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Effect of summer legumes incorporation on quality parameters of succeeding *Kharif* rice

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Abstract

In Navsari, Gujarat, at the College Farm of Navsari Agricultural University, a field experiment was conducted in the summer and *kharif* of 2021 and 2022. With 4 main plots and 6 subplot treatments, the experiment comprised of twenty-four treatment combinations that were replicated 3 times in a split plot design. Results posed that significantly higher milling quality parameters and protein content of rice was found when rice grown in dhaincha incorporated plots (T3) and it was followed by green gram (T1), cowpea (T2) incorporated plots, and significantly lower values were seen in the fallow treatment (T4) for both years and in the pooled analysis. However, amylose and amylopectin content in rice was non-significant during the study. In the case of recommended levels tested during *kharif* in rice, significantly higher values of milling quality parameters, amylose, amylopectin, and protein content percentage were higher with application of 100% RDF (W1) and *fb* 75% RDF + 25% N from FYM (W4) during 2021-2022 and in pooled basis. Whereas the treatment No-fertilizer application (W6) recorded lower values throughout both the years and on a pooled basis. The experimentation revealed that dhaincha incorporation and 100% RDF proved as better in enhancing milling quality attributes and protein content whereas amylose and amylopectin percentages did not vary under residue incorporation.

Keywords amylopectin, amylose, milling quality parameters, protein content, summer legumes

Introduction

Rice (*Oryza sativa* L.) is a staple and most popular food in Asia and for over half of all people on the earth, which has been recognized as the global grain. It contributes around 40% of the nation's overall production of food grains. Crop residues are crucial for the stability of agricultural ecosystems and are a valuable source of plant nutrients. A 9.2 Mt C loss, equivalent to the CO_2 emitted by the annual in situ burning of over 23 Mt of rice residues in northwest states [1]. Crop residue burning is a serious threat to the environment; instead, crop residues that are opulent in nutrients can mimic as fertilizer input [2], reported that approximately 30-40 % of the N, 25-35 % of the P, 70-85 % of the K, and 35-45 % of the S received by cereals stay in vegetative portions at maturity, providing plant nutrients upon mineralization and improving soil biophysical conditions, thus aiding in reducing fertilizer dosage to some extent. Therefore, fertilizer demand which is resultant of the growing population to increase yield, its excessive usage, and improper management practices deteriorating the health of soil at a faster pace. In order to minimize the effect of modernization and to increase the soil fertility levels, residue incorporation serves as a tool and this also aids in reducing crop residue burning. This could be an alternative approach to reducing fertilizer consumption. Under the condition of crop residue incorporation (aid in fertilizer conservation or soil conservation which is reflected in sustainable agriculture), the quality of rice has to be analyzed where quality is one of the prime criteria for market value, nutrition, etc. Rice production, consumption, and consumer preference are significantly influenced by the physicochemical properties of rice grains, which include physical attributes like chalkiness, shape, size, perfection, and appearance as well as chemical composition like amylose (a linear homopolymer of glucopyranose units linked by α-(1,4) linkage), amylopectin (a branched homopolymer of glucopyranose with α-(1,4) and α-(1,6) linkage) [3], protein content, and lipid content. As a result, consumers are exerting increasing pressure on rice producers to upgrade the quality of their rice grains, as the market price of rice is significantly impacted by its poor physical condition, lowering the income of value-chain operators [4]. To check the quality of rice when it is grown after crop residue incorporation research is requisite to probe the issues of crop residue incorporation under varied recommended levels of nutrient doses in *kharif* rice with the objective to investigate the aftermath of incorporation of summer sown legumes on quality of succeeding *kharif* rice.

