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ELEVATING TRADE QUALITY OF WHEAT GRAIN THROUGH INTEGRATED NUTRIENT MANAGEMENT: A COMBINATION STUDY OF ORGANIC AND INORGANIC FERTILIZERS

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ABSTRACT

In wheat, the world staple food crop, integrated nutrient management to wheat grain quality is the most important. Determining its market value. This is clearly demonstrated in wheat markets like the EU and North America, where consumers worldwide prefer high-quality wheat because of its baking and processing characteristics. Price and consumption will be affected by quality differences of the same product, locally produced and imported. This study aimed at the effect of integrated nutrition management (INM) on grain quality of wheat. The analytical parameters were based on the important crude wheat parameters of protein, gluten, starch and hectoliter weight. The experiments were carried out at Crop Research Centre, Uttaranchal University on 7 treatments such as various levels of inorganic and organic farming nutrient levels. The treatment having 50% NPK and application of *Azotobacter* gave the highest grain quality and improved protein and gluten contents. Thus, this research highlights the importance of N management for improving wheat quality and proposes that perhaps integrated nutrient solution for crops might be useful in improving both N and wheat quality. Farmers' sustainable agriculture for food production and enhanced value of the wheat trade is pointed out as one of major factors affecting the change.

***Keywords* :** Biofertilizer; Gluten content; Hectolitre weight; Nutrient management; Wheat quality.

Introduction

The wheat staple food crop (*Triticum aestivum* L) is of huge importance globally and it is the quality of the grain that makes the difference in its market value both nationally and internationally. The value of high-quality wheat can be immediate, in export markets like the European Union or North America, where better baking quality is valued more (Svanidze *et al*., 2021). For instance, the quality of the grains in the domestic market is significantly different from the preference and processing demands of the region, thereby impacting local price and consumption pattern (Ahmed *et al*., 2024). Stakeholders who want to position themselves optimally on both the global and local agricultural market will need to do some research on the factors that influence grain quality (Bold *et al*. 2017). Small to medium farmers are often presented with significant challenges to produce the more quality products needed by the growing urban population (Miguel, 2024). It exacerbates dependence on imports and contributes to the gradual exclusion from critical value chains of a large number of wheat growers. A plethora of production related constraints may obstruct enhancement of quality of output among producers for instance market imperfections like access to credit, risk management issues and intransigent attitudinal factors such as the inferior commercial trade attributes of wheat grain (Yaheliuk *et al*., 2024; Karlan *et al*., 2014; Suri *et al*., 2024). The size of the grains, protein content and overall nutritional value of wheat respectively influence its trade quality and end use products like bread, pasta or any processed food (Kadjo *et al*., 2016). The demand for the high-quality wheat grain is increasing and the farmers and researchers are seeking to enhance the grain quality while maintaining the production practices (Benyishay and Mobarak, 2019).

Integration of nutrition management (INM) amalgamates organic and inorganic fertilizers to improve plant development and productivity is one of the most effective strategies for improving wheat grain quality (Darjee *et al*., 2023). INM does not only deliver a nutrient balance, but also improve soil health; reducing the risk of environmental degradation caused by over-reliance on chemical fertilizers (Bisen and Hemalatha, 2023; Kumar *et al*., 2024). INM includes organic fertilizers that may promote the restoration of soil health (Carter *et al*., 2013; Duflo *et al*., 2014). In addition, organic amendments provide micronutrients that are regularly missing from synthetic fertilizers. Organic manures (biofertilizer, farmyard manure, vermicompost and press mud) can be used to improve the physical and biological properties of the soil, which include soil structure and microbial activity, while inorganic fertilizers can be used to enhance plant growth by providing readily available nutrients. Biofertilizers are mainly made from beneficial microorganisms and added to seeds or soil to increase the microbial rhizosphere population and biological activity of the beneficial microorganisms (Lamlom *et al*., 2023). Organic fertilizers contain fulvic and humic acids, which are essential for elevating soil fertility and plant nutrition through better nutrient uptake, increasing root growth, and reducing stress from the environment, thus greatly boosting the productivity and quality of crops (Ahmad *et al*., 2018; Atia *et al*., 2014). Others observed the functional significance of uptake of nutrients and enhancement of quality of soil due to the presence of fulvic and humic acids (Canellas *et al*., 2015; Gomaa *et al*., 2015; Moghadam *et al*., 2014; Cordeiro *et al*., 2011; Shafaqat Ali *et al*., 2015).

