Research Article

Evaluation of Grain Quality of Maize, Rice and Wheat Under Different Tillage, Mulching and Fertilizer Management Practices

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Abstract

A field experiment with different cropping systems was carried out during 2014-15 and 2015-16 at Students' Research Farm, Department of Agronomy, Punjab Agricultural University, Ludhiana to study the effect of different tillage and fertilizer management practices on quality of maize, rice and wheat. The experiment comprised of eight combinations of tillage (Minimum and conventional) and cropping systems (rice-wheat, maize-vegetable pea-spring maize, maize-toria-spring maize, maize-potato-spring maize) and four combinations of fertilizer and mulch. Protein content in maize (4.4 and 5.6%), wheat (2.6 and 3.7%) and spring maize (3.5 and 3.6%) was higher under minimum tillage as compared to conventional tillage. Milled (69.67 and 69.83%) and head rice (57.08 and 56.92 %) recovery was higher under conventional tillage. Combined application of organic manure (FYM) and inorganic fertilizer improved the milled and head rice recovery as compared to inorganic fertilizers alone. Highest protein content (11.62 and 11.81%), β-carotene (4.37 and 4.54 ppm) and hectolitre weight (79.0 and 77.7 kg/hl) of wheat were obtained with application of combination of FYM and inorganic fertilizers along with mulch (75% RDF + 25% N through FYM + mulch). Protein content in maize and spring maize was also higher under mulch treatments.

Keywords: β-carotene, Fertilizers, FYM, Milled rice, Protein content, Quality

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Introduction

Rice, wheat and maize are the three most important cereal crops in world. The demand for cereals in Asian countries during 2000-2030 was projected to grow at the rate of 1.6 percent compared to the food grains' growth rate of 1.3 percent during the corresponding period [1]. Agronomic parameters are significant from production point of view. Food security concerns in India will be taken care of with the passage of food security bill 2013, which targets to provide food grains at subsidized rates to 2/3rd rural population and half of the urban poor population living below the poverty line. According to a recent WHO report, 85 % women and young children below the age of 5 years in India are malnourished and anaemic. Hence, nutritional security is of paramount importance along with food security. It is estimated that global demand for grains will double by 2050, and an increase in crop yields and quality improvement is critical to the global food supply for future populations [2].

The improvement in quality is a continuous process employing various techniques such as development of new varieties with application of plant breeding and biotechnology. The quality of crops is influenced by the interaction of a number of factors, including cultivar, soil, climate, cropping practices and grain storage conditions [3]. Grain protein content is the result of complex interactions between Nitrogen and water availability, yield and temperature. Agronomic methods such as tillage and fertilization can influence the quality of crops. Protein content not influenced significantly by tillage practices [4], in contrast, [5] reported higher grain protein content for conventional tillage (CT) than for no tillage (NT). The effects of nutrients, in particular nitrogen, phosphorus, and potassium on growth and yield of crops have been intensively investigated. However, studies involving in grain quality are still quite limited.

The combined application of chemical fertilizers with farmyard manure has favourable effect on the transferability and distribution of nutrients from shoot to grains in rice in addition to increase in dry matter accumulation [6]. The long-term combined application of organic manure and inorganic fertilizers improved the nitrogen uptake and productivity of rice [7]. The positive effect of straw mulch on crop yields is widely studied [8-9]. Plastic mulch could improve the protein content in maize and decrease the starch content [10]. The poor and

imbalanced use of fertilizers is one of the factors responsible for low yield and poor grain quality of crops. Keeping the above view in consideration, the present investigation was undertaken to study the effect of tillage, mulching and fertilizers alone or combination on the grain quality parameters of maize, rice, wheat and spring maize.

