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Effect of integrated nutrients management on wheat growth in the foothills of the Himalayan zone

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Abstract
In a field experiment conducted at the Department of Agronomy, Dev Bhoomi Uttarakhand University in Dehradun, Uttarakhand, researchers aimed to understand how different combinations of inorganic fertilizers and biofertilizers affected the nutritional quality and organic matter status of wheat crops. The experiment included nine treatments, with one serving as a control and another consisting of 100% inorganic treatment. These treatments were tested using seven different combinations of inorganic, organic, and biofertilizers. Wheat was sown in December 2022 and harvested in April 2023. The sandy loam soil at the experimental site had medium levels of organic carbon and available total nitrogen but low levels of available total phosphorus and available total potassium, with a slightly acidic pH. Among the treatments, T_7 (100% RDF+PSB+VC) demonstrated the highest growth parameters and better yield components compared to other treatments. However, it is important to conduct further investigations and validate the findings in at least one more season before making recommendations to the farming community.

Keywords: Experiment included, organic matter, researchers

Introduction
Wheat, one of the world's major cereal crops, has a rich history and plays a vital role in global agriculture. It originated around 10,000 years ago and has since become one of the most cultivated crops worldwide, along with rice and maize. Wheat's adaptability allows it to thrive in various climates, from tropical regions to northern latitudes. In India, wheat is a significant crop, particularly in states like Uttar Pradesh, Punjab, and Haryana, due to its price stability. The Uttarakhand Himalaya region, heavily reliant on agriculture, has seen a slight increase in wheat production. Wheat's gluten protein component gives it unique qualities for dough formation, making it suitable for a wide range of food products. Genetic studies have focused on wheat gluten, particularly its storage proteins, known as glutenins and gliadins. These proteins contribute to dough strength and are important for processing quality. Maintaining genetic diversity in wheat populations is crucial for resilience against challenges such as pests, diseases, and changing environmental conditions. Future wheat production in India faces various challenges, including heat stress, water scarcity, and disease risks. Addressing these challenges will be essential for sustainable wheat production in the country.

Materials and Methods
The study titled "Effect of Integrated Nutrients Management on Growth and Yield of Wheat (*Triticum aestivum* Variety- HD 2967) in the Foothills of the Himalayan Zone" was conducted at Dev Bhoomi Uttarakhand University's experimental field in Dehradun, Uttarakhand during the winter (Rabi) season of 2021-2022. The field is located near Naugaon, in the Tarai region, at an altitude of approximately 650 m above sea level. The study focused on the HD-2967 variety of *Triticum aestivum*, which is recommended for rain-fed and irrigated areas in several states of India. Dehradun experiences a moderate climate, with moderate temperatures and significant rainfall throughout the year. The experimental field had slightly acidic soil with moderate levels of nitrogen and potassium, but low phosphorus content. The study employed a randomized block design with three replications and nine treatment combinations to thoroughly investigate the growth and yield of wheat.
Treatments are:

- NO Nitrogen, Phosphorus and Potassium T_1.
- 100% Recommend dose of Fertilizer T_2.
- 100% + Recommend dose of Fertilizer + Phosphorous solubilizing bacteria T_3.

- 100% Recommend dose of Fertilizer + Phosphorous solubilizing bacteria +vermicompost (2 t/ha) T_4.
- 50% Recommend dose of Fertilizer T_5.
- 50% Recommend dose of Fertilizer + Phosphorous solubilizing bacteria T_6.
- 100% Recommend dose of Fertilizer + Phosphorous solubilizing bacteria +Vermicompost (2 t/ha) T_7.
- 75% Recommend dose of Fertilizer T_8.
- 75% Recommend dose of Fertilizer +Phosphorous solubilizing bacteria T_9.
- 75% Recommend dose of Fertilizer + Phosphorous solubilizing bacteria + Vermicompost (2 t/ha) T_{10}.