The ability of the output to be easily and clearly recognized in terms of quality is a precondition for market incentives for better quality output. Numerous characteristics delineate the quality of agricultural products (Miguel, 2024). There is a good correlation between the two quality attributes (produced and price). The existing quality indicators could be used by farmers to obtain returns on investment to enhance the potential quality of their products, the latent quality. This in turn means that it is not economical to implement expensive assessments of these latent quality attributes, and thus it will lead to lower price premiums and lower investments by agriculturists in improving these product attributes. There is anecdotal evidence that traders can ensure an expense that is too high to provide better than observed qualities to the processing companies and millers (Abate and Bernard, 2017). Thus, traders will probably be more willing to invest more screening costs to assess these quality traits. These costs include fixed costs (sunk costs) such as vehicles used for transportation, and variable costs such as labour costs (Casaburi, 2013; Casaburi and Reed, 2022; Bergquist and Dinerstein, 2020).

This study aims to comparatively evaluate the impact by both natural and synthetic chemicals on the trade superiority of wheat grain, focusing on key quality parameters such as protein content, hectoliter weight, grain starch content and gluten content influenced by several treatments. The study aims to develop an integrated nutrient management strategy to discover the best incautious nutrient management strategies for both improving grain quality and sustainable agriculture.

Materials and Methods

The research experiment was conducted at Crop Research Centre, Uttaranchal University, Dehradun (Uttarakhand) at an altitude of 1410 feet, 0.3408° N latitude and 77.9544° E longitude in the rainy seasons of *Rabi* season (November to April) 2021-22. Soil conditions before sowing are identified by carrying out analysis of the soil in the experimental field by certain biochemical and physiological characteristics (Table 1).

Table 1: Biochemical and physiological circumstances of the experimenting field.

Sr. No.	Particular	Composition	Method used	Reference
	Physical properties			
1.	Sand	53.40 %	International pipette method	Piper, 1966
2.	Silt	25.40 %	International pipette method	
3.	Clay	21.30 %	International pipette method	
4.	Soil texture	Sandy clay loam	Textural triangle	Black *et al.*, 1965

	Chemical properties			
1.	pH	7.2	PH meter using glass electrode	Jackson, 1973
2.	EC	0.29 dSm^{-1}	EC mater using conductivity method	
3.	Organic carbon	0.785 %	Wet chromic acid digestion	Walkley and Black, 1934
4.	Available N	125.4 kg ha^{-1}	Alkaline permanganate method	Kjeldahl, 1883
5.	Available P	12 kg ha^{-1}	Olsen's method	Olsen *et al*., 1954
6.	Available K	145.7 kg ha^{-1}	Ammonium acetate extract using flame photometer	Muhr *et al*., 1963

Experimental details

The research employed a Randomized Block Design (RBD) with three replication of seven treatments on the single gene dwarf variety of wheat, HDM-1553, which is resistant to rust and has a wide range of adaptations was taken with treatments i.e., T_1- 100 % recommended NPK (120:60:40 Kg ha^{-1}), T_2- 75 % of recommended NPK (90:45:30 Kg ha^{-1}) with *Azotobacter*, T_3-50 % of recommended NPK (60:30:20 Kg ha^{-1}) with *Azotobacter*, T_4- Only 100% FYM, T_5-50 % of recommended NPK with 100% FYM and *Azotobacter* and, T_6- 100% FYM with *Azotobacter*, and T_7-Control (No fertilizer). Farmyard manure (1.18: 0.45: 0.86 NPK) @12.5 t ha^{-1} was applied 15 days before sowing at the last time of ploughing and mixed with soil. Liquid *Azotobacter* @10 ml kg^{-1} was used for seed treatment. The standard procedure is used to analyze qualitative parameters such as dry gluten content, wet gluten content, protein content, starch and hectoliter weight at the grain moisture content of 13%. The rinsing out technique specified in the ISO: 21415-1:2006 is used for the determination of the dry and wet gluten contents in wheat flour while the Kjeldahl method is used for the overall protein concentration. The visco-elastic material, comprising largely of two protein components (gliadin as well as glutenin) in a moistened state is formed in wet gluten. Enzymatic colorimetric method is used to analyse the starch content. Hectolitre weight (or weight per unit volume) is the weight of 100 litres of wheat and even is the most simplistic prerequisites of wheat superiority. It gives us a good indication of flour production. In USA alongside Canada, hectoliter weight is represented in terms of lb/bushel (pounds per bushel) where as in Europe and India, it is showed as kg $hectolitre^{-1}$. The more the hectoliter weight, the more flour will be produced. In addition to the composition of its chemicals, the components that affect the hectoliter weight include kernel shape and uniformity of kernel size, as well as how the kernels are placed in the container when it is filled, and the density of the grain, that is, the kernel itself. The data were analyzed statistically and the results were evaluated by the F-test with a critical difference (CD) at the 0.05 probability level.

