PLANT SCIENCE TODAY
ISSN 2348-1900 (online)
Vol 12(1): 1-7
https://doi.org/10.14719/pst.3195

HORIZON
e-Publishing Group

RESEARCH ARTICLE

Influence of organic inputs on the grain quality of wheat (*Triticum aestivum* L.)

Manvir Kaur[1*], Harinderjeet Kaur[2] & Charanjit Singh Aulakh[3]

[1]Department of Agronomy, Lovely Professional University, Jalandhar 144 411, Punjab, India

[2]Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana 141 004, Punjab, India

[3]College of Agriculture, Punjab Agricultural University, Ludhiana 141 004, Punjab, India

*Email: manvir.agr.pau@gmail.com/manvir.26499@lpu.co.in

OPEN ACCESS

ARTICLE HISTORY
Received: 23 December 2023
Accepted: 21 November 2024
Available online
Version 1.0 : 04 February 2025
Version 2.0 : 07 February 2025

Check for updates

Additional information

Peer review: Publisher thanks Sectional Editor and the other anonymous reviewers for their contribution to the peer review of this work.

Reprints & permissions information is available at https://horizonepublishing.com/journals/index.php/PST/open_access_policy

Publisher's Note: Horizon e-Publishing Group remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Indexing: Plant Science Today, published by Horizon e-Publishing Group, is covered by Scopus, Web of Science, BIOSIS Previews, Clarivate Analytics, NAAS, UGC Care, etc
See https://horizonepublishing.com/journals/index.php/PST/indexing_abstracting

CITE THIS ARTICLE
Kaur M, Kaur H, Aulakh CS. Influence of organic inputs on the grain quality of wheat (*Triticum aestivum* L.). Plant Science Today. 2025; 12(1): 1-7. https://doi.org/10.14719/pst.3195

Abstract

Wheat grain quality is a major concern as it feed a large population of the world and it is also a chief source of nutrition in developing countries. Extensive research has been carried out to enhance its nutritional value and quality and nutrient supply is one of the most favorable procedures. The present study also focusses on improving and analysing grain quality traits through addition of organic inputs such as FYM, vermicompost and biofertilizers and was conducted at Trans-Gangetic regions (Punjab) in a loamy sand soil with medium levels of available nitrogen. The experiment consisted of different levels of FYM, vermicompost, inorganic fertilizers (to supply N) and biofertilizer inoculation and unfertilized control. Among various organic treatments, higher FYM level, $FYM_{250+Biof}$ had the highest GAS (5.93 and 5.63), SDS-sedimentation value (49.7 and 35.3 cc) and protein content (12.4 and 12.3%) during both the years. Significantly lower phenol reaction score was also observed with $FYM_{250+Biof}$ (3.3 and 4.2 for the year 2016-17 and 2017-18). Also, the micro-nutrient content (Cu, Fe, Zn and Mn) was significantly higher with organic inputs indicating wide range of nutrient supply and improved status of soil. Protein being a chief factor to influence various quality parameters had strong correlation with grain hardness (r = 0.946 and 0.961), hectolitre weight (r = 0.943 and 0.846), SDS (r = 0.979 and 0.963) and gluten. PRS, an undesirable factor, had negative correlation with all the other factors. Micronutrients, such as Cu, Fe Zn and Mn also had variable correlation with different parameters.

Keywords

biofertilizers; FYM; grain appearance; grain hardness; gluten content; protein content; organic wheat; SDS - Sedimentation Value; vermicompost

Introduction

Wheat being a staple food in developing countries, is the chief source of energy (calories) as well as protein (1). In 2023, India had wheat production of 112.74 million metric tonnes while Punjab produced 168 lakh metric tonnes. Various quality traits in wheat (such as gluten content, SDS-sedimentation value, protein content, grain hardness etc.) are further interconnected and collectively influence the quality of wheat generated products especially *chappati*. The increased concern about nutritive status of wheat as well as system of production has raised the demand for organic food with each passing day. The application of organic inputs is generally based on its N content as nitrogen is the most yield limiting nutrient in wheat and play a significant role in determination of grain yield as well as quality of grain (2). Due to quick nutrient releasing inorganic fertilizers, huge amount of nitrogen is lost through denitrification and volatilization etc. thus slow nutrient releasing input are supposed to sustain the nutrient supply throughout the cropping season. In addition, organic inputs enhance microbial population in rhizosphere which facilitate organic matter decomposition and nutrient cycling (3, 4). Contrary to assumption that wheat quality is genetically controlled, addition of organic manures along with inorganic/chemical inputs, has proven to improve yield and soil health, owed to the beneficial effect on soil properties, soil moisture, better nutrient availability, favourable micro-climate for root growth and supply of micronutrients (5-7). As illustrated in literature increase in micronutrient content in grains cause an increment in total sugar, hardness of grain, stress protein proline and carotenoids (8). It was further reported that the genotypes which had higher Zn content had lower protein as well as gluten. Also, there are numerous studies which support the enhanced protein content, grain hardness, grain appearance, sedimentation value and gluten content with increased fertilization (9-14) or FYM (14-18). Studies also revealed that application of *Azotobacter* result in decrease in lysine content and an increase in starch content of wheat (15). Some studies also describe non-significant effect of application of only FYM and vermicompost on grain hardness and sedimentation value but combined application of FYM/ Vermicompost or biofertilizers and rice residues resulted in a significant increase in the concentration of N, P, K, Zn, Fe and Mn in wheat grain and improved quality when compared with control (9, 12, 20-21). In addition, it is worth discussing that there are studies from different corners of world which support the non-significant effect of organic manures on grain quality and validate inorganic and organic farming system as equivalent to each other. As observed in a long-term experiment conducted at Switzerland, when wheat grains were analysed for different quality traits (such as protein content, phosphate levels, anti-oxidative capacity, phenols, fibre (carbohydrates), fructan, oxalate and phytic acid) and while comparing organic and inorganic farming systems, non-significant results or negligible variations were observed (22). Keeping in view the above aspects, the present study was planned to investigate the effect of organic nutrient sources on quality of organic wheat (*Triticum aestivum* L.)