Experimental Results

Number of plants germinated

At 20 DAS, treatment T_4 (100% RDF+PSB+VC) exhibited the highest germination rate with an average of 20.6 plants. T_3 (100% RDF+PSB) showed slightly lower germination at 17.8 plants, while T_1 (without NPK) had the lowest germination rate with an average of 14.4 plants. T_5 (50% RDF) displayed slightly better germination than T_1, averaging 14.6 plants.

Plant height

At 40 DAS, T_4 (100% RDF+PSB+VC) treatment resulted in the tallest plants, measuring 16.6 units. T_3 (100% RDF+PSB) followed with a height of 13.6 units. T_1 (without NPK) had the shortest plants at 8.6 units, while T_5 (50% RDF) showed a slightly higher height of

Number of tillers per m^2

At harvest, T_4 (100% RDF+PSB+VC) and T_3 (100% RDF+PSB) treatments had the highest tiller counts of 195 and 180.3 respectively, while T_1 (without NPK) and T_5 (50% RDF) treatments showed lower tiller numbers of 119 and 122. These results highlight the importance of nutrient supplementation, specifically 100% RDF with PSB and VC, in promoting increased tiller production.

Plant fresh weight

At harvest, T_4 (100% RDF+PSB+VC) had the highest plant weight of 223.4 units, followed by T_3 (100% RDF+PSB) with a weight of 192 units. T_1 (without NPK) had the lowest weight of 143.9 units, while T_5 (50% RDF) showed a weight of 159.9 units. These results demonstrate the significant impact of nutrient treatments on plant weight at harvest.

Plant dry weight

At harvest, the treatment with 100% RDF+PSB+VC (T_4) showed the highest dry plant weight of 114.8 units, followed by the treatment of 100% RDF+PSB (T_3) with a dry weight of 97.3 units. The treatment without NPK (T_1) exhibited a lower dry plant weight of 71.6 units, while the treatment with 50% RDF (T_5) showed a dry weight of 74.3 units.

Leaf area

At harvest, T_4 (100% RDF+PSB+VC) showed the highest leaf area of 168.5 units, followed by T_3 (100% RDF+PSB) with a leaf area of 159.3 units. T_1 (without NPK) displayed a lower leaf area of 136.8 units, while T_5 (50% RDF) had a similar leaf area of 138.7 units. These results highlight the positive impact of 100% RDF+PSB+VC treatment (T_4) on leaf area, while T_1 (without NPK) had the lowest leaf area among the treatments.

Table 1: Plant characters by the application of treatment at harvest stage

S. No	Treatments	Height	No/Tiller	Plant Fresh weight	Plant dry weight	Leaf area
T_1	NPK	36.3	119	143.9	71.6	136.8
T_2	100% RDF	43.6	169.6	176.7	88.9	157.4
T_3	RDF+PSB	44	180.3	192	97.3	159.3
T_4	RDF+PSB+VC	53	195	223.4	114.8	168.5
T_5	50% RDF	39.8	122	159.9	74.3	138.7
T_6	50% RDF+PSB	41.2	123	161.2	75.2	139.9
T_7	100% RDF+PSB+VC	41.3	137.2	162.3	77.8	140.9
T_8	75% RDF	42.3	148.3	162.8	79.4	144.1
T_9	75% RDF+PSB	42.8	151.2	164.6	86.4	147.2
T_{10}	75% RDF+PSB+VC	42.8	155.2	173.2	88	150.5