Materials and Methods

The field experiment with different cropping systems was carried out during 2014-15 and 2015-16 at Students' Research Farm, Department of Agronomy, Punjab Agricultural University, Ludhiana, representing the Indo-Gangetic alluvial Plains situated at 30º56´ N latitude and 75 º 52` E longitudes with an altitude of 247 meter above the sea level. The experiment was laid out in split-plot design with four replications. The experiment comprised of combination of two tillage methods *viz.* minimum tillage (MT) and conventional tillage (CT) and four cropping systems *viz*. rice-wheat, maize-vegetable pea-spring maize, maize-toria-spring maize, maize-potato-spring maize in main plots and combination of fertilizer and mulch *viz*. 100% recommended dose of fertilizers (100% RDF), 75 % RDF + 25 % N through FYM, 100% RDF plus mulch and 75 % RDF + 25 % N through FYM plus mulch in sub-plots. The soil of experimental site was loamy sand in texture with slight alkaline in pH (7.76), medium in organic carbon (0.42%), poor in available N (225.9 kg/ha), high in available P (23.6 kg/ha) and low in available K (128.8 kg/ha).

Grain samples for different quality parameters were analysed in the Cereal Technology Lab of Food Science and Technology Department, Punjab Agricultural University, Ludhiana. The quality parameters of different crops were analysed by following methods:

Protein content: Crude protein content in grains of wheat, maize and spring maize was determined directly by multiplying the nitrogen content (%) in the seed by a factor of 6.25 and expressed in percentage

Rice

Brown rice percentage: The clean paddy samples (100 g) were shelled in laboratory sheller. Shelled (brown) rice was weighed and expressed as percentage.

$$\text{Brown rice recovery (\%)} = \frac{\text{Brown rice obtained (g)}}{\text{Total paddy taken (g)}} \times 100$$

White rice percentage: Brown rice samples were milled (polished) in Mc Gill, Miller No. 2 to remove the bran.

$$\text{White rice recovery (\%)} = \frac{\text{White rice obtained (g)}}{\text{Total paddy taken (g)}} \times 100$$

Head rice percentage: Rice grading device was used to separate broken kernel from milled rice after milling. The kernel with more than two-third length was considered as head rice and expressed as percentage.

$$\text{Head rice recovery (\%)} = \frac{\text{Head rice obtained (g)}}{\text{Total paddy taken (g)}} \times 100$$

Grain length: breadth ratio: For measurement of length and breadth ten kernels of rice were arranged in straight line and cumulative length was measured in mm. Average of length and breadth was taken in mm and grain length: breadth ratio was calculated.

Maize

Estimation of total sugars

The total sugars in grain samples were estimated using concentrated sulphuric acid and 5% phenol [11].

Wheat

Dry and wet gluten content

Weighed sample of wheat flour (20 g) was made into dough ball by adding approximately 12.5 ml of distilled water. The ball was kept in water for 30 minutes and then washed under tap water in muslin cloth to remove starch and other soluble and separate the gluten. The gluten after squeezing to remove water as far as possible was weighed and then dried until constant weight at 100°C and recorded as per cent dry gluten.

β-carotene

Water saturated butanol was used to extract β-carotene pigment according to [12]. Weighed 8 g of semolina in a stoppered 100 ml air tight bottle to which 40 ml water saturated butanol was added. The contents were mixed and kept overnight in the dark and mixed again before filtration. Absorbance of the filtrate was measured at 440 nm using Spectrophotometer spectronic-20 employing the water saturated butanol as blank. The value was multiplied by the factor 30.1 to obtain the value for pigment, expressed as β-carotene ppm.

Hectolitre weight

The hectolitre weight was measured using the hectolitre weight apparatus designed by Directorate of Wheat Research, Karnal and expressed in kg/hl.

Results and Discussion

Quality parameters of rice

Different tillage and fertilizer treatments had no significant influence on quality attributes of rice (**Table1**). Conventional tillage resulted in higher brown rice recovery (80.56 and 80.47%), milled rice recovery (69.67 and 69.83%) and head rice recovery (57.08 and 56.92 %) as compared to minimum tillage during both the years. The higher L: B ratio was also obtained under conventional tillage (4.24 and 4.26) as compared to minimum tillage being at par with each other. Application of 75% RDF + 25% N through FYM increased the milling quality of rice. Higher brown rice, miller rice and head rice recovery was obtained with combined application of organic manure and chemical fertilizers (75% RDF + 25% N through FYM) as compared to chemical fertilizers alone (100% RDF). The L: B ratio was also improved with application of 75% RDF + 25% N through FYM as compared to 100% RDF. Hulling percentage and milling percentage increased due to combined use of FYM and chemical fertilizers [13].