Materials and Methods

The field experiment was conducted during *rabi* season (winter) for two consecutive years i.e. in 2016-17 and 2017-18. The experimental location is in the central plain region of Punjab under the Trans-Gangetic agro-climate zone of India. Ludhiana with 30°56´ N latitude and 75°52´ E longitude and a height of 247 m above the mean sea level represent a sub-tropical and semi-arid climate. The soil was loamy sand in texture with pH 7.5 and low organic carbon (0.45%), medium in available N (280 kg ha^{-1}) and K (135 kg ha^{-1}) and high in available P (39 kg ha^{-1}). The experiment was conducted in randomized block design with ten number of treatments viz; FYM application to supply 125/187.5/250 kg N ha^{-1} with or without Biofertilizer (consortium), VC_{125} to supply 125 kg N ha^{-1}, Biofertilizer (consortium), Control (unfertilized) and Recommended dose of fertilizers (RDF) with N, P and K @ 125, 62.5 and 30 kg ha^{-1} respectively. Whole FYM and vermicompost were applied during field preparation and thoroughly mixed in soil. The seed was inoculated with biofertilizer (consortium) @ 1250 g ha^{-1}, dried in shade and sown as per the treatments. In inorganically fertilized (RDF) plots, nitrogen (125 kg ha^{-1}) was applied in two splits i.e at the time of sowing and at first irrigation, in the form of urea (46% N) and DAP (18% N). P (P_2O_5) and K (K_2O) were applied in the form of DAP (46% P_2O_5) and MOP (60% K_2O) @ 62.5 and 30 kg ha^{-1} respectively. The crop was sown manually by *pora* method with a seed rate of 100 kg ha^{-1} with row spacing of 20 cm. For raising the crop, general recommendation of PAU, Ludhiana were followed. Produce of all the plots was threshed separately and the grain weight was recorded after cleaning. A total rainfall of 108.8 and 86.4 mm was received during 2016-17 and 2017-18 respectively. The data was statistically analysed as prescribed by Cochran and Cox (1963) and compared at 5% level of significance (23) with the help of CPCSI software.

Procedures

The following procedures/ practices were adopted for evaluation of various quality traits of wheat grain.

Grain appearance score: Grain appearance score, a visual test, is based on luster (3), colour (2), shape (2) and size (3). Bold grains with an attractive shape, amber golden colour and the luster of the grain are the major criteria for scoring. Based on these observations, treatment-wise samples were observed and graded on a scale ranging from 1-10.

Hectolitre weight (volume basis): The falling grains form an overhead storage hopper are collected in a cylinder of 100 mL capacity, weighed and expressed as kilogram per hectolitre (kg hl^{-1}). It also represents density of grains.

Grain hardness: Randomly picked ten grains of each treatment are broken with pressure applied through gauge of grain hardness tester (OSK 8055, OGAWA SEIKI CO., LTD Tokyo, Japan) and mean was calculated as the grain hardness.

Sedimentation value: The ground (through Cyclotec 1093, Foss Tecator) wheat samples were analysed for SDS sedimentation value.

Protein content: “Infratec 1241 (FOSS)” near infrared (NIR) transmittance grain analyser was used to determine protein content of grain samples.

Gluten quantity and quality: Glutomatic 2100 system (supplied by M/S Perten, Germany) was used for determination of glute content. Kneaded soaked soft dough was put into the Glutomatic wash chamber having 88-micron polyester sieve. The washed meal was then transferred to a chamber equipped with a coarse 840-micron sieve to wash out bran particles for 30 seconds. The completely washed undivided wet gluten piece was then centrifuged in a special sieve cassette for one minute at 6000 rpm in gluten index centrifuge. The fraction passed through the sieves and the fraction remaining on the inside of the sieve was collected separately and weighed separately as well as total. The total wet gluten piece was dried at 150°C four min in the Glutork 2020 and then weighed.

Phenol reaction score: Overnight 100 soaked grains were submerged in 1% phenol and observed for degree of darkness on a 1-10 scale.