Results and Discussion

Hectoliter weight

Weight of the kernels or weight of 100 kernels is a major physical quality characteristic affecting wheat that is indicative of grain density, soundness, and milling quality. The nutrient management treatments differed significantly (Fig. 1; Table 2) in hectoliter weight. The lowest hectoliter weight (76.57 kg hl^{-1}) was obtained in the control treatment, which suggests that grain filling was poor because nutrient availability was poor. Highest hectoliter weight (80.12 kg hl^{-1}) was recorded under the treatment of 50% RDF+ FYM+ *Azotobacter* and 100% RDF (78.73 kg hl^{-1}) respectively. The increase in hectoliter weight in I.I. system might be due to better nutrient availability during the growth period of the crop which leads to better photosynthetic efficiency, assimilate translocation and grain filling. Protein synthesis, endosperm development and efficient grain filling are stimulated by adequate nutrition with nitrogen, which in turn results in denser and well-filled grains, with increased test weight. The same positive changes to wheat grain quality and hectoliter weight with balanced nutrient management have been reported by Gooding *et al*. (2003), Fageria (2014), and Marschner (2012).

Table 2: Qualitative features of wheat as a function of varying doses of RDF with FYM and biofertilizer methods.

Treatments	Hectoliter weight (kg hl^{-1})	Dry Gluten %	Wet Gluten %	Protein content %	Starch %
T_1	78.73	9.03	27.32	12.28	67.13
T_2	78.12	8.74	26.41	12.25	66.30
T_3	77.53	8.57	25.86	12.21	65.56
T_4	76.96	8.21	24.43	12.15	65.16
T_5	80.12	9.51	30.10	12.40	68.00
T_6	79.87	9.17	28.89	12.30	65.23
T_7	76.57	7.83	23.01	12.09	64.40
SE(m)±	**0.110**	**0.027**	**0.137**	**0.022**	**0.082**
CD (P=0.05)	**0.316**	**0.079**	**0.394**	**0.064**	**0.236**

Protein content

Protein is one of the most significant quality parameters which affect the nutritional and processing quality of wheat grain. Protein content in the grain was found to be significantly different between nutrient management treatments (Fig. 1; Table 2). The control treatment had the lowest protein percentage (12.09%) due to low nitrogen supply. The maximum level of protein content (12.40%) was achieved under 50% RDF + FYM + *Azotobacter*, while 100% RDF had 12.28%. Nitrogen is a major component of amino acids, peptides, enzymes, and proteins; thus, more N is available more protein can be synthesized in wheat grains. The combination of organic and inorganic nutrient supply via integrated nutrient management allows for a constant supply of nitrogen for uptake and grain protein accumulation. The concentrations of nitrogen in grain and protein are closely related and can be estimated by applying the conversion factor:

$$\textbf{Protein (\%) = Nitrogen (\%)} \times \textbf{6.25}$$

The findings are consistent with the results reported by Fageria (2014), Marschner (2012) and Triboi *et al*. (2006) which indicated that adequate nitrogen nutrition has a significant effect on wheat grain protein concentration.

Wet gluten content:

The ability to form a dough with acceptable elasticity, extensibility and bread-making ability is a very important quality trait of the wheat known as wet gluten. The treatments showed significant differences in wet gluten content (Fig. 3; Table 2). The lowest wet gluten content (23.11%) was recorded under control while highest wet gluten content (30.10%) was obtained with 50% RDF + FYM + *Azotobacter* and FYM + *Azotobacter* (28.89%). The nitrogen absorbed is largely used in the production of the gluten proteins, which are mainly gliadin and glutenin. Integrated nutrient management helps to increase nitrogen availability, thereby improving dough quality by increasing protein synthesis and gluten formation. The use of FYM along with biofertilizers helps to enhance the biological activity, nutrient mineralization and root growth of the soil, which in turn increases nutrient uptake and the gluten content. Shewry and Halford (2002), Triboi *et al*. (2006), Marschner (2012) and Fageria (2014) have made similar observations on the importance of nitrogen nutrition on the synthesis of gluten protein and wheat quality.