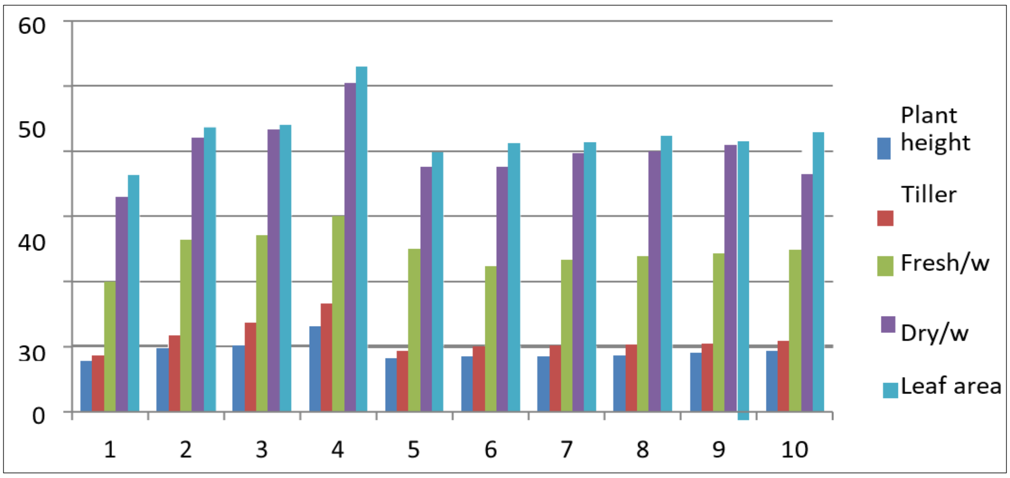


Fig 1: Plant characters by the application of treatment at harvest stage

Leaf area index (LAI)
At harvest, the treatment of 100% RDF+PSB+VC (T_4) showed the highest leaf area index of 9.3 units, followed by the treatment of 100% RDF+PSB (T_3) with a leaf area index of 8.5 units. The treatment without NPK (T1) and the treatment with 50% RDF (T_5) exhibited lower leaf area indices of 6 and 6.2 units, respectively.

Growth Ratio of the Crop (CGR)
At 80 DAS until harvest, the treatments of 100% RDF+PSB+VC (T_4) and 100% RDF+PSB (T_3) demonstrated maximum crop growth rates of 0.00487 and 0.0049, respectively. The treatment without NPK (T1) and the treatment with 50% RDF (T_5) displayed lower crop growth rates of 0.01667 and 0.00877, respectively.

Accumulations of dry matter (in g/0.5 m)
At harvest, the treatment of 100% RDF+PSB+VC (T_4) showed the highest dry matter accumulation of 109.5 units, followed by the treatment of 100% RDF+PSB (T_3) with a dry matter accumulation of 97.63 units. The treatment without NPK (T1) exhibited a lower dry matter accumulation of 72.4 units, while the treatment with 50% RDF (T_5) displayed a dry matter accumulation of 76.9 units.

Leaf Area Duration (LAD)
At 80 DAS until harvest, the treatment of 100% RDF+PSB+VC (T_4) exhibited the maximum leaf area duration of 162.6 days, followed by the treatment of 100% RDF+PSB (T_3) with a leaf area duration of 136.7 days. The treatment without NPK (T1) displayed a lower leaf area duration of 80.6 days, while the treatment with 50% RDF (T_5) showed a leaf area duration of 99.2 days.

Table 2: Plant characters by the application of treatment at harvest stage

Treatment	Leaf area index	Growth Ratio	Accumulation of dry	Leaf area duration
T_1	6	0.00484	72.4	83.5
T_2	7.2	0.00853	89.2	87.3
T_3	8.5	0.00877	97.6	89
T_4	9.3	0.01667	109.5	60.5
T_5	6.2	0.0049	76.9	64.3
T_6	6.5	0.0052	78.4	67.4
T_7	6.2	0.0066	81.3	71.4
T_8	7.2	0.00079	82.5	76.4
T_9	8.4	0.00808	85.8	89
T_{10}	8.5	0.00843	86.2	83.5

