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Influence of flag leaf clipping, variety and sowing dates on nutritional quality in rice [*Oryza sativa* L.]

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Rice [*Oriza sativa* L.] is the most popular cereal throughout the world serving as a staple food for 39 countries and nearly half of the world's population (Juliano, 1993). It occupies 43.8 million hectares with a total production of 96.4 million tonnes of rice (Anon., 2009). Among many approaches available to break the yield barrier, hybrid rice technology appears to be the most feasible and adaptable one amongst the farmers. The area under hybrid rice during 2004 was about 5.60 lakh hectares, which is expected to double during 2005 (Mishra, 2005). With the development of stable, widely adapted hybrids, large scale seed production, and its distribution, aggressive technology transfer activities, this technology is moving faster than before. Rice hybrids with a yield advantage of 15-20 percent over the check varieties have become popular in Uttar Pradesh, Jharkhand, Chhattisgarh, Punjab, Haryana, Karnataka, Maharashtra and Goa. Warren and Farell, (1990) observed in rice bran from Australia that over half of the P was in phytate form; phytate content was about 33g kg^{-1} in the rice brans of different rice cultivars, examined. The phytate content in different varieties of uncooked rice ranged between 0.05 and 0.22% which after cooking decreased up to 82% (Mameesh and Tomar, 1993). Dhaliwal *et al.* (1986) observed in rice cultivators that grain crude protein content was increased by late transplanting. Late transplanting reduced the minimum cooking time. Lin *et al.* (1971) obtained protein content 9.51%, ash content 1.62%, fat content 3.24%, starch content 79.67%, reducing sugar content 1.5% with enhanced productivity, hybrid rice technology will enable farmers to get more yield from less land so that additional land can be utilized for crop diversification. Grain quality is an end product of interaction among genetic, nutritional and environmental factors. Thus, among the different management practices, planting period is a major non-monetary input which plays a significant role in determining growth, yield and quality of hybrid rice. As because the flag leaf has a major contribution in translocation of nutrients to the grain after anthesis stage, another treatment of flag leaf clipping may impart some effect on performance of the crop. The present investigation was carried out to ascertain the quality of the grains in three rice hybrids as influenced by date of planting and flag leaf clipping.

The field experiment was conducted at R. R. S. Raghunathpur of BCKV in split split plot design with three replications, having 18 treatment combinations comprising of 3 planting dates in main plots, three hybrid rice varieties in the subplot and flag leaf clipping in the sub-subplots. In each plot twenty five days old seedlings were transplanted with two seedlings per hill adopting a spacing 15×15 cm apart between rows and hills. The sub plots area was 6 m^2 each.

Details of the treatment of experiments

Treatment	Treatment code	Particulars
Main plot	D_1	16^{th} July
3 dates of planting	D_2	31^{st} July
	D_3	13^{th} August
Sub plot	V_1	PAC 832
3 cultivars	V_2	Suruchi 5319
	V_3	PA 6444
Sub-sub plots		
2 treatment of flag leaf	F_1	No flag leaf clipped
	F_2	Flag leaf clipped at the anthesis stage.

Short communication

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Freshly harvested paddy grain 50 g from each replicate was collected and dried in the sun before in an oven at 40^0C until a constant weight was obtained. Each sample was then dehusked then ground to a fine powder with an electrical grinder. The powdered and dried samples were stored in plastic lock bags for analysis. The total sugar and starch contents were determined using universal anthrone method (Hedge *et al.*, 1962). The crude protein content was based on the organic nitrogen content, which was determined by the Kjeldahl procedure. (Sadasivam and Manickam, 1992) The crude protein content was calculated by the equation. Crude protein content (%) = percent nitrogen × 5.95. A dried sample 5 g was extracted with petroleum ether (60-80) in a soxlet apparatus for 8 hours. The petroleum ether was then removed from the extraction flask and the weight of the petroleum ether soluble material was obtained. The crude fat content was calculated as a percentage of fresh weight of sample (Sadasivam and Manickam, 1992).

$$\text{Crude fat in ground sample \%} = \frac{\text{Weight of oil (g)}}{\text{Weight of sample}} \times 100$$

Dried powdered sample were digested in A. R. grade of triacid mixture of HNO_3: H_2SO_4: $HC1O_4$ (10: 1: 4) as described by (Jackson 1973). The volume of digested extract was made to 50 ml with double distilled water and stored in a plastic container after passing through Whatman no. 42 filter paper. The concentration of manganese and zinc in the extract was determined by atomic absorption spectrophotometer (Perkin Elmer model, 2380) while potassium were determined by flame photometer (Chminto model 1020). Calcium plus magnesium (Ca + Mg) concentration in the extract was estimated from digested sample by titration with EDTA using eriochrome black T (EBT) indicator whereas the calcium concentration in the extract was determined by EDTA titration using calcon indicator (Piper,1950). Phytate was determined by the method of (Boland et al. 1975). Finely ground 1.5 g samples were used for phosphorus determination. Phosphorus content of the digest was determined calorimetrically by vanadomolybdate method (Jackson, 1973). Phytic acid was calculated on the assumption that it contains 28.2% of phosphorus.