Table 1 Quality parameters of rice as influenced by tillage and fertilizer management practices

Treatment	**Brown rice %)**		**Milled rice (%)**		**Head rice (%)**		**Grain L:B ratio**	
Tillage	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
MT	79.89	80.10	69.00	69.00	55.67	55.92	4.14	4.14
CT	80.56	80.47	69.67	69.83	57.08	56.92	4.24	4.26
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Fertilizer × mulch								
100% RDF	80.05	79.82	68.72	69.00	56.17	55.83	4.18	4.16
75% RDF +25% N FYM	80.17	80.15	69.45	69.17	56.33	56.17	4.18	4.19
100% RDF Mulch	80.12	80.48	69.50	69.67	56.33	56.83	4.19	4.22
75% RDF +25% N FYM Mulch	50.56	81.68	69.67	69.83	56.67	56.84	4.21	4.24
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Quality parameters of kharif and spring maize

The protein content in spring maize was slightly higher than *kharif* maize. Higher temperature in spring season may lead to higher protein content (**Table 2**). The higher temperature in post-anthesis period enhances the protein content [14]. Tillage methods had significant influence on crude protein content of *kharif* maize. Minimum tillage resulted in significantly higher protein content (10.40 and 10.58%) in *kharif* maize as compared to conventional tillage, whereas, at par with each other in spring maize. Similar results were reported by [15] under zero tillage as compared to

conventional tillage. Total sugars content in grain of *kharif* and spring maize was not influenced significantly with tillage.

With respect to protein content and total sugars content in *kharif* and spring maize grains, non-significant difference was observed under different cropping systems, fertilizer and mulch treatments (Table 2). Application of 75% RDF + 25% N through FYM plus mulch resulted in higher crude protein content (10.41 & 10.51% in *kharif* maize and 10.70 & 11.00% in spring maize), but at par with other treatments. Application of organic manures in combination with inorganic fertilizers supply nutrients in synchrony with crop growth resulted in higher nitrogen content and more protein. Higher protein content in spring and autumn maize under mulch as compared to no mulch was also reported by [16]. Total sugars content was higher in 100% RDF as compared to other treatments in both *kharif* and spring maize.

Table 2 Quality parameters of *Kharif* and spring maize as influenced by tillage, mulching and fertilizer management practices

	***Kharif m*aize**				**Spring maize**			
Treatment	**Crude Protein (%)**		**Total Sugars (%)**		**Crude Protein (%)**		**Total Sugars (%)**	
Tillage	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
MT	10.40	10.58	3.80	3.76	10.74	11.00	3.86	3.86
CT	9.96	10.00	3.90	3.82	10.36	10.60	3.91	3.90
CD (p=0.05)	0.37	0.32	NS	NS	NS	NS	NS	NS
Cropping systems								
M-VP-SM	10.28	10.43	3.79	3.68	10.64	10.89	3.86	3.81
M-T-SM	10.16	10.18	3.90	3.87	10.48	10.73	3.90	3.94
M-P-SM	10.13	10.24	3.84	3.82	10.54	10.78	3.89	3.88
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Fertilizer × mulch								
100% RDF	9.93	10.11	3.96	3.90	10.37	10.64	4.03	3.99
75% RDF +25% N FYM	10.08	10.21	3.87	3.81	10.52	10.73	3.94	3.91
100% RDF + Mulch	10.25	10.30	3.82	3.74	10.62	10.86	3.80	3.84
75% RDF +25% N FYM + Mulch	10.47	10.51	3.73	3.71	10.70	11.00	3.76	3.78
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Quality parameters of wheat