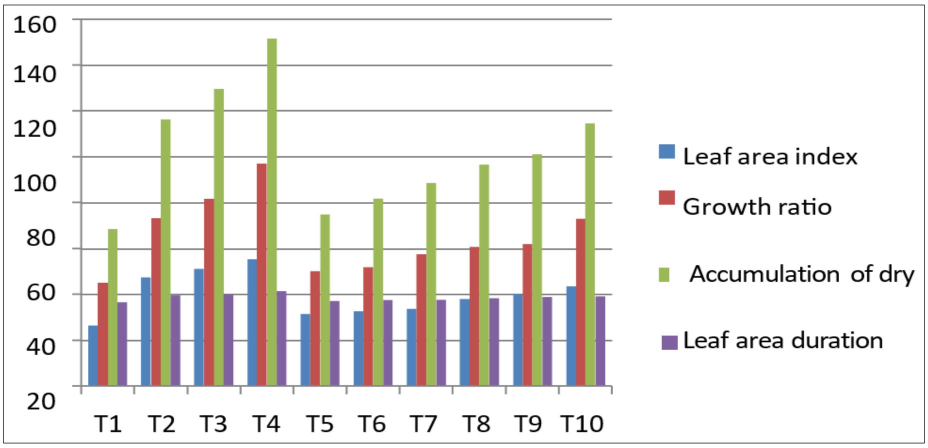
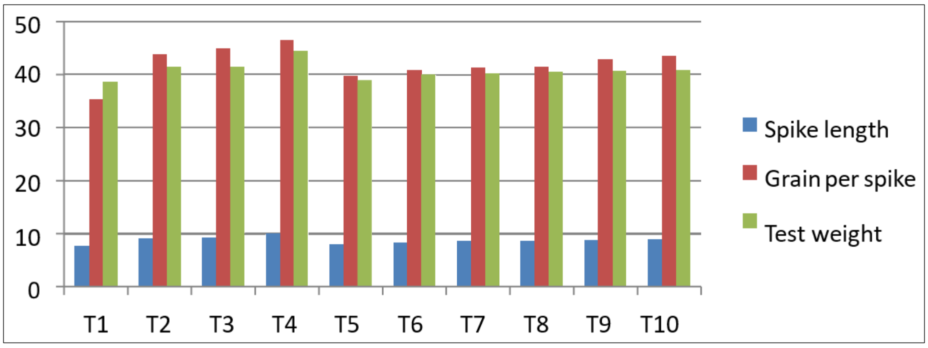


Fig 2: Plant characters by the application of treatment at harvest stage

Spike detail
During the evaluation of test S weight, T_4 (100% RDF+PSB+VC) showed the highest value of 44.4, followed by T_3 (100% RDF+PSB) with a test weight of 41.5. T1 (without NPK) had the smallest measurement weight of 38.7, while T_5 (50% RDF) also showed a lower test weight of 38. These results highlight the positive impact of 100% RDF+PSB+VC treatment (T_4) on test weight, while T1 (without NPK) had the lowest weight among the treatments.

Table 3: Detail of spike in different treatment

Treatment	Spike length	Grain per spike	Test weight
T_1	7.8	35.3	38.7
T_2	9.1	43.8	41.4
T_3	9.2	44.9	41.5
T_4	10.1	46.5	44.4
T_5	8.1	39.7	38.9
T_6	8.3	40.8	40
T_7	8.6	41.2	40.2
T_8	8.7	41.4	40.5
T_9	8.8	42.9	40.67
T_{10}	8.9	43.5	40.76
T_{10}	0.484	1.067	0.672



Detail of spike in different treatment

Grain yield

T_4 (100% RDF+PSB+VC) treatment showed the highest yield of 55.5, followed by T_3 (100% RDF+PSB) with a yield of 51.4. T_1 (without NPK) had the lowest grain yield of 26.6, while T_5 (50% RDF) yielded 31.6. These results emphasize the importance of nutrient treatments in achieving higher grain yields, with T_4 performing the best and T_1 the worst among the treatments.

Straw yield

The treatment of 100% RDF+PSB+VC (T_4) exhibited the maximum yield of 97.2, followed by the treatment of 100% RDF+PSB (T_3) with a yield of 81.8. The lowest straw yield was observed in the treatment without NPK (T_1), with a yield of 45.02, and the treatment with 50% RDF (T_5) yielded 50.2.