The data collected as described in this chapter were subjected to statistical analysis by the analysis of variance method (split-split plot designed). Significant deference between two means values were obtained by CD calculation using t-test (Gomez and Gomez, 1984).

Average data of chemical composition of the hybrid rice cultivars were presented in table- 1and 2. It was observed from the table that total sugar scored highly significant differences. However, the effects of flag leaf clipping and that of V×F produced non significant values. The experiment revealed that D_2 had a pronounced effect on total sugar and had produced the highest score (1.85%). The effect of variety also resulted highly significant difference where V_1 exhibited 1.41% total sugar followed by V_2 (1.07%) and V_3 (1.30%). The D×V interaction produced a significantly high value (1.87%) in D_3V_1 whereas in case of interaction D×F the highest value of 1.49% in D_3F_2 was observed. Total sugar was also affected significantly by the interaction D×V×F where the highest value (1.95%) was offered by $D_3V_1F_2$. Dunand and Dilly, (1982).

The starch content was also significantly influenced by planting date, variety, flag leaf clipping and the interaction D×V whereas all other effects had been found no significant. It was discernible from the present experiment that the latest planting date (D_3) produced the highest amount of starch (66.83) in grain. Moreover, the V_1 is the best performer with respect to Starch content (65.85%) followed by V_2 (64.39%) and V_3 (62.21%). Ramarathnam and Kulkarni (1988) recorded earlier starch contents of 65% to 72% in grain of rice cultivars. Again flag leaf clipping affected adversely producing (61.41%) starch as compared to (66.88%) in plants with intact flag leaf. Abou-khalifa *et al.* (2008) reported that, sugar, and starch parameters were severely affected to decrease by the removal of flag leaf. Furthermore, the highly significant effect of DxV interaction produced 69.23% starch in D_1V_1.

Crude protein content was affected by flag leaf clipping producing significant difference between the values. F_1 yielded 9.27% protein followed by 8.72% in F_2. All other values were found non significant though high scores of 9.66% in D_3V_2, 9.96% in both $D_3 \times V_2F_1$ and $D_2V_2F_1$ were obtained. This finding was contradictory with that of Dhaliwal *et al.* (1986) who reported an increase of crude protein following late transplanting. The crude protein content of varieties were 8.65% (V_1) 9.12% (V_3), and 9.22 (V_2), which were support to the earlier report of 6.2% to 9.4% (Dipti *et al.*, 2003). The effect of variety and that of flag leaf clipping produced highly significant difference in crude fat content whereas all other values were found no significant. Among the varieties V_3 produced maximum amount of fat (0.66%) followed by V_2 (0.64%) and V_1 (0.34%). These values were centered on 0.4% recorded earlier by Swills *et al.* (1982). Amongst the flag leaf clipping treatments F_1 produced the higher value (0.62%) than F_2 (0.48%). The amount of phytate and potassium failed to produce values with significant difference in both the cases of variety and treatments as well as interactions.

