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Effect of agro-ecological conditions and sowing practices on wheat quality attributes

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Abstract

The field experiment was conducted under four thermal environments (E₁:15th November, E₂:30th November, E₃:15th December, E₄:30 December) and three sowing methods (M₁: Broadcast, M₂: Line sowing and M₃: Bed planting) with three replications in Split Plot Design at Narmadapuram M.P. Results revealed that grain yield maximum (5262 and 4941 kg ha⁻¹) was found significantly higher in 15th November sowing environment as compared to other sowing environments. Quality parameters viz., the protein content, gluten, sedimentation and grain hardness were significantly superior in 30th December sowing environment and bed planting are positive correlated and increase these quality parameters in wheat grain. The hectolitre weight, iron and zinc were significantly highest in 15th November sowing environment with bed planting method. The study indicates that early sowing (November 15th) is optimal for maximizing wheat grain yield, while late sowing (December 30th) combined with bed planting favors better grain quality parameters. However, a trade-off exists between yield and quality as the highest yielding environment produced lower quality grain.

Keywords: Sowing time, planting method, quality parameters, wheat

Introduction

Wheat (*Triticum aestivum* L.) is a cornerstone crop in global agriculture, belonging to the Poaceae family. Its adaptability to diverse agro-climatic conditions and high productivity has made it a staple food for billions. As a symbol of the Green Revolution, wheat cultivation has been instrumental in achieving food security worldwide (Alam, 2013) [2]. Being a thermo-sensitive long-day plant, temperature is a critical climatic factor influencing wheat's growth and yield. Despite India's substantial wheat surplus, malnutrition remains a pressing issue. While developing high-nutrient wheat varieties takes time, optimizing agronomic practices can rapidly enhance both yield and quality. Tailoring wheat production to meet diverse local nutritional needs is increasingly vital. Additionally, maintaining high-quality wheat is crucial for India's growing export market. The paradox of malnutrition existing in a country with a substantial wheat surplus is a critical issue. While India has made significant strides in food security, the quality of the diet remains a concern. Wheat, as a staple food, has a pivotal role in addressing this.

Wheat is a primary carbohydrate source (71.18%) and a leading global provider of plant-based protein. Protein content varies regionally, with higher levels in central and peninsular India compared to the north. Madhya Pradesh boasts the highest flour extraction rate at 70%. As a whole grain, wheat offers essential nutrients, fiber, iron (3.19 mg), and zinc (2.65 mg). By conducting comprehensive research in these areas, it is possible to develop effective agronomic strategies to increase the nutritional value of wheat while maintaining or improving yields. This can contribute to addressing malnutrition and improving public health. The crux of the proposed research lies in enhancing wheat's nutritional value through agronomic interventions rather than solely relying on the time-consuming process of developing new varieties.

By focusing on optimizing agronomic practices, this research offers a practical and scalable approach to improving wheat nutrition, with the potential to have a far-reaching impact on human health and food systems. Adopting a multidisciplinary approach and collaborating with

farmers, policymakers, and nutritionists, this research can make a significant contribution to improving the nutritional landscape of India and beyond.

Materials and Methods

Field experiments were conducted for two consecutive *rabi* seasons (2019-20 and 2020-21) at Jawaharlal Nehru Krishi Vishwa Vidyalaya, All India Co-ordinated Research Project on Wheat, Zonal Agricultural Research Station, Powarkheda, Narmadapuram (M.P.). The study site, characterized by deep black Vertisol soil (pH 7), is situated in the Malwa plateau and Narmada sown hills agro-climatic zone. This region experiences a tropical sub-humid climate with hot, dry summers and cool, dry winters. According to the NBSS&LUP, Nagpur, the area falls under agro-ecological region 10 (Central Highlands, Malwa and Bundelkhand), specifically the hot sub-humid (dry) eco-region encompassing the Malwa plateau, Vindhya, Satpura, and Narmada Valley. The experiment involved four sowing environments and three planting methods.

Quality Parameters

Protein content

The protein content was determined by using conventional micro-Kjeldahl digestion and distillation procedure as given in AOAC (1984).

Nitrogen and protein percent was calculated by the following formula:

$$\text{Nitrogen} = \frac{14 \times \text{Normality of H}_2\text{SO}_4 \times \text{Vol. of H}_2\text{SO}_4 \times 10}{\text{weight of sample (mg)} \times 100}$$

Protein percent in the sample was estimated by following formula:

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

Gluten Determination

Gluten is isolated from flour by washing away starch and soluble components using a sodium chloride solution. A 10-gram flour sample is required for this analysis.