Mineral content (Cu, Fe, Zn and Mn): The mineral concentrations (Cu, Fe, Zn and Mn) were estimated by the instrument, Spectra AAS, VARIAN. The technique used by the instrument was Atomic Absorption Spectrophotometry and expressed as ppm (24).

Results and Discussion

Grain appearance score

As per the name of the physical parameter, its more about the appearance/aesthetic value of grain. Grain appearance score (GAS) is grain grading based on size/plumpness of grain, shape and colour (or luster). Bolder grain (or glossier or uniform) grains indicate higher grain appearance score. The fact is also supported from the correlation matrix for the crop year 2016-17 (Table 5) and 2017-18 (Table 6) as grain appearance score was strongly correlated with grain hardness (r = 0.974 and r = 0.907 for the crop year 2016-17 and 2017-18). In the first experimental year, GAS was significantly higher with RDF (6.13) than rest of the treatments but was statistically equivalent with the higher levels of FYM, FYM_{250} (5.93) and $FYM_{250+Biof}$ (5.93). All the organic treatments were statistically equivalent to each other except FYM_{125} (5.63), $FYM_{125+Biof}$ (5.63) and VC_{125} (5.70). Grain appearance score with unfertilized control (5.56) was statistically at par with FYM_{125}, $FYM_{125+Biof}$ and $FYM_{187.5}$ and Biof.

In 2017-18, the grain appearance score was highest for RDF (5.63) and it was statistically at par with medium levels of FYM, $FYM_{187.5}$ (5.50) and $FYM_{187.5+Biof}$ (5.50) and higher levels of FYM, FYM_{250} (5.63) and $FYM_{250+Biof}$ (5.63) (Table 1). These results are in line with previous report which reported increased grain appearance score with increased nitrogen application (9). Among various organic treatments, $FYM_{250+Biof}$ had significantly better grain appearance score and it was statistically at par with FYM_{250}. Control and Biof (5.37, each) resulted in significantly lower and statistically equivalent grain appearance score as low nutrient supply resulted in shrivelled and lustreless grains. A decline in grain appearance score to the tune of 1.26, 1.26 and 2.5% was recorded when control was compared with FYM_{125}, $FYM_{125+Biof}$ and VC_{125}. Poor crop health due to limitation of nutrients resulted in poor translocation of photosynthates, so the sink size shrunk and resulted in smaller and shrivelled grains. Biof recorded a little improvement over control treatment as it did not supply the nutrients but only eased the availability of nutrients through microbial activity and alteration in the rhizosphere. This may be the reason for increased grain appearance score with increasing nutrition level with FYM application or inorganic fertilizer application (25).

Hectolitre weight (volume basis)

More hectolitre weight depicts more uniform, denser and healthier grains hence it signifies flour extraction and stock space requirement of produce. During 1st experimental year, among various organic treatments, $FYM_{250+Biof}$ (79.5 kg hl^{-1}) was lead significantly than VC_{125} (77.2 kg hl^{-1}) and Biof (76.8 kg hl^{-1}) but maintained statistical similarity to remaining FYM levels. In 2017-18, the differences among various treatments failed to attain a level of significance. However, RDF, had the highest hectolitre weight (76.17 kg hl^{-1}) followed by $FYM_{250+Biof}$ with the heaviest grains (76.0 kg hl^{-1}) among different FYM treatments. Unfertilized control had the lowest hectolitre weight (74.3 kg hl^{-1}) (Table 1). Hectolitre weight can be altered by crop management practices although it is a genetic character of crop indicating significant as well as non-significant results with different treatments (26).

Grain hardness

Grain hardness is owed to more protein content and better bonding of starch and protein molecules. Higher grain hardness results in better chapattis as harder grains result in better grinding or breakdown of starch resulting in higher water absorption in dough. With addition/increase of nitrogen, improvement in grain hardness is also observed depicting its strong correlation with grain protein content (r = 0.946 and 0.961 for the year 2016-17 and 2017-18) (9,13). This is the reason also for highest grain hardness among all treatments during both the years. In 2016-17, among various organic treatments, $FYM_{250+Biof}$ (10.2) resulted in significantly higher grain hardness except FYM_{125} (9.71), VC_{125} (9.63), Biof (9.51) and control (9.51) and was statistically at par with rest of the treatments (Table 1) in contrast some studies reported that application of FYM to supply 187.5 Kg N ha^{-1} resulted in grain hardness which was statistically equivalent with RDF (26) or failed to show any significant effect on grain harness (20). Significantly lower grain hardness was observed in control which was devoid of any nutrient supply.

Sedimentation value

Sodium dodecyl sulphate (SDS - sedimentation value) is used to judge the protein quality which further influences the gluten strength of wheat flour. Higher SDS-sedimentation value indicates better gluten quality. Inorganic fertilizers resulted in significantly higher SDS-sedimentation value during both the experimental years (i.e. 51.3cc in 2016-17 and 38.0cc in 2017-18. In 2016-17) (Table 2). In 2016-17, application of nitrogen @ 125 kg ha^{-1} with FYM (FYM_{125} and $FYM_{125+Biof}$), vermicompost (VC_{125}) and Biof and control resulted in statistically equivalent results for SDS values). Some studies support higher SDS values with organic inputs (27) such as vermicompost (28) while some researchers did not observe any favourable results (20).

