction CD (5 %)	NS	NS	NS			NS	3.5

NS=Non-significant

78.8% to 80.7 % brown rice recovery, 70.7% to 73.4% milled rice recovery and 57.9% to 62.3% head rice recovery. Similar results were reported by Singh (2002).

Physico-chemical properties:

Gel consistency:

Gel consistency measures the tendency of cooked rice to harden when it cools down. The gel consistency values (Table 1) in all the treatments was between 87.7 to 97.2, were greater than 61 mm. Therefore, all the treatments showed soft gel consistency. Rice with soft gel consistency cook tender and remain soft even after cooking (Juliano, 1979). Breeders are trying to devolp heigh yielding varities with soft gel consistencey (Khush *et al.*, 1979). Rice with soft to medium gel consistency is preferred by most rice consumers (Sarkar *et al.*, 1994).

Gelatinization temperature:

Gelatinization temperature is the temperature at which the starch in rice begins the process of cooking. At this point the starch granules take in the water and lose their crystalline nature, a change which is irreversible. Time required for cooking milled rice is determined by gelatinization temperature. The results show (Table 1) that there was no effect of different planting technique (irrigation method) and weed control treatments on the alkali spreading and clearing values. All treatments showed 7, 6 value for alkali spreading and clearing, respectively. Alkali spreading value is inversely related to temperature at which rice starch granules gelatinized (Mutters and Thompson, 2009). So, these are recorded low in gelatinization temperature (55-69^{o} C).

Protein content:

Protein content in rice is one of the important quality characters, which influence the quality of grains. The data on protein content presented in Table 1 show that there was no significant effect of planting technique(irrigation method), weed control treatments and the interaction of the two parameters on protein content of rice. All treatments showed value of protein content in between 7.9% to 8.4%. Singh (2002) and Kaur (2004) observed no differences in grain protein content due to planting techniques and varied amount of irrigation water.

Grain yield:

Grain yield is the ultimate outcome on the basis of the cumulative effect of various treatments on the different yield attributing characters. The data on grain yield given in Table 1 reveal that when averaged over unweeded control and herbicide use conditions, the yield reduced significantly in bed and furrow transplanted rice under all the irrigation methods in comparison to recommended practice. Weed management through herbicide use helped to register a significant increase (64.0%) in grain yield over unweeded control.

Irrespective of the planting technique, under unweeded control conditions the grain yield was significantly superior under different irrigation systems in the order that (F) < (Inun. B+F) < (Inun. B) < (BM) whereas under herbicide use conditions the order of statistical superiority, with regards to grain yield under different irrigation system was (F) < (Inun. B+F) = (Inun. B) = (BM). This has clearly demonstrated the significantly higher values for various yield attributes under herbicide use conditions. These findings are in conformity with as postulated by Kumar *et al.* (2004) and reported by Sandhu *et al.* (1992). The treatment 2R/F(Inun. B+F) × herbicide (when irrigation water was allowed just to pass over the bed for first 15 days after transplanting) yielded at par, resulted in 23.9 per cent saving in terms of net water expense and 27.7 per cent increase in net water-expense-efficiency when compared with recommended practice × herbicide.

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