Table 1: Chemical composition of rice cultivars

Treatment	Total sugar	Starch	Crude protein	Fat	Phytate	K	Ca	Mg	Zn	Mn
Planting date			(%)					(mg100^{-1}g)		
D_1	1.30	63.16	8.72	0.51	0.58	22.29	22.45	58.03	1.49	3.20
D_2	1.85	62.45	9.81	0.58	0.57	22.17	24.88	56.81	1.62	3.11
D_3	1.44	66.83	9.26	0.55	0.56	22.03	27.38	57.52	1.63	3.33
SEm (±)	**0.05**	**0.66**	**0.21**	**0.07**	**0.01**	**0.49**	**0.28**	**0.60**	**0.04**	**0.09**
LSD (0.05)	**0.26**	**2.58**	**NS**	**NS**	**NS**	**1.82**	**NS**	**NS**	**NS**	**NS**
Variety										
V_1	1.41	69.85	8.65	0.34	0.59	22.06	26.43	58.80	1.34	2.63
V_2	1.07	64.39	9.22	0.64	0.56	22.47	24.95	61.94	1.42	3.52
V_3	1.30	62.21	9.12	0.66	0.57	21.96	2033	51.62	1.99	3.48
SEm (±)	**0.05**	**0.76**	**0.26**	**0.04**	**0.01**	**0.44**	**0.60**	**0.67**	**0.04**	**0.06**
LSD (0.05)	**0.22**	**23**	**NS**	**0.17**	**NS**	**NS**	**2.58**	**2.89**	**0.17**	**0.26**
Flag leaf clipping										
F_1	1.33	66.88	9.27	0.62	0.57	22.45	24.76	58.23	1.60	3.21
F_2	1.20	61.41	8.72	0.48	0.57	21.88	23.03	60.68	1..56	3.21
SEm (±)	**0.05**	**0.56**	**0.15**	**0.02**	**0.011**	**0.43**	**0.38**	**0.42**	**0.03**	**0.04**
LSD (0.05)	**NS**	**0.20**	**0.44**	**0.001**	**NS**	**NS**	**1.54**	**1.29**	**NS**	**NS**
Planting date × variety										
D_1V_1	1.26	69.23	8.25	0.31	0.62	22.20	22.63	59.03	1.26	2.56
D_1V_2	1.13	61.91	8.42	0.61	0.58	23.46	24.68	63.56	1.43	3.48
D_1V_3	1.51	58.28	8.92	0.61	0.30	21.21	20.05	51.50	1.79	3.55
D_2V_1	1.12	60.96	8.60	0.33	0.59	21.18	29.20	57.90	1.46	2.52
D_2V_2	0.73	64.86	9.58	0.68	0.56	21.80	24.93	61.28	1.36	3.47
D_2V_3	1.13	61.53	8.85	0.73	0.57	21.55	20.53	51.26	2.04	3.34
D_3V_1	1.87	67.35	8.53	0.37	0.56	22.81	27.46	59.48	1.31	2.83
D_3V_2	1.36	33.66	9.66	0.63	0.54	22.16	25.25	60.98	1.45	3.61
D_3V_3	1.10	66.81	9.60	0.65	0.59	21.13	20.43	52.11	2.13	3.55
SEm (±)	**0.09**	**1.32**	**0.46**	**0.07**	**0.02**	**0.76**	**1.03**	**1.16**	**0.07**	**0.11**
LSD (0.05)	**0.39**	**5.69**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Planting date × flag leaf clipping										
D_1F_1	1.29	65.85	9.19	0.61	0.57	21.87	23.64	58.30	1.56	3.10
D_1F_2	1.31	60.47	8.25	0.42	0.59	22.71	21.26	57.76	1.42	3.30
D_2F_1	1.32	65.87	9.36	0.66	0.56	22.97	25.62	58.52	1.59	3.16
D_2F_2	0.78	59.83	8.65	0.50	0.58	21.37	24.15	55.11	1.65	3.05
D_3F_1	1.40	98.93	9.25	0.58	0.58	22.51	25.02	57.88	1.66	3.37
D_3F_2	1.49	64.73	9.27	0.52	0.55	21.56	23.74	57.16	1.60	3.28
SEm (±)	**0.09**	**0.97**	**0.27**	**0.04**	**0.02**	**0.75**	**0.66**	**0.73**	**0.05**	**0.07**
LSD (0.05)	**0.37**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Variety × flag leaf clipping										
V_1F_1	1.50	68.42	8.93	0.39	0.59	21.86	27.55	59.66	1.32	2.66
V_1F_2	1.33	63.27	8.36	0.28	0.59	22.26	25.31	57.94	1.37	2.61
V_2F_1	1.12	67.81	9.44	0.71	0.57	22.12	26.43	62.78	1.47	3.53
V_2F_2	1.03	68.97	9.00	0.57	0.55	22.83	23.47	61.10	1.40	3.51
V_3F_1	1.38	64.43	9.44	0.75	0.55	23.37	20.30	52.25	2.06	3.45
V_3F_2	1.22	59.58	8.81	0.57	0.56	20.55	20.37	51.00	1.91	3.51
SEm (±)	**1.22**	**0.57**	**0.27**	**0.04**	**0.02**	**0.76**	**0.66**	**0.74**	**0.05**	**0.07**
LSD (0.05)	**0.09**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Cont..