Dry gluten content:

The trend of the dry gluten content was similar to that of the wet gluten content. The lowest dry gluten content (7.83%) was recorded in the control treatment, the highest was obtained in 50% RDF + FYM + *Azotobacter* (9.51%) followed by FYM + *Azotobacter* (9.17%). Dry gluten is the true protein content of wheat after the removal of water from wet gluten and is used as a good measure of the processing quality of wheat. The reason for this increase in dry gluten content under INM could be due to better N uptake and better protein biosynthesis. The combination of improving soil physical properties and microbial activity through the use of organic manures and providing nutrient availability and uptake through the application of biofertilizers improves grain quality. Shewry and Halford (2002), Triboi *et al*. (2006), Marschner (2012) and Fageria (2014) have reported similar beneficial effects of nitrogen nutrition and balanced nutrient management on the accumulation of gluten and wheat grain quality.

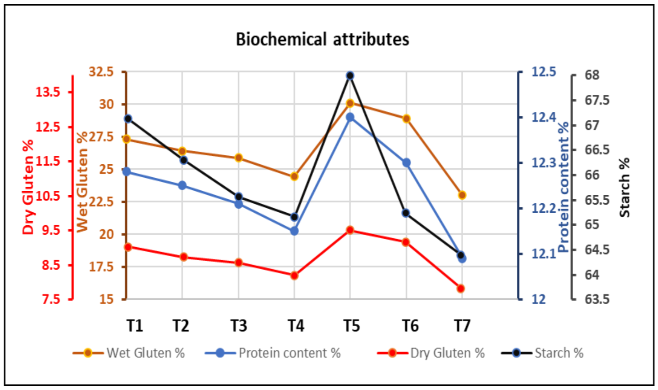

Fig. 1: Effect of different treatment practices on hectoliter weight of wheat.

Starch content

Starch is the main storage carbohydrate of wheat grains and is a major component in grain weight, flour yield and end-use quality. There were significant differences in the starch content among the treatments (Fig. 2; Table 2). The starch content under 50% RDF + FYM + *Azotobacter* was lowest (64.40%) and 50% RDF + FYM (65.23%) had the highest starch content followed by FYM + *Azotobacter* (65.42%). Balanced nutrient management increases photosynthetic activity and carbohydrate synthesis, resulting in more starch in developing grain. Nitrogen, phosphorus and potassium contribute to photosynthesis, energy transfers and assimilate transport, which helps to boost the production of carbohydrates and grain filling. The advantage of an integrated nutrient management is that this allows for a slow and gradual release of nutrients and, at the same time, boosts soil health, thus allowing starch biosynthesis to improve. Gooding *et al*. (2003), Fageria (2014), Marschner (2012) and Hawkesford *et al*. (2012) report similar findings for the effect of nutrient availability on carbohydrate accumulation and grain quality.

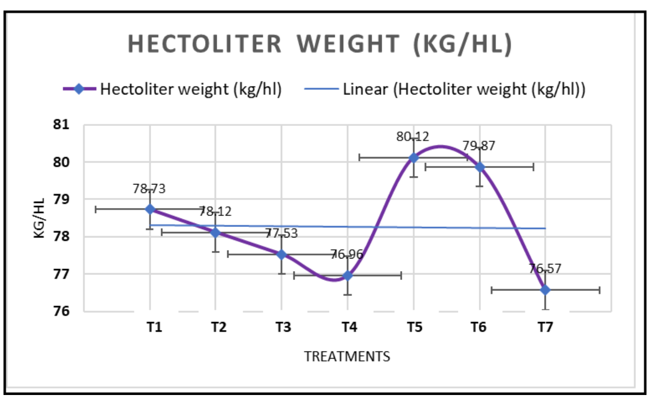

Fig. 2 : Effect of different treatment practices on qualitative yield of wheat.

Conclusion

This learning emphasises the important role that nitrogen management has to play in optimising wheat grain quality. Integrated nutrient strategies which included a combination of chemical fertilizers and organic inputs led to significantly higher protein content, hectoliter weight, gluten and chlorophyll content. Grain quality was positively related with chlorophyll, which is one of the major indicators of photosynthetic efficiency and nutrient uptake. The above observations are from different fertilization rates and fertiliser concentrations. Wheat variety HDM-1553 achieved better Plant Qualitative Parameters when planted with 50% RDF (chemical), FYM and Biofertilizer (60:30:20NPK kg ha^{-1} + FYM @12.5 t ha^{-1} + *Azotobacter* @ 10ml kg^{-1} seed). The use of organic matter proved to be effective in enhancing soil health and crop performance. While the specific optimal nutrient management strategy may vary depending on regional and environmental conditions, the results of this study provide valuable insights for farmers seeking to enhance wheat grain quality and productivity.