Table 1. Effect of nutrition treatments on grain appearance, test weight and grain hardness of wheat grains

Treatment	Grain appearance (max score 10)		Hectolitre weight (kg hl^{-1})		Grain hardness (kg)	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
FYM_{125}	5.63	5.40	78.2	75.2	9.71	8.08
$FYM_{125+Biof}$	5.63	5.43	78.3	75.3	9.73	8.16
$FYM_{187.5}$	5.73	5.50	78.7	75.3	9.77	8.23
$FYM_{187.5+Biof}$	5.80	5.50	79.0	75.3	9.94	8.33
FYM_{250}	5.93	5.63	79.5	75.7	10.13	8.51
$FYM_{250+Biof}$	5.93	5.63	79.5	76.0	10.20	8.53
VC_{125}	5.70	5.43	77.2	75.2	9.63	8.04
Biof	5.60	5.37	76.8	74.5	9.51	7.97
Control (Unfertilized)	5.56	5.37	76.5	74.3	9.51	7.93
RDF	6.13	5.63	79.7	76.2	10.75	9.00
CD (p=0.05)	0.23	0.17	1.5	NS	0.47	0.41
SEm(±)	0.08	0.05	0.1	0.1	0.12	0.11

*The figures in subscript are quantity of kg N ha^{-1}; FYM - Farmyard manure; Biof - Biofertilizer; VC - Vermicompost; RDF - Recommended dose of fertilizers.

Protein content

Protein content is the chief quality parameter of wheat grain and a parameter to influence the quality of product/*chapatti* of wheat flour. An optimum range of protein content is 9-12%, most favourable for chapatti making. Nitrogen, the primary component of amino acids, determines the protein content in grain. In general, with each increment in nitrogen level, as associated improvement is protein content is also recorded (11,12,29). In the current experiment, RDF resulted in highest protein content during both consecutive years (12.8% in 2016-17 and 13.8% in 2017-18 respectively). In 2016-17, FYM_{250} and $FYM_{250+Biof}$ successfully attained statistical equivalence with RDF (14-15, 30). Among organic treatments, $FYM_{250+Biof}$ resulted in significantly higher protein content (12.4%) than all the treatments but was statistically at par with FYM_{250} (12.3%) and $FYM_{187.5+Biof}$ (11.9%). FYM_{125} (11.2%) was statistically at par with VC_{125} (11.3%) and Biof (10.8%) but significantly better than unfertilized control (10.6%) (Table 2) similar findings were also reported earlier (31). Unfertilized control recorded a 20.75% decline in protein content when compared with RDF.

Phenol reaction score

Phenol reaction score (PRS) helps to determine the enzyme tyrosinase activity in the grains which influence tyrosine availability to humans. The said enzyme leads to greyish or blackish appearance of wheat flour dough kept for a long time, which is an un-desirable feature. Wheat flour reaction with phenol and resulted extent of grey/black colour is designated as phenol reaction score and lower values indicates better dough quality. With current experiment significantly lower PRS is recorded with highest levels of nutrition wheat inorganic or organic (i.e. with RDF and $FYM_{250+Biof}$ 3.3, each) among all the treatments during both the years. Poor nutritive status of Control lead to the highest PRS (3.8) which was in comparison with FYM_{125}, $FYM_{125+Biof}$, $FYM_{187.5}$, $FYM_{187.5+Biof}$, VC_{125} and Biof. In contrast, some studies support no influence of any of nutrition treatments (FYM and inorganic fertilizers) (25).

Gluten quantity and quality

Gluten as influenced by protein content, indicates the dough quality of wheat as higher binding capacity due to high protein improves dough quality.

Statistical equivalence was with $FYM_{250+Biof}$ (17.30%) and all the other organic treatments as well as RDF except Biof (11.20%) in the first experimental year. In 2017-18, $FYM_{250+Biof}$ recorded significantly higher wet gluten content (14.97%) among all the treatments. $FYM_{187.5+Biof}$, $FYM_{250+Biof}$ (14.83%) and RDF (14.83%) also attained statistical lead equivalent to $FYM_{250+Biof}$ (Table 3). Enhanced nutrient supply eventually led to improved protein content and ultimately improved gluten content. Availability of complex nutrient supply though organic inputs surpassed nutrient supply through inorganic fertilizers. Similarly, dry gluten content was again higher with high organic inputs except for the second year of experiment where RDF had a lead over organic supplies. As far as the gluten index was concerned, it was significantly higher with RDF (83.67%) among all the treatments and equivalent with $FYM_{250+Biof}$ (82.97%) and FYM_{250} (83.00%). Similar trend was observed in 2017-18 (Table 3).

Mineral content in grain (Cu, Fe, Zn and Mn)

As evident from results recorded, organic inputs are the potential sources of macro and micro-nutrients. Some studies support improved micro-nutrient uptake also (32).