Methodology

The field experiment was administered on clayey texture and slightly alkaline soils of NAU at plot F/17 at College Farm, Navsari (Gujarat) during the summer and *kharif* seasons of 2021 and 2022. The available N in the soil of the experimental field was low (247.70 kg/ha), the available P_2O_5 was medium (47.82 kg/ha), the organic carbon content was medium (0.72%), and the available K_2O was high (377.12 kg/ha). The main plot treatments used in the experiment were T1: Green gram, T2: Cowpea, T3: Dhaincha, and T4: Fallow. These treatments were sown during the summer and were replicated thrice using a randomized block design. Green gram (T1) and cowpea (T2) residues from summer legume crops were added after the seed harvest, and dhaincha (T3) was added to plots at 50% flowering. Six sub-plot treatments were drawn for each main plot treatment throughout the *kharif* season based on the levels of the recommended fertilizer dose for *kharif* rice, which include W1: 100% RDF (100: 30: 00 N-P_2O_5-K_2O kg/ha), W2: 75% RDF, W3: 50% RDF, W4: 75% RDF + 25% N from FYM, W5: 50% RDF + 50% N from FYM, and W6: No-fertilizer application; resulting in 24 treatment combinations replicated thrice in a split plot design. Calculating the protein content (%) of rice involved multiplying the nitrogen content of the grain by 5.95 [5]. After being thoroughly dried to a moisture content of 12–14%, 120 g of rough rice from each treatment was run through a paddy sheller (Satake-Make). The weight of the dehulled kernel was then obtained, and the hulling percentage was computed using the following formula provided by Bandyopadhyay and Roy [6]. The milled rice drawn after polishing was separated into broken and unbroken (whole) kernels. The head rice recovery, is calculated as the ratio of unbroken (> 2/3rd of total length) to the initial weight of paddy sample (120 g) and expressed in percentage according to the formula given by Bandyopadhyay and Roy [6]. The de-hulled kernels recovered after hulling were milled in a rice polisher (Satake-Make) for one minute. The milled rice thus drawn was weighed in grams and the milling value was computed as the ratio of milled rice to the initial weight of the paddy sample (120 g) and expressed in percentage according to the formula given by Bandyopadhyay and Roy [6].

Hulling (%) = {Weight of dehulled grain (g)}/ {Weight of paddy (g)} X 100

Milling (%) = {Weight of milled grain (g)}/ {Weight of paddy (g)} X 100

Head Rice Recovery (%) = {Weight of whole polished grain (g)}/ {Weight of paddy (g)} X 100

Amylose, a linear component of starch, has a substantial impact on the cooking and eating properties of rice. It has a significant impact on how cooked rice will texture as well. According to the method outlined by Sadasivam and Manickam [7], the percentage of grain amylose content was calculated.

Procedure for standard curve for amylose estimation

In a volumetric flask, combine 40 mg of amylose with 1 mL of rectified spirit. Then, 9 mL of 0.1 N sodium hydroxide is added. Shake well, then boil for 15 minutes over a water bath to form a 100 ml solution in a volumetric flask. In 3 replications, pipette out 1 ml, 2 ml, 3 ml, 4 ml, and 5 ml of the standard amylose into volumetric flasks. Add 0.2 ml of acetic acid and 2 ml of iodine + KI to 1 ml of standard amylose solution; likewise, add 0.4 ml of acetic acid and 2 ml of iodine + KI to 2 ml of standard amylose solution; and so on for 3 ml, 4 ml, and 5 ml. Make up the solution to 100 ml after adding the KI and iodine, cover the flasks with a black cloth, and take a reading at 620 nm using a spectrophotometer after 20 minutes.

Procedure of analysis of amylose content in rice

To affirm that every sample has the same moisture level, make sure they have all been kept in the same room for two days. Pour 1 ml rectified spirit and 8 ml 0.1 N NaOH into a long test tube measuring 100 mg rice flour. Give the test tube a good shake and let it sit in a water bath for fifteen minutes. Once the sample has been digested, pour it into a 100 ml volumetric flask and top it off with more liquid. Three replications of a 5 ml solution should be drawn into three 100 ml volumetric flasks. Add 1 ml of acetic acid and 2 ml of I2-KI reagent to each 5 ml solution to make 100 ml in a volumetric flask. Because I2-KI loses color when exposed to light, cover all of the flasks with black cloth. Take readings with the spectrophotometer after adjusting it to 620 nm. The quantum of amylose is determined by its presence. The computation was performed by plotting the net optical density (absorbance) on the y-axis and the amylose concentration on the x-axis of a conventional graph. The concentration of amylose in biological samples can be determined using the graph's equation. Alternatively, the multiplication factor (MF) is created by multiplying the X/Y value (A) around the graph's midpoint by the dilution factor (20) to obtain B (MF). To find the amylose content (%), multiply the biological sample's net optical density by B. The formula provided by Torruco-Uco et al., [8] was used to ascertain the amount of amylopectin.