Procedure

- 1. Dough Formation:** Knead 25 grams of flour with approximately 15 mL of water to form a dough ball. Allow the dough to hydrate for one hour by immersing it in water.
- 2. Gluten Isolation:** Gently knead the dough under a gentle stream of water using a fine sieve to remove starch. Continue washing until the water runs clear.
- 3. Drying:** Shape the remaining gluten into a ball, remove excess water, and dry it in an oven at 100°C for 24 hours.
- 4. Calculation:** Determine the dry gluten content by weighing the dried gluten.

Determination of Hectolitre weight (kg/hl)

A tube of 100 ml capacity was filled by grains that fell from a defined height using an overhead storage hopper. The grains were levelled in the tube with the help of a metallic lid and then grains were weighed and was recorded as kg hl⁻¹. Hectolitre weight (or weight per unit volume) is the weight of 100 litres of wheat and is the simplest criteria of wheat quality. It gives us a rough index of flour yield. Higher the hectolitre weight, the better is the flour yield. The factors affecting the hectolitre

weight are kernel shape and uniformity of kernel size, orientation of kernels in container when it is filled, density of the grain influenced by structure of grain and its chemical composition.

Determination of Sedimentation value

Grind 100 g. of wheat in lab grinder. Sieve ground wheat using 100 mesh. Place 3.2 g of flour in 100-ml glass stoppered graduated cylinder. Add 50 ml water containing bromophenol blue. Mix thoroughly flour and water by moving the cylinder horizontally 12 times. Start the timer and place the cylinder on shaker for 5 min. remove the cylinder end add 25 ml isopropyl alcohol - lactic acid reagent. Place the cylinder again on shaker for 5 min. and let stand exactly 5 min. at the end of 5 min read the volume in ml of sediment in cylinder.

Calculate the value on 14% moisture basis. Sedimentation value is an index of quantity and quality of gluten.

Sedimentation value corrected to 14% moisture,
Uncorrected Sedimentation value

$$X = \frac{100 - 14}{100 - \text{original flour moisture}}$$

Determination of Hardness Measurement

Approximate 100 grains were randomly obtained from each sample. Each 100 grains sample was located in the sample hopper of the machine for measurement of grain hardness.

Determination of iron and zinc content in grain

One gram of plant material was taken in 100 ml conical flask, 10 ml mixture of di acid mixture (2.5:1 of AR grade HCL4:HNO₃ respectively) was added to each flask and whole mass was digested on hot plate to get white solution. The digestate was transferred in 50 ml volumetric flask and volume was made up to the mark with distilled water and analysed on atomic absorption spectro-photometer (Jackson, 1965)

Results and Discussion

The data table 1 presents a comprehensive analysis of wheat quality parameters under different sowing environments and methods. Key parameters include protein content, gluten index, hectolitre weight, sedimentation, grain hardness index, iron, and zinc content.

Protein content

The protein content was significantly superior in 30th December sowing environment (11.65) followed by 15th December (11.15). While significantly lowest protein content (10.88) was observed in 15th November sowing environment. Protein content is directly influenced by sowing environment later sowings (December) resulted in significantly higher protein content compared to earlier sowings (November). Bed planting method was recorded significantly highest protein content (11.51) followed by broadcast method (11.00). While significantly lowest protein content was noted in line sowing (10.96). Bed planting resulted in significantly higher protein content compared to broadcast and line sowing. The findings confirm previous research. Bed planting significantly increased protein content compared to other methods. Nitrogen application also positively impacted protein content. Studies by Ooro *et al.* (2011) [19], Szmigiel *et al.* (2014) [27], Massoudifar *et al.* (2014) [17], Sun *et al.* (2014) [26], and Shu-Ping support these findings.

Gluten index

The gluten index was significantly superior in 30th December sowing environment (52.18) followed by 15th December (49.95). The significantly lowest gluten (46.14) was recorded in 15th November sowing environment. Later sowings (December) resulted in significantly higher gluten index values compared to earlier sowings (November). Bed planting method was observed significantly highest gluten (50.14) and at par with line sowing (50.02). Significantly lowest gluten index was observed in broadcast method (49.07). Bed planting and line sowing showed significantly higher gluten index values compared to broadcast sowing. The study suggested that Gluten index was increased by delayed in sowing beyond 15th November each delay of 15 days to 30th December. Bed planting and line sowing resulted in higher gluten index compared to broadcast sowing. This is likely due to increased nutrient uptake, leading to better photosynthesis and grain filling. Flour protein content directly correlates with gluten content. The efficiency of converting protein into gluten is measured by the WG/P ratio, a key indicator of gluten production efficiency.