In 2016-17, different levels of FYM as well as VC_{125} resulted in significantly higher Cu content when compared with RDF literary supports are available in favour of these observations (20, 33) and some with contrast results (25). Decline in Cu content in grain with rise in FYM application is owed to the formation of stable complexes of fulvic and humic acids with Cu. Also, microbiological immobilization decreases availability of Fe and Cu and improved Mn and Zn concentration in soil which also indicates antagonistic effect of these nutrients on each other (34).

While comparing FYM_{125} and VC_{125} it was observed that vermicompost (36.0 ppm) resulted in higher micro-nutrient content as compared to FYM (33.5 ppm) owing to higher micro-nutrient supply (35, 36). In addition to this Zn and Fe were not influenced with organic inputs (20). Biofertilizers containing *Azotobacter* (the siderophore producing strain) enhanced Fe content in grain due to formation Fe chelates in the soil (27). Zn and Mn content in grain also followed the same trend as was in Cu and Fe during both the years. Inoculation with Biof resulted in a little increment in micro-nutrient content in grain but it was unable to attain any level of significance. It was also reported that inoculation with biofertilizers helps to increase the availability of micronutrients such as Fe, Zn, Cu and Mn (27).

Correlation among various quality parameters

Various quality parameters had different extents of correlations among each other. Some parameters were significant at 0.01% level of significance while others were significant at 0.05% level

Table 2. Effect of nutrition treatments on SDS, protein and phenol reaction score of wheat grains

Treatment	SDS (cc)		Protein (%)		Phenol reaction score (max score 10)	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
FYM_{125}	46.0	34.0	11.2	10.9	3.7	5.1
$FYM_{125+Biof}$	47.0	34.3	11.4	11.0	3.6	4.8
$FYM_{187.5}$	47.2	34.7	11.6	11.5	3.5	4.8
$FYM_{187.5+Biof}$	48.3	34.7	11.9	11.6	3.5	4.8
FYM_{250}	49.0	35.0	12.3	11.7	3.4	4.3
$FYM_{250+Biof}$	49.7	35.3	12.4	12.3	3.3	4.2
VC_{125}	46.3	34.7	11.3	11.4	3.6	4.8
Biof	45.5	33.0	10.8	10.8	3.6	5.1
Control (Unfertilized)	45.5	33.0	10.6	10.7	3.8	6.1
RDF	51.3	38.0	12.8	13.8	3.3	3.8
CD (p=0.05)	2.6	1.6	0.6	0.7	0.3	0.7
SE m(±)	0.3	0.2	0.2	0.3	0.1	0.3

*The figures in subscript are quantity of kg N ha^{-1}; FYM - Farmyard manure; Biof - Biofertilizer; VC - Vermicompost; RDF - Recommended dose of fertilizers.

Table 3. Effect of nutrition treatments on gluten content in wheat grains

Treatment	Gluten content (%)					
	Wet gluten		Dry gluten		Gluten index	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
FYM_{125}	15.33	11.60	6.03	5.00	81.93	86.20
$FYM_{125+Biof}$	15.70	12.37	6.10	5.10	82.17	86.52
$FYM_{187.5}$	16.37	13.13	6.47	5.57	82.23	86.56
$FYM_{187.5+Biof}$	17.03	13.87	6.80	5.77	83.00	87.03
FYM_{250}	17.13	14.83	7.30	6.20	83.00	87.18
$FYM_{250+Biof}$	17.30	14.97	7.40	6.20	82.97	87.29
VC_{125}	15.93	11.90	6.17	5.27	81.87	87.04
Biof	11.20	10.17	5.03	4.67	78.30	85.55
Control (Unfertilized)	11.23	10.27	5.00	4.47	78.10	85.15
RDF	16.87	14.83	7.00	6.30	83.67	87.84
CD (p=0.05)	2.22	1.41	0.39	0.39	1.04	1.01
SE m(±)	0.6	0.5	0.3	0.3	0.2	0.1

*The figures in subscript are quantity of kg N ha^{-1}; FYM - Farmyard manure; Biof - Biofertilizer; VC - Vermicompost; RDF - Recommended dose of fertilizers.

Table 4. Effect of nutrition treatments on mineral content (Cu, Fe, Zn and Mn) in grain

Treatment	Mineral content (ppm)							
	Cu		Fe		Zn		Mn	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
FYM_{125}	4.1	2.2	33.5	31.2	15.8	22.2	14.3	15.0
$FYM_{125+Biof}$	4.3	2.4	34.5	31.3	16.1	23.0	14.4	15.2
$FYM_{187.5}$	4.4	2.5	36.8	32.6	17.7	23.3	15.7	15.3
$FYM_{187.5+Biof}$	4.4	2.5	36.8	32.0	17.7	23.6	16.0	15.8
FYM_{250}	4.8	2.9	44.0	34.1	19.7	24.3	16.8	16.3
$FYM_{250+Biof}$	4.9	3.1	44.2	34.1	21.1	24.5	17.4	16.8
VC_{125}	4.4	2.4	36.0	33.9	17.8	22.4	15.0	15.4
Biof	2.8	1.6	24.3	20.8	12.9	19.5	10.1	13.2
Control (Unfertilized)	2.9	1.50	23.7	18.4	12.4	18.9	9.7	13.0
RDF	3.4	1.9	34.2	29.9	15.5	22.7	12.8	14.2
CD (p=0.05)	0.4	0.31	2.9	2.2	1.2	1.7	1.4	1.1
SE m(±)	0.4	0.3	1.2	1.0	0.7	0.4	0.7	0.3