$$\text{Amylopectin} = (100 - \text{Amylose \%})$$

With the same randomization on the same field, the experiment was carried out for two years in succession. Statistical techniques as outlined by Panse and Sukhatme [9] were used to analyze the data on various factors. Due to the potential importance of the treatments x season interaction and the error variances in the seasons, the straightforward analysis of variance technique may not be applicable in two different seasonal situations. As a result, the approach provided by Cochran and Cox [10] was used to calculate the pooled analysis of the summer legumes and succeeding *kharif* rice throughout the course of two years. To investigate the homogeneity of variance caused by error, the [11] test was used. In order to determine whether or not there is a season x treatment interaction, the variance obtained from the season x treatment components was compared to a combined estimate of error variance. Analysis of variance (ANOVA) and DMRT test were used to identify statistically significant differences among treatments for the pooled data. The level of significance for all analyses was $P \leq 0.05$.

Results and Discussion

Milling quality parameters

It was seen that summer legumes and nutrient levels had a substantial impact on milling quality parameters *viz*., hulling (%), milling (%), and head rice recovery (HRR) of rice grain (Table 1). For both study years, interaction was not determined to be significant. Similar results were found in pooled data. Among the summer legumes, rice grown in dhaincha (T3) incorporated plots recorded significantly higher hulling, milling, and head rice recovery percentages in comparison to fallow (T4) in both years of study. However, dhaincha (T3) was comparable with green gram (T1) but significantly differed with cowpea (T2), and in turn green gram (T1) and cowpea were statistically on par over both the years of study. The lower percentage was recorded in the fallow (T4) treatment and it differs significantly when equated to other summer legumes in both years of study. In pooled study, among summer legumes, dhaincha (T3) recorded significantly higher milling and head rice recovery percentage whereas in hulling percentage it was at par with green gram (T1). However, a lower percentage of milling quality parameters was recorded in fallow (T4). The percentage trend of milling quality parameters was T3>T1>T2>T4 in 2021, 2022, and in the pooled study (Table 1). In the pooled study, among the different nutrient doses applied to *kharif* rice, the higher percentage of milling quality parameters was recorded in 100% RDF (W1) and it differs significantly with the remaining treatments (Table 1). Similarly, the disparities between other treatments were also significant. The No-fertilizer application treatment (W6) had a lower percentage of hulling, milling, and head rice recovery.

Table 1. Hulling, milling and head rice recovery of *kharif* rice as influenced by different treatments

Treatments	Hulling (%)			Milling (%)			Head rice recovery % (HRR)		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Main plots (summer legumes)									
T1	68.48	69.68	69.08	63.46	64.25	63.86	60.30	61.08	60.69
T2	66.58	67.36	66.97	61.91	62.93	62.42	58.72	59.07	58.90
T3	70.50	71.04	70.77	65.60	66.21	65.90	62.42	63.05	62.74
T4	64.16	65.20	64.68	59.58	60.09	59.84	56.30	56.99	56.65
SEm±	1.07	1.07	0.76	0.67	0.68	0.48	0.83	0.62	0.52
CD (P ≤ 0.05)	3.69	3.71	2.33	2.32	2.36	1.47	2.88	2.15	1.60
CV (%)	6.72	6.65	6.68	4.54	4.57	4.56	5.95	4.39	5.22
Sub plots (*kharif* rice)									
W1	76.32	74.67	75.49	71.06	70.69	70.88	67.90	67.32	67.61
W2	67.29	67.64	67.47	62.13	62.36	62.25	58.95	58.94	58.95
W3	62.46	62.48	62.47	57.18	57.37	57.28	54.01	54.02	54.01
W4	73.01	73.97	73.49	67.97	68.63	68.30	64.79	65.67	65.23
W5	68.69	70.50	69.59	62.57	65.51	64.04	59.39	62.08	60.73
W6	56.81	60.68	58.75	54.92	55.65	55.29	51.56	52.27	51.92
SEm±	0.81	0.84	0.58	0.67	0.70	0.48	0.66	0.68	0.47
CD (P ≤ 0.05)	2.30	2.39	1.64	1.91	2.01	1.36	1.88	1.94	1.33
Interaction (T x W)									
SEm±	1.61	1.68	1.64	1.33	1.41	0.97	1.31	1.36	0.95
CD (P ≤ 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Significant interactions with Y	-	-	NS	-	-	NS	-	-	NS
CV (%)	4.14	4.25	4.19	3.69	3.85	3.77	3.83	3.91	3.87