Hectolitre weight

The hectolitre weight was significantly highest in 15th November sowing environment (81.08 kg/hl) followed by 30th November (78.56 kg/hl). The hectolitre weight was recorded significantly lowest (70.89 kg/hl) in 30th December sowing environment. Bed planting method was found significantly highest (77.98 kg/hl) followed by line sowing (76.50 kg/hl). While significantly lowest hectolitre weight was observed in broadcast method (75.33 kg/hl). Lower hectolitre weight with sowing beyond November month could be due to smaller and shrivelled grains along with lesser weight of the grains due to higher temperature during reproductive phase. Variety significantly impacted hectolitre weight, while sowing time was the primary factor influencing wheat yield. Additionally, the interplay between sowing time and variety also significantly affected yield. The result is supported by findings of Kaur *et al.* (2010) [12]. It appears that high grain yields were associated with high hectolitre mass. Hectolitre weight is a crucial determinant of wheat quality, often correlated with potential flour yield. Manley *et al.*, (2009) [16].

Sedimentation value

The sedimentation was significantly highest in 30th December sowing environment (48.14ml) followed by 15th December (45.61ml). The sedimentation was observed significantly lowest (43.67 ml) in 15th November sowing environment. Later sowing dates (December) resulted in significantly higher sedimentation values compared to earlier sowings (November). The sedimentation a key indicator of dough quality. However, this needs to be balanced with other factors like yield and disease susceptibility. Bed planting method was found significantly highest (46.73 ml) followed by line sowing (45.60 ml). While significantly lowest sedimentation was recorded in broadcast method (44.10 ml). It was each 15 days delay in sowing 15th November to 30th December the sedimentation was increased. Bed planting exhibited the highest sedimentation, followed by line sowing, with broadcast sowing showing the lowest values. The choice of sowing method can influence sedimentation, with

bed planting and line sowing appearing to be more beneficial. Higher sedimentation was also reported by Eslami *et al.* (2014) [8].

Grain hardness

The grain hardness was significantly highest in 30th December sowing environment (74.24) and followed by 15th December (73.39). The grain hardness was observed significantly lowest (70.68) in 15th November sowing environment. Bed planting method was found significantly highest (39.23) and at par with line sowing (39.04). Significantly lowest grain hardness was observed in broadcast method (38.15). It was each 15 days delay in sowing 15th November to 30th December the grain hardness index was increased. Endosperm texture, primarily determined by grain hardness, is the cornerstone of wheat quality. Protein content and gluten strength are additional critical factors influencing overall quality. Endosperm texture significantly impacts milling, baking, and the final product's characteristics, serving as a key determinant for wheat classification. Late sowing and line sowing generally increase grain hardness. This finding aligns with previous research by Campbell (2007) [5], Eslami *et al.* (2014) [8], Abdullah *et al.* (2007) [1], Kaur *et al.* (2010) [12], Hakim *et al.* (2012) [10], Farooq *et al.* (2015) [9] and Prasad (2016) [21].

Iron content

The iron content was significantly superior in 15th November sowing environment (40.51 ppm) followed by 30th November (39.36 ppm). The significantly lowest (36.58 ppm) was observed in 30th December sowing environment. Earlier sowing might be advantageous for maximizing iron content in wheat grains. However, this needs to be considered in conjunction with other factors like yield and grain quality. Bed planting method was found significantly highest (38.94 ppm) followed by line sowing (38.73 ppm). Significantly lowest iron was observed in broadcast method (37.84 ppm). The choice of sowing method can influence iron accumulation in wheat grains, with bed planting and line sowing appearing to be more effective. Amarsheetiwar *et al.* (2018) [3] reported delayed sowing induced heat stress significantly impacted wheat grain micronutrient content and yield.