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References

Ahmed, J., Ptaszek, P., Basu, S., and Khan, M. A. (Eds.). (2016). *Advances in food rheology and its applications*. Woodhead Publishing. https://doi.org/10.1016/C2014-0-01710-5

Black, C. A. (Ed.). (1965). *Methods of soil analysis. Part I: Physical and mineralogical properties* (Agronomy Monograph No. 9). American Society of Agronomy.

Canellas, L. P., Olivares, F. L., Aguiar, N. O., Jones, D. L., Nebbioso, A., Mazzei, P., and Piccolo, A. (2015). Humic and fulvic acids as biostimulants in horticulture. *Scientia Horticulturae*, **196**, 15-27. https://doi.org/10.1016/j.scienta.2015.09.013

Carter, M. R., Sanderson, J. B., MacLeod, J. A., and White, R. P. (2013). Influence of compost and manure on soil quality and crop productivity. *Canadian Journal of Soil Science*, **93**(1), 1-12. https://doi.org/10.4141/cjss2012-091

Duflo, E., Kremer, M., and Robinson, J. (2014). Nudging farmers to use fertilizer: Theory and experimental evidence from Kenya. *American Economic Review*, **101**(6), 2350-2390. https://doi.org/10.1257/aer.101.6.2350

Fageria, N. K. (2014). *Nitrogen management in crop production*. CRC Press.

Gooding, M. J., Ellis, R. H., Shewry, P. R., and Schofield, J. D. (2003). Effects of restricted water availability and increased temperature on the grain filling, drying and quality of winter wheat. *Journal of Cereal Science*, **37**(3), 295-309. https://doi.org/10.1006/jcrs.2002.0501

Hawkesford, M. J., Araus, J. L., Park, R., Calderini, D., Miralles, D., Shen, T., Zhang, J., and Parry, M. A. J. (2012). Prospects of doubling global wheat yields. *Food and Energy Security*, **2**(1), 34-48. https://doi.org/10.1002/fes3.15

Jackson, M. L. (1973). *Soil chemical analysis*. Prentice Hall of India Pvt. Ltd., New Delhi.

Kjeldahl, J. (1883). Neue Methode zur Bestimmung des Stickstoffs in organischen Korpern [New method for the determination of nitrogen in organic substances]. *Zeitschrift fur Analytische Chemie*, **22**(1), 366-382. https://doi.org/10.1007/BF01338151

Lamlom, S. F., El-Bassiouny, H. M. S., and Bakry, B. A. (2023). Biofertilizers and sustainable crop production: A review. *Agronomy*, **13**(4), 1024. https://doi.org/10.3390/agronomy13041024

Marschner, P. (2012). *Marschner's mineral nutrition of higher plants* (3rd ed.). Academic Press.

Muhr, G. R., Datta, N. P., Sankarasubramoney, H., Dever, F., and Lelay, V. K. (1963). *Soil testing in India* (2nd ed.). United States Agency for International Development (USAID), New Delhi.

Olsen, S. R., Cole, C. V., Watanabe, F. S., and Dean, L. A. (1954). *Estimation of available phosphorus in soils by extraction with sodium bicarbonate* (USDA Circular No. 939). United States Department of Agriculture, Washington, DC.

Piper, C. S. (1966). *Soil and plant analysis*. Hans Publishers, Bombay.

Shewry, P. R., and Halford, N. G. (2002). Cereal seed storage proteins: Structures, properties and role in grain utilization. *Journal of Experimental Botany*, **53**(370), 947-958. https://doi.org/10.1093/jexbot/53.370.947

Singh, B. (2019). Integrated nutrient management for sustainable crop production and soil health. *Indian Journal of Fertilisers*, **15**(11), 1180-1188.

Subbiah, B. V., and Asija, G. L. (1956). A rapid procedure for the estimation of available nitrogen in soils. *Current Science*, **25**, 259-260.

Svanidze, M., Gotz, L., and Glauben, T. (2021). Food security and the wheat market: Global trade implications. *Food Security*, **13**(2), 375-390. https://doi.org/10.1007/s12571-020-01113-2

Triboi, E., Martre, P., and Triboi-Blondel, A. M. (2006). Environmentally induced changes in protein composition in developing wheat grains. *Journal of Cereal Science*, **43**(3), 229-241. https://doi.org/10.1016/j.jcs.2005.09.001

Walkley, A., and Black, I. A. (1934). An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science*, **37**(1), 29-38. https://doi.org/10.1097/00010694-193401000-00003