*The figures in subscript are quantity of kg N ha^{-1}; FYM - Farmyard manure; Biof - Biofertilizer; VC - Vermicompost; RDF - Recommended dose of fertilizer

of significance. There were some parameters which had negative correlation such as PRS with grain appearance (r = -0.919 and -0.876), grain hardness (r = -0.863 and -0.884) during both the years. Micronutrients, such as Cu, Fe Zn and Mn even had no significant correlation with other parameters at all (grain appearance and grain hardness in 2016-17 and grain hardness, SDS- sedimentation value and grain protein content in 2017-18). Some parameters had strong correlation among each other such as grain appearance with grain hardness (r = 0.974 and 0.907 in 2016-17 and 2017-18 respectively) as bolder the grain better will be the grain appearance score. Higher protein content reflects more bonding and strength among protein and starch resulting in higher grain hardness. Thus, protein content can be a determining factor for grain hardness. Also, a strong correlation among two (r = 0.946 and 0.961 for the year 2016-17 and 2017-18) support the study. Protein is also a determining factor for SDS- sedimentation value and the same is evident from strong correlation coefficient (r) of 0.979 and 0.963 for the year 2016-17 and 2017-18.

Table 5. Correlation Matrix for quality parameters (2016-17)

	GAS	HW	GH	SDSV	PRT	PRS	WG	DG	GI	CU	FE	ZN	MN
GAS	1.000												
HW	0.847**	1.000											
GH	0.974**	0.849**	1.000										
SDSV	0.976**	0.894**	0.977**	1.000									
PRT	0.967**	0.943**	0.946**	0.979**	1.000								
PRS	-0.919**	-0.859**	-0.863**	-0.922**	-0.941**	1.000							
WG	0.698*	0.878**	0.659*	0.729*	0.833**	-0.723*	1.000						
DG	0.838**	0.842**	0.783**	0.859**	0.935**	-0.864**	0.942**	1.000					
GI	0.740*	0.901**	0.731*	0.773**	0.862**	-0.732*	0.985**	0.924**	1.000				
CU	0.330^{NS}	0.633*	0.245^{NS}	0.373^{NS}	0.523^{NS}	-0.465^{NS}	0.850**	0.783**	0.765**	1.000			
FE	0.625^{NS}	0.816**	0.537^{NS}	0.645*	0.767**	-0.720*	0.914**	0.937**	0.854**	0.935**	1.000		
ZN	0.540^{NS}	0.722*	0.428^{NS}	0.557^{NS}	0.683*	-0.679*	0.861**	0.884**	0.776**	0.945**	0.979**	1.000	
MN	0.454^{NS}	0.734*	0.367^{NS}	0.490^{NS}	0.634*	$-.585^{NS}$	0.906**	0.861**	0.831**	0.983**	0.963**	0.967**	1.000

Where GAS- grain appearance score, HW - Hectolitre weight, GH - Grain hardness, SDSV - SDS sedimentation value, PRT - Protein, PRS - Phenol reaction score, WG - Wet gluten, DG - Dry gluten, GI - Gluten index, CU - Cu content in grain, FE - Fe content in grain, ZN - Zn content in grain and MN - Mn content in grain.

**correlation is significant at 0.01 level

*correlation is significant at 0.05 level

NS non-significant

Table 6. Correlation Matrix for quality parameters (2017-18)

	GAS	HW	GH	SDSV	PRT	PRS	WG	DG	GI	CU	FE	ZN	MN
GAS	1.000												
HW	0.903**	1.000											
GH	0.907**	0.896**	1.000										
SDSV	0.830**	0.900**	0.955**	1.000									
PRT	0.829**	0.846**	0.961**	0.963**	1.000								
PRS	-0.876**	-0.941**	-0.884**	-0.880**	-0.842**	1.000							
WG	0.963**	0.938**	0.875**	0.834**	0.783**	-0.875**	1.000						
DG	0.974**	0.937**	0.897**	0.866**	0.829**	-0.915**	0.986**	1.000					
GI	0.846**	0.942**	0.840**	0.909**	0.825**	-0.927**	0.903**	0.926**	1.000				
CU	0.645*	0.665*	0.348^{NS}	0.333^{NS}	0.231^{NS}	-0.576^{NS}	0.740*	0.694*	0.642*	1.000			
FE	0.604^{NS}	0.771*	0.450^{NS}	0.550^{NS}	0.385^{NS}	-0.694*	0.741*	0.721*	0.809**	0.878**	1.000		
ZN	0.763*	0.850**	0.596^{NS}	0.612^{NS}	0.483^{NS}	-0.765**	0.883**	0.843**	0.835**	0.925**	0.946**	1.000	
MN	.633*	0.687*	0.366^{NS}	0.374^{NS}	0.258^{NS}	-0.589^{NS}	0.751*	0.706*	0.687*	0.989**	0.913**	0.942**	1.000

Where GA- grain appearance score, HW - Hectolitre weight, GH - Grain hardness, SDSV - SDS sedimentation value, PRT - Protein, PRS - Phenol reaction score, WG - Wet gluten, DG - Dry gluten, GI - Gluten index, CU - Cu content in grain, FE - Fe content in grain, ZN - Zn content in grain and MN - Mn content in grain.