Zinc content

The zinc was significantly superior in 15th November sowing environment (42.96 ppm) followed by 30th November (41.52 ppm). The significantly lowest (37.53 ppm) was observed in 30th December sowing environment. Bed planting method was found significantly highest (40.82 ppm) and at par with line sowing (40.60 ppm). Significantly lowest zinc was observed in broadcast method (39.70 ppm). Bed planting and line sowing might provide better soil conditions for zinc and iron uptake, potentially due to improved aeration, water infiltration, or nutrient availability. Early sowing and bed planting enhanced iron and zinc content in wheat grains. These findings align with Kaur *et al.* (2010) [12]. Delayed sowing reduced zinc content, potentially due to adverse conditions during grain development. Wheat is a valuable source of dietary fiber, iron, and zinc when consumed as a whole grain.

Table 1: Protein, Gluten index, Hectolitre, Sedimentation, grain hardness, Iron and Zinc of wheat as influenced by different environments and sowing methods

Treatment	Protein (%)			Gluten Index (%)			Hectolitre weight (kg/hl)			Sedimentation (ml)			Grain Hardness index			Iron (ppm)			Zinc (ppm)		
	19-20	20-21	Mean	19-20	20-21	Mean	19-20	20-21	Mean	19-20	20-21	Mean	19-20	20-21	Mean	19-20	20-21	Mean	19-20	20-21	Mean
Different environments																					
E ₁ :15th Nov.	11.0	10.7	10.9	46.6	45.7	46.1	81.8	80.4	81.1	43.3	44.0	43.7	71.7	69.1	70.4	41.0	40.0	40.5	43.9	42.0	43.0
E ₂ :30th Nov.	11.1	10.8	10.9	48.2	46.6	47.4	79.2	77.9	78.6	44.4	44.6	44.5	72.5	69.8	71.1	40.1	38.6	39.4	42.1	40.9	41.5
E ₃ :15th Dec.	11.3	11.0	11.2	50.8	49.1	49.9	76.6	75.2	75.9	45.1	46.1	45.6	74.7	71.9	73.3	38.1	37.1	37.6	40.1	38.9	39.5
E ₄ : 30th Dec.	11.8	11.5	11.7	53.4	51.0	52.2	71.6	70.2	70.9	47.7	48.6	48.1	75.1	73.1	74.1	36.1	37.1	36.6	38.1	37.0	37.5
S.Em ±	0.13	0.12	0.13	0.10	0.43	0.23	0.27	0.26	0.27	0.13	0.22	0.17	0.23	0.18	0.20	0.12	0.12	0.12	0.12	0.13	0.12
CD at 5%	0.46	0.43	0.45	0.36	1.48	0.79	0.94	0.92	0.93	0.46	0.76	0.58	0.81	0.62	0.70	0.40	0.42	0.41	0.43	0.46	0.43
Sowing methods																					
M ₁ : broadcast	11.1	10.9	11.0	49.1	46.9	48.0	76.0	74.7	75.3	43.8	44.5	44.1	73.0	70.6	71.8	38.1	37.5	37.8	40.4	39.0	39.7
M ₂ : Line sowing	11.1	10.8	11.0	50.0	48.3	49.2	77.2	75.8	76.5	45.3	46.0	45.6	73.9	71.5	72.7	39.0	38.4	38.7	41.3	39.9	40.6
M ₃ : Bed Planting	11.6	11.4	11.5	50.1	49.1	49.6	78.7	77.3	78.0	46.4	47.0	46.7	73.6	70.8	72.2	39.2	38.7	38.9	41.5	40.2	40.8
S.Em ±	0.15	0.15	0.15	0.30	0.51	0.35	0.27	0.26	0.27	0.39	0.36	0.36	0.24	0.20	0.22	0.29	0.28	0.29	0.29	0.28	0.29
CD at 5%	0.45	0.45	0.45	0.90	1.54	1.06	0.80	0.79	0.80	1.16	1.07	1.08	0.73	0.61	0.66	0.87	0.85	0.86	0.88	0.83	0.86

Conclusion

Optimizing sowing time and method significantly influences wheat quality parameters, particularly protein content, gluten index, hectolitre weight, sedimentation, grain hardness, iron, and zinc. Earlier sowing and bed planting generally enhanced nutritional value and grain quality. These findings underscore the critical role of agronomic practices in improving wheat's nutritional profile and overall suitability for diverse end-uses. By carefully considering these factors, it is possible to produce wheat with superior quality attributes, contributing to both human health and food security.

Authorship Contribution

DK: Research Design and Execution, Data Management, Tools and Technology, Writing - review & editing; **VK:** Conceptualization, Communication and Presentation, Writing - review & editing; **OT:** Data Steward, Writing - review & editing; **ASN:** Investigation; **MJ:** Resources; **JM:** Resources.

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