Table 3 Quality parameters of wheat as influenced by tillage, mulching and fertilizer management practices

Treatment	**Crude protein content (%)**		**Wet gluten (%)**		**Dry gluten (%)**		**β-carotene (ppm)**		**Hectolitre Weight (kg/hl)**	
Tillage	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
MT	11.62	11.80	32.16	33.78	11.80	11.15	4.36	4.52	78.8	77.5
CT	11.32	11.43	31.57	32.76	10.27	10.37	4.07	4.45	77.1	76.0
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Fertilizer × mulch										
100% RDF	11.37	11.42	30.97	32.27	10.32	10.37	4.08	4.45	76.9	76.0
75% RDF +25% N FYM	11.41	11.54	31.69	33.23	10.49	10.74	4.10	4.47	77.3	76.3
100% RDF + Mulch	11.49	11.66	32.29	33.68	10.54	10.79	4.32	4.50	78.4	77.0
75% RDF +25% N FYM + Mulch	11.62	11.81	32.50	33.89	10.80	11.15	4.37	4.54	79.0	77.7
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Protein content is the main feature of grain quality which imparts vitreousness in grains and determines their end use quality. The perusal of data in **Table 3** indicates that among two tillage methods, the protein content values were non-significant for both years, however, numerically higher protein content was reported in minimum tillage (11.62 and

11.80%) as compared to conventional tillage (11.32 and 11.43%). Among fertilizer and mulch treatments, the highest values of protein content (11.62 and 11.81%) were reported in 75% RDF +25% N FYM plus mulch treatment, but at par with other treatments. Application of combined application of FYM and inorganic fertilizers (75% RDF +25% N FYM) without mulch resulted in higher protein content (11.41 and 11.54%) as compared to 100% RDF.

β-carotene is a pigment in wheat grain that imparts a characteristic golden hue to wheat semolina. It is precursor of vitamin A and it is of nutritional significance. Different tillage and fertilizer treatments not influenced the β-carotene content significantly. However, higher value of β-carotene was recorded in minimum tillage (4.36 and 4.52 ppm). All fertilizer and mulch treatments were at par with each other in term of β-carotene, but 75% RDF +25% N FYM plus mulch resulted in higher β-carotene content (4.37 and 4.54 ppm). Wet and dry gluten content in grains was also higher in minimum tillage as compared to conventional tillage. Application of 75% RDF +25% N FYM resulted in higher wet (31.69 and 33.23%) and dry gluten (10.49 and 10.74%) as compared to 100% RDF. Higher dry and wet gluten and β-carotene in combined application of organic and inorganic fertilizers were reported by [17].

Hectolitre weight is the measurement of weight per unit volume and is positively and linearly correlated to the flour recovery as higher hectolitre weight is indicative of an improved endosperm to bran ration [18]. Under tillage methods, minimum tillage resulted in higher hectolitre weight as compared to conventional tillage (77.1 and 76.0 kg/hl). Among different fertilizer and mulch treatments the highest values of hectolitre weight (79.0 and 77.7 kg/hl) was reported with 75% RDF +25% N FYM plus mulch which were at par with other fertilizer and mulch treatments. Application of 100% RDF resulted in lowest values of hectolitre weight (76.9 and 76.0 kg/hl). Combined application of manure and fertilizers resulted in increased availability of nitrogen resulted in higher grain density. Similar results also reported by [19].

Conclusion

It can be concluded that application of combined application of organic manures (FYM) and chemical fertilizer along with mulch caused an improvement in the crude protein content of wheat and maize, and β-carotene and hectolitre weight in wheat. The quality parameters of rice (brown rice, milled rice and hear rice percentage) were higher under conventional tillage and combined application of organic and inorganic fertilizers.

Acknowledgement

First author acknowledges the Department of Science and Technology, Government of India for providing fellowship in the form of INSPIRE fellowship vide IF 140502 during Ph.D. programme.

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Publication History
Received 22nd Feb 2017
Revised 10th Mar 2017
Accepted 10th Mar 2017
Online 30th Mar 2017