Biological yield

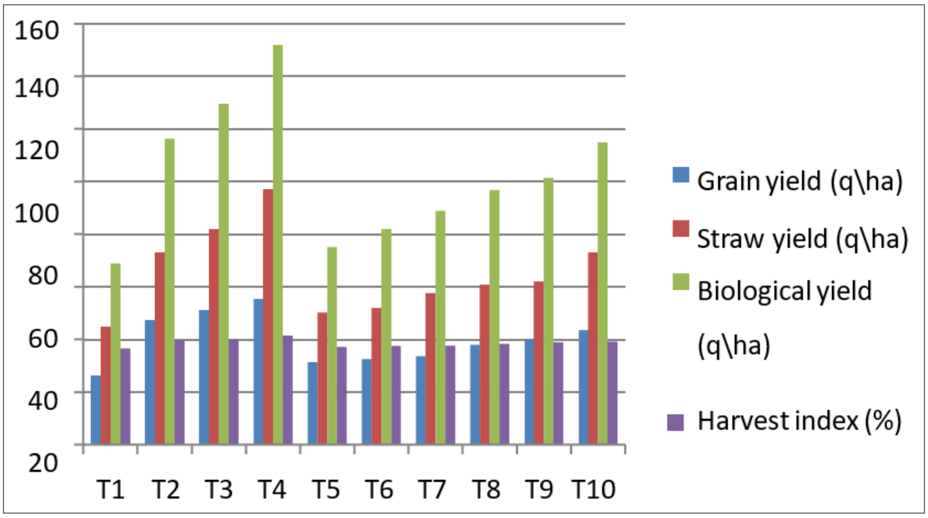
The treatment of 100% RDF+PSB+VC (T_4) showed the highest yield of 151.7, followed by the treatment of 100% RDF+PSB (T_3) with a yield of 129.5. The lowest biological yield was observed in the treatment without NPK (T_1), with a yield of 68.7, and the treatment with 50% RDF (T_5) yielded 74.94.

Harvest index

The treatment of 100% RDF+PSB+VC (T_4) displayed the highest index of 41.7, followed by the treatment of 100% RDF+PSB (T_3) with an index of 40.3. In the aftermath of the treatment, the coefficient of harvesting was found to be smallest. without NPK (T_1), with an index of 36.8, and the treatment with 50% RDF (T_5) had an index of 37.3.

Table 5: Detail of grain yield, straw yield, biological yield and harvest index in different treatment

Treatment	Grain yield (q\ha)	Straw yield (q\ha)	Biological yield (q\ha)	Harvest index (%)
T_1	26.6	45.02	68.7	36.8
T_2	47.6	73.2	116.2	39.7
T_3	51.4	81.8	129.5	40.3
T_4	55.5	97.2	151.7	41.7
T_5	31.6	50.2	74.94	37.3
T_6	32.8	51.9	81.83	37.8
T_7	33.78	57.6	88.69	37.9
T_8	38.11	60.8	96.64	38.6
T_9	40.3	62	101.2	39.03
T_{10}	43.7	73	114.7	39.4



Detail of grain yield, straw yield, biological yield and harvest index

Conclusion

The economic analysis conducted for this study revealed that treatment T_4, which used 100% RDF+PSB+VC, resulted in the best wheat growth and significantly higher yields compared to other treatments. In contrast, treatment T_1, which did not receive any NPK, had the lowest yield across all parameters evaluated. Treatments T_3 and T_2, combining 100% RDF+PSB and 100% RDF, showed minor growth improvements. However, treatments T_{10}, T_9, and T_8, utilizing 75% RDF+PSB+VC, 75% RDF+PSB, and 75% RDF respectively, displayed noticeable growth increases. On the other hand, treatments T_7, T_6, and T_5, using 50% RDF+PSB+VC and 50% RDF+PSB, showed unsatisfactory growth. The experiment highlighted the significant impact of specific nutrients on field performance and emphasized the importance of nutrient choice and combination for optimal crop growth.

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