**correlation is significant at 0.01 level

*correlation is significant at 0.05 level

NS non-significant

Conclusion

The experimental results revealed that nutrition play an important role in determination of wheat grain quality and the same is influenced by both inorganic and organic sources. There was increment in quality parameters with organic inputs when compared with control, but the higher and quick nutrient releasing nature of inorganic fertilizers lead the supply of nutrients especially nitrogen to crop and resulted in higher protein content, grain hardness and sedimentation value. But at the same time heterogeneous nature of organic inputs resulted in supply of higher and a good range of different nutrients as compared to control.

Acknowledgements

NA

Authors' contributions

MK participated in the design of the study and performed the statistical analysis and compilation of data and manuscript preparation. HK participated in quality analysis and manuscript correction. CSA conceived of the study and participated in its design and coordination and manuscript correction.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None

References

1. Mitura K, Cacak-Pietrzak G, Feledyn-Szewczyk B, Szablewski T, Studnicki M. Yield and grain quality of common wheat (*Triticum aestivum* L.) depending on the different farming systems (Organic vs. Integrated vs. Conventional). Plants. 2023 Feb 23;12(5):1022. https://doi.org/10.3390/plants12051022
2. Zecevic V, Boskovic J, Knezevic D, Micanovic D. Effect of seeding rate on grain quality of winter wheat. Chilean Journal of Agricultural Research. 2014;74(1);23-28. https://doi.org/10.4067/S0718-58392014000100004
3. Pandey J, Singh A. Opportunities and constraints in organic farming: an Indian perspective. Journal of Scientific Research. 2012;56(1):47-72.
4. L-Baeckström G, Hanell U, Svensson G. Nitrogen use efficiency in an 11-year study of conventional and organic wheat cultivation. Communications in soil science and plant analysis. 2006 Mar 1;37(3-4):417-49. https://doi.org/10.1080/00103620500449302
5. Aulakh MS, Singh G. Integrated nutrient management: experience from South Asia. Integrated nutrient management for sustainable crop production. 2008:285-326. https://doi.org/10.1201/9781439828465.ch7
6. Benbi DK, Biswas CR, Bawa SS, Kumar K. Influence of farmyard manure, inorganic fertilizers and weed control practices on some soil physical properties in a long-term experiment. Soil Use and Management. 1998 Mar;14(1):52-54. https://doi.org/10.1111/j.1475-2743.1998.tb00610.x
7. Bhagat RM, Bhardwaj AK, Sharma PK. Long-term effect of residue management on soil physical properties, water use and yield of rice in north-western India. Journal of the Indian Society of Soil Science. 2003;51(2):111-17.
8. Kaur N, Kaur H, Mavi GS. Assessment of nutritional and quality traits in biofortified bread wheat genotypes. Food Chemistry. 2020 Jan 1; 302:125342. https://doi.org/10.1016/j.foodchem.2019.125342
9. Kaur H. Performance of bread wheat [*Triticum aestivum* (L.) emend. Fiori & Paol] cultivars in relation to nitrogen. M.Sc. Thesis. 2020. Punjab Agricultural University, Ludhiana, India.
10. Mattas KK, Uppal RS, Singh RP. Nitrogen management and varietal effects on the quality of durum wheat. Research Journal of Agricultural Science. 2011;2(2):279-53.
11. Zečević V, Đokić D, Knežević D, Mićanović D. The influence of nitrogen foliar application on yield and bread making quality parameters of wheat. Kragujevac J. Sci. 2004;26:85-90.
12. Kaur J. Precision nutrient management in wheat (*Triticum aestivum* L.) using nutrient expert and green seeker (Doctoral dissertation, Ph. D dissertation, Punjab Agricultural University, Ludhiana, Punjab, India).
13. Coventry DR, Poswal RS, Yadav A, Gupta RK, Gill SC, Chhokar RS et al. Effect of tillage and nutrient management on wheat productivity

and quality in Haryana, India. Field Crops Research. 2011 Sep 12;123(3):234-40. https://doi.org/10.1016/j.fcr.2011.05.016