RDF: 100-30-00 NPK kg/ha; GM: Green manure
Note: T1: Green gram; T2: Cowpea; T3: Dhaincha (GM); T4: Fallow
W1: 100 % RDF; W2: 75 % RDF; W3: 50 % RDF; W4: 75 % RDF + 25 % N from FYM; W5: 50 % RDF + 50 % N from FYM; W6: No fertilizer application

Crop residue incorporation acts in improving organic content leading to uptick in kernel length which might result in better development of grain leading to higher head rice recovery in dhaincha incorporation [12]. During 2021, the application of 100% RDF (W1) resulted in the highest hulling, milling, and head rice recovery percentages, which was significantly superior to the other treatments. In 2021, the treatments differ considerably from one another, and the pattern is W1>W4>W5>W2>W3>W6. Whereas, in 2022 the highest hulling, milling, and head rice recovery percent was registered with the application of 100% RDF (W1) but it was comparable with 75% RDF + 25% N from FYM (W4) and the rest of the treatments differ significantly. However, a lower percentage of milling quality parameters was recorded in the No-fertilizer application treatment (W6). Combination of organic i.e., through crop residue of dhaincha along with inorganic fertilizer resulted in better milling quality parameters [13]. In the trial, there was no noticeable change in the interaction (Table 1). Higher physical quality parameters (Figures 1 and 2) were noticed in dhaincha incorporation with 100% RDF (T3W1). The higher efficacy of these treatments could be attributed to improvements in the physical, chemical, and microbiological environment of the soil, which creates a favorable setting for greater plant nutrient availability. Whereas the independent or solo application of some chemical or inorganic fertilizer supplies few components in sufficient quantities to increase rice grain quality, chemical fertilizers alone impair the physical qualities and microbial activity of soil [14]. Cognate findings have been reported by Jana et al., [15].

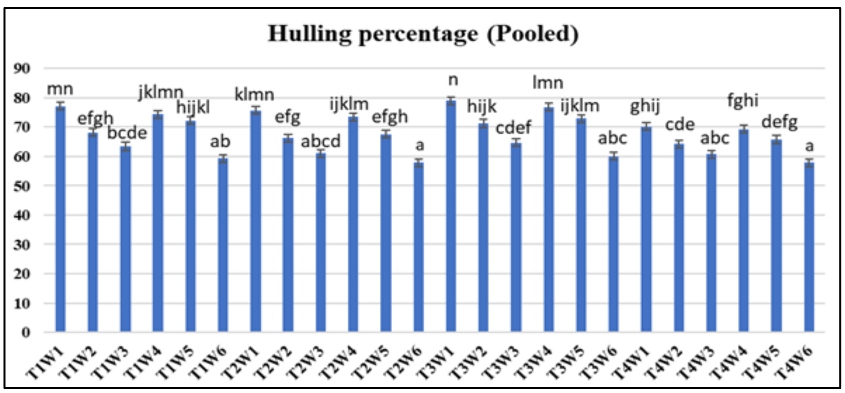

Figure 1. Effect of summer legume incorporation on hulling percentage of rice
(Bars indicated and *fb* same letter, within bars, do not differ significantly by Duncans new multiple range test at 5% probability)