Table 1: Chemical composition of rice cultivars

Treatment	Total sugar	Starch	Crude protein	Fat	Phytate	K	Ca	Mg	Zn	Mn
			(%)					($mg100^{-1}g$)		
Planting date × variety × flag leaf clipping										
$D_1V_1F_1$	1.16	71.46	8.98	0.36	0.60	20.73	24.56	58.63	1.28	2.54
$D_1V_1F_2$	1.35	67.00	8.66	0.26	0.64	23.66	20.70	59.43	1.24	2.57
$D_1V_2F_1$	1.40	65.23	8.98	0.70	0.60	22.46	25.96	63.96	1.49	3.38
$D_1V_2F_2$	0.86	58.73	7.85	0.53	0.57	24.46	23.40	63.16	1.38	3.59
$D_1V_3F_1$	1.31	60.86	9.62	0.76	0.51	22.43	20.40	52.3.	1.92	3.37
$D_1V_3F_2$	1.70	55.70	8.23	0.46	0.55	20.00	19.70	50.70	1.66	3.73
$D_2V_1F_1$	1.52	64.73	9.06	0.36	0.60	21.00	29.83	59.50	1.46	2.57
$D_2V_1F_2$	0.70	57.20	8.13	0.30	0.58	21.36	28.56	56.30	1.46	2.47
$D_2V_2F_1$	0.66	68.96	9.96	0.80	0.54	23.00	26.76	62.86	1.30	3.53
$D_2V_2F_2$	0.80	68.76	9.20	0.56	0.58	20.60	23.10	59.70	1.43	3.42
$D_2V_3F_1$	1.76	63.93	9.06	0.83	0.56	24.93	20.26	53.20	2.00	3.40
$D_2V_3F_2$	0.84	59.13	8.63	0.63	0.58	22.16	20.80	49.33	2.08	3.28
$D_3V_1F_1$	1.80	69.46	8.76	0.45	0.58	23.86	28.26	60.86	1.22	2.68
$D_3V_1F_2$	1.95	65.63	8.30	0.30	0.55	21.76	26.66	58.10	1.40	2.80
$D_3V_2F_1$	1.30	69.23	9.36	0.63	0.57	20.90	26.56	61.53	1.51	3.68
$D_3V_2F_2$	1.40	63.43	9.96	0.63	0.49	23.43	23.93	60.43	1.40	3.54
$D_3V_3F_1$	1.10	68.00	9.63	0.66	0.59	22.76	20.23	51.26	2.27	3.59
$D_3V_3F_2$	1.10	65.13	9.95	0.63	0.59	19.35	20.63	52.96	1.99	3.51
SEm (±)	**0.15**	**1.69**	**0.47**	**0.07**	**0.03**	**1.31**	**1.14**	**1.27**	**0.09**	**0.12**
LSD (0.05)	**0.61**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Note: NS - Non significance

The phytate content in varieties ranged between 0.56% and 0.59% which was nearer to the value reported earlier (0.6 -1.02%) by (Wei *et al.*, 2007). The varietal performance in case of potassium ranged from 21.96 to 22.47 (mg 100^{-1} g)g was lower than the earlier report (30 mg 100^{-1} g) of Watts and Dronzek (1981).The effects of planting date, variety and flag leaf clipping were highly significant on the content of calcium. So far as the date of planting was concerned the maximum value (24.88 mg 100^{-1} g) was produced by D_2 followed by D_1 (22.45 mg 100^{-1} g) and D_3 (24.38 mg 100^{-1} g). Amongst the varieties V_1 showed best result (26.43 mg 100^{-1} g) followed by V_2 (24.95 mg 100^{-1} g) and V_3 (20.33mg 100^{-1} g). Plants with flag leaf contributed a higher value of (24.76mg 100^{-1} g) than 23.05mg 100^{-1} g) in plants without flag leaf. Some high values of calcium were produced by combinations D_2V_1 (29.20), D_3V_1 (27.46), D_2F_1 (25.62), V_1F_1 (27.55), $D_2V_2F_1$ (29.83), $D_2V_1F_2$ (28.56), $D_3V_1F_1$ (28.26mg 100^{-1} g) though these were no significant.

In each treatment the results were lower than the values of calcium reported earlier (35-63.5mg 100^{-1} g) by Dekeman *et al.*, 1982. Effect of variety produced highly significant magnesium contents whereas effects of flag leaf clipping produced significant values of the mineral. In case of all other treatments and interactions the values were non significant. Amongst the varieties V_2 offered the highest value (61.94mg 100^{-1} g) followed by V_1 (58.80mg 100^{-1} g) and V_3 (51.62mg 100^{-1} g) These values were quite lower than the value of (110mg 100^{-1} g) reported earlier by (Watts and Dronzek 1981). Flag leaf clipping produced a 2.66% magnesium content in kernel which is lower than in plants having intact flag leaf. In case of zinc all the effects were found non-significant except the effect of variety which was highly significant. V_3 produced the highest zinc content (1.99mg 100^{-1} g) followed by V_2 (1.42 (mg 100^{-1} g) and V_1 (1.34mg 100^{-1} g) These values were lower than the range (2.05 – 2.72mg $100g^{-1}$) found earlier by (Park 1981). Treatment of variety was also observed highly significance in case of manganese content. In this case V_2 offered the highest value (3.52mg 100^{-1} g) followed by V_3 (2.48mg 100^{-1} g) and V_1 (2.63mg 100^{-1} g). All other effects on manganese content has been found non-significant. This result was contradictory to the earlier report (1.70mg 100^{-1} g) of Watts and Dronzerk, (1981).

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