14. Kharub AS, Chander S. Effect of organic farming on yield, quality and soil-fertility status under basmati rice (*Oryza sativa*)-wheat (*Triticum aestivum*) cropping system. Indian Journal of Agronomy. 2008;53(3):172-77. https://doi.org/10.59797/ija.v53i3.4855
15. Singh AK. Conversion to organic agriculture. Sudhi Ranjan Garg; 2007.
16. Mehta A, Kaur M, Gupta SK, Singh RP. Physico-chemical, rheological and baking characteristics of bread wheat as affected by farmyard manure and nitrogen management. Res Punjab Agic Univ. 2006;43:263-70.
17. Thakur SS, Pandey IB, Mishra SS. Effect of organic manure, fertilizer level and seed rate on yield and quality of late-sown wheat (*Triticum aestivum*). Indian Journal of Agronomy. 1999;44(4):44. https://doi.org/10.59797/ija.v44i4.3581
18. Dhaliwal JK, Saroa GS, Dhaliwal SS. Effect of nutrient management practices on wheat grain quality under Basmati rice-wheat system. Agricultural Research Journal. 2015;52(3):43-47. https://doi.org/10.5958/2395-146X.2015.00035.6
19. Bareth VS, Singh RK, Parihar CM. Effect of nutrient management using aqua-fertilization on yield, quality and nutrient uptake of wheat (*Triticum aestivum* L.) under dryland conditions. Annals of Agricultural Research. 2014;27(3).
20. Davari M, Sharma SN, Mirzakhani M. The effect of combinations of organic materials and biofertilisers on productivity, grain quality, nutrient uptake and economics in organic farming of wheat. Journal of organic systems. 2012;7(2):26-35.
21. Singh R, Agarwal SK. Effect of organic manuring and nitrogen fertilization on productivity, nutrient-use efficiency and economics of wheat (*Triticum aestivum*). Indian Journal of Agronomy. 2004;49 (1):49-52. https://doi.org/10.59797/ija.v49i1.5155
22. Langenkämper G, Zörb C, Seifert M, Mäder P, Fretzdorff B, Betsche T. Nutritional quality of organic and conventional wheat. Journal of Applied Botany and Food Quality. 2012 Dec 11;80(2):150-54.
23. Cochran WG, Cox GM. Experimental Designs, 2 nd. Edi. 306-09.
24. Test SD. with Pelshenke and Zeleny Tests'. Cereal Chem. 1979;56 (6):582-84.
25. Mahato S, Kafle A. Comparative study of azotobacter with or without other fertilizers on growth and yield of wheat in western hills of Nepal. Annals of Agrarian Science. 2018;16(3):250-56. https://doi.org/10.1016/j.aasci.2018.04.004
26. Debalin S. Performance of wheat (*Triticum aestivum* L.) varieties under different levels of farmyard manure (Doctoral dissertation, Punjab Agricultural University, Ludhiana).
27. Bulut S, Öztürk A, Karaoğlu MM, Yildiz N. Effects of organic manures and non-chemical weed control on wheat. II. Grain quality. Turkish Journal of Agriculture and Forestry. 2013;37(3):271-80. https://doi.org/10.3906/tar-1208-19
28. Malik BS, Paul S, Ahlawat AK, Singh AM, Shivay YS. Productivity and quality of wheat spp grown with different fertilization condition. Indian Journal of Agricultural Sciences. 2009;79(8):636.
29. Massoudifar O, Darvish Kodjouri F, Noor Mohammadi G, Mirhadi MJ. Effect of nitrogen fertilizer levels and irrigation on quality characteristics in bread wheat (*Triticum aestivum* L.). Archives of agronomy and soil science. 2014;60(7):925-34. https://doi.org/10.1080/03650340.2013.856004
30. Channabasana Gowda CG, Patil NKB, Patil BN, Awaknavar JS, Ninganur BT, Ravi Hunje RH. Effect of organic manures on growth, seed yield and quality of wheat.2008.
31. Dhaliwal JK, Saroa GS, Dhaliwal SS. Effect of nutrient management practices on wheat grain quality under Basmati rice-wheat system. Agricultural Research Journal. 2015;52(3):43-47. https://doi.org/10.5958/2395-146X.2015.00035.6
32. Sheikh MA, Dwivedi P. Physico-chemical parameters of organic manure, soil and impact of organic manure and NPK fertilizer on seed germination of soybean and wheat. International Journal of Engineering Technologies and Management Research. 2017;4 (12):118-30. https://doi.org/10.29121/ijetmr.v4.i12.2017.604
33. Singh SP. Effect of integrated nutrient management on wheat (*Triticum aestivum*) yield, nutrient uptake and soil fertility status in alluvial soil. Indian Journal of Agricultural Sciences. 2019;89(6):929-33. https://doi.org/10.56093/ijas.v89i6.90761
34. Rathod DD, Rathod PH, Patel KP, Patel KC. Integrated use of organic and inorganic inputs in wheat-fodder maize cropping sequence to improve crop yields and soil properties. Archives of Agronomy and Soil Science. 2013;59(11):1439-55. https://doi.org/10.1080/03650340.2012.724171
35. Barlas NT, Cönkeroğlu B, Unal G, Bellitürk K. The effect of different vermicompost doses on wheat (*Triticum vulgaris* L.) nutrition. Tekirdağ Ziraat Fakültesi Dergisi. 2018;15(2):1-4.
36. Admasu A, Tadesse K. Response of organic and inorganic fertilizers on growth and yield of wheat at Kulumsa in Arsi Highlands of Ethiopia. Open Access Journal of Agricultural Research. 2018;3 (6):2474. https://doi.org/10.23880/OAJAR-16000180