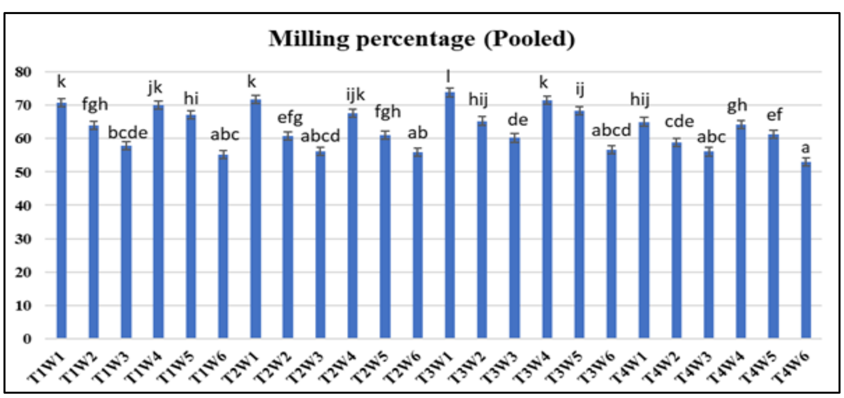

Figure 2. Effect of summer legume incorporation on milling percentage of rice
(Bars indicated and *fb* same letter, within bars, do not differ significantly by Duncans new multiple range test' at 5% probability)

The suggested NPK fertilizer (W1) resulted in improved milling recovery, higher head rice percentage, and abate in rice broken %. The absolute control (T4W6) had a lower milling recovery, and a larger percentage of broken rice (Table 1). This could be attributed to enhanced shelling amenability, high grain size, and a low number of chalky grains found under prescribed NPK fertilizer use when grown on dhaincha incorporated plots [16].

Amylose (%)

Preceding summer legume incorporation exerted no substantial influence on the amylose content (%) of rice grain (Table 2). Amylose content (%) in rice grains follow the trend of T3>T1>T2>T4 numerically during the experimentation. This might be caused by increased nutritional availability, absorption, and uptake, which would increase the amount of nutrients in grains [17].

Rice grain amylose content (%) was not considerably altered by nutrient doses applied in *kharif* rice during either the individual years or in pooled data. However, among the treatments tested 100% RDF (W1) registered higher amylose content numerically and the lowest was recorded in the No-fertilizer treatment (W6) during both years of trial and in pooled study. Consistent grain filling, dense packing of grain as measured by 1000 grain weight and improved nutritional uptake by the grain in all treatments due to nutrients given by crop residue, fertilizer, and FYM [18].

Table 2. Amylose, amylopectin, and protein content in *kharif* rice grain as influenced by different treatments

Treatments	Amylose content in rice grain (%)			Amylopectin content in rice grain (%)			Protein content in rice grain (%)		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Main plots (summer legumes)									
T1	22.47	23.00	22.74	77.53	77.00	77.26	8.01	8.10	8.05
T2	22.49	23.09	22.79	77.51	76.91	77.21	7.88	7.98	7.93
T3	22.49	23.31	22.90	77.51	76.69	77.10	8.08	8.18	8.13
T4	22.01	22.52	22.26	77.99	77.48	77.74	7.45	7.55	7.50
SEm±	0.62	0.61	0.44	0.62	0.61	0.44	0.07	0.08	0.05
CD (P ≤ 0.05)	NS	NS	NS	NS	NS	NS	0.24	0.26	0.16
CV (%)	11.78	11.27	11.52	3.39	3.36	3.38	3.71	4.01	3.87
Sub plots (*kharif* rice)									
W1	22.92	23.55	23.23	77.08	76.45	76.77	8.44	8.54	8.49
W2	22.52	23.14	22.83	77.48	76.86	77.17	7.76	7.86	7.81
W3	22.17	22.79	22.48	77.83	77.21	77.52	7.49	7.59	7.54
W4	22.72	23.34	23.03	77.28	76.66	76.97	8.23	8.32	8.28
W5	22.15	22.76	22.46	77.85	77.24	77.54	7.92	8.01	7.96
W6	21.70	22.30	22.00	78.30	77.70	78.00	7.30	7.39	7.34
SEm±	0.46	0.47	0.33	0.46	0.47	0.33	0.06	0.05	0.04
CD (P ≤ 0.05)	NS	NS	NS	NS	NS	NS	0.16	0.15	0.11
Interaction (T x W)									
SEm±	0.92	0.94	0.93	0.92	0.94	0.93	0.11	0.10	0.11
CD (P ≤ 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Significant interactions with Y	-	-	NS	-	-	NS	-	-	NS
CV (%)	7.11	7.10	7.10	2.05	2.12	2.08	2.52	2.26	2.39

RDF: 100-30-00 NPK kg/ha; GM: Green manure
Note: T1: Green gram; T2: Cowpea; T3: Dhaincha (GM); T4: Fallow
W1: 100 % RDF; W2: 75 % RDF; W3: 50 % RDF; W4: 75 % RDF + 25 % N from FYM; W5: 50 % RDF + 50 % N from FYM; W6: No fertilizer application

Amylopectin (%)

There was no discernible impact from the rice amylopectin content (%) data. However, among the summer legume treatments higher amylopectin content (%) in rice grain was recorded in the fallow treatment (T4), and lower amylopectin content (%) was found in dhaincha (T3). In different nutrient doses applied in kharif rice, the higher amylopectin was observed in No-fertilizer treatment (W6) and lower was reported in 100% RDF (W1). Moreover, the interaction was determined to be non-significant over the course of the two experiment years. Similar reports of non-significant impact of residue incorporation on amylopectin content were found by different researchers [17-18].

Protein content (%)

The inclusion of dhaincha (T3) resulted in the highest protein content in rice grain (Table 2), which was statistically similar with green gram (T1) and cowpea (T2) incorporation treatments and considerably superior to summer fallow (T4). Similarly, in both years of study and pooled data (Figure 3) the differences between green gram (T1) and cowpea (T2) were not significant.

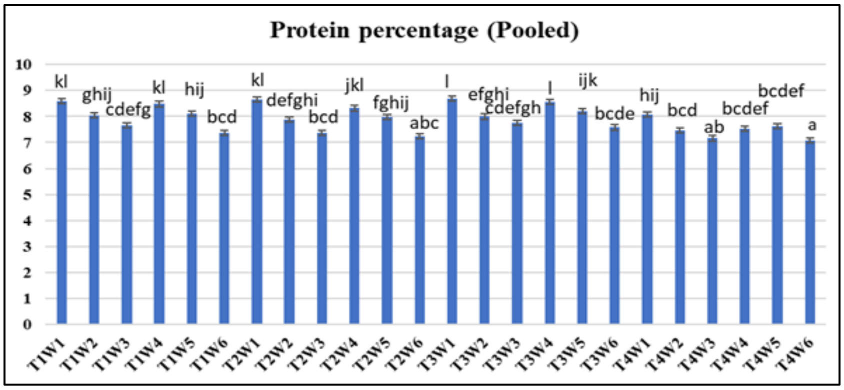

Figure 3. Effect of summer legume incorporation on protein percentage of rice
(Bars indicated and *fb* same letter, within bars, do not differ significantly by Duncans new multiple range test' at 5% probability)

Compared to the other treatments, the 100% RDF (W1) plots yielded rice grains with significantly greater protein content (%). During both years of study, the protein content (%) in rice grain varied in the following order: W1>W4>W5>W2>W3>W6 (Table 2). A similar pattern was observed in the pooled analysis (figure 3) reported similar findings of Sangeetha et al., [16]. Higher protein content (Figure 3) was noticed in the treatment T3W1 (dhaincha incorporation with 100% RDF). This could be related to the build-up in nitrogen content in grain because residue integration delivers nitrogen in soil following decomposition, resulting in increased nutrient intake by the rice plant and higher protein content [19]. The improvement in nutrient uptake and mobilization, especially N concentrations, which was due to better nutrient accumulation in plants due to the provision of more nutrients from the residues which were applied prior to rice sowing resulting in T3W1 as a better treatment, can be attributable to the balloon in physical quality parameters such as hulling (Figure 1), milling (Figure 2), and head rice recovery percentages and positive correlation with yield and microbes. The result, there was a rise in protein content (Figure 3) and a decline in breakage loss [20].

Conclusion

Residue incorporation of cowpea, dhaincha, and green gram had no effect on amylose and amylopectin content whereas protein content and milling quality parameters were found to be significant. However, among different recommended levels, 100% RDF was found to be better along with dhaincha incorporation during the study.

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