Journal of Applied and Natural Science
17(1), 133 - 141 (2025)
ISSN : 0974-9411 (Print), 2231-5209 (Online)
journals.ansfoundation.org

Research Article

Sustainable and efficient maize (*Zea mays* L. *Var.* PMH-11) production strategies by intervention of Integrated nutrient management

Dipak Gite*
Department of Agronomy, School of Agriculture, Lovely Professional University, Phagwara-144411 (Punjab), India
Sushant Patil
Department of Agronomy, School of Agriculture, Lovely Professional University, Phagwara -144411 (Punjab), India
Saumya Sharma
Department of Agronomy, School of Agriculture, Lovely Professional University, Phagwara -144411 (Punjab), India
Pallavi
Department of Agronomy, School of Agriculture, Lovely Professional University, Phagwara-144411 (Punjab), India
Ashok Dambale
Department of Agronomy, School of Agriculture, Lovely Professional University, Phagwara -144411 (Punjab), India

*Corresponding author. Email: dipakgite01@gmail.com

Article Info
https://doi.org/10.31018/jans.v17i1.6160
Received: September 04, 2024
Revised: February 01, 2025
Accepted: February 07, 2025

How to Cite
Gite, D. *et al.* (2025). Sustainable and efficient maize (*Zea mays* L. *Var.* PMH-11) production strategies by intervention of Integrated nutrient management. *Journal of Applied and Natural Science*, 17(1), 133 - 141. https://doi.org/10.31018/jans.v17i1.6160

Abstract
The incorporation of organic manures is needed to improve ecological stability due to the intensive use of chemical fertilizers. Applying chemical fertilizers in conjunction with farm yard manure (FYM) slows down the loss of soil health and enhances the quality of the soil for future demands. The present research was conducted to assess the influence of the integrated nutrient management (INM) on growth, yield, nutrient concentration and quality parameters of maize (*Zea mays* L.). The study included twelve treatment combinations with four levels of RDF (Control, 50, 75, and 100% RDF ha^{-1}), three levels of FYM (Control, 5, and 10 t ha^{-1}) , and a Split Plot Design (SPD) that was assigned to the main plot and subplot. The results indicated that 100% RD of inorganic fertilizers + FYM @ 10 t ha^{-1} showed significant positive impact on plant height (152.88 cm), number of leaves $plant^{-1}$ (10.37), leaf area $plant^{-1}$ (4005.03 cm^2), leaf area index $plant^{-1}$ (3.34), Dry matter accumulation (157.94 g $plant^{-1}$), chlorophyll index (40.18), number of cobs $plant^{-1}$ (2.33), grain numbers cob^{-1}(438.93), protein content in grains (10.64%), nitrogen content in grains (1.702%) and stover (0.567%), phosphorous content in grains (0.382%) and stover (0.213%), and potassim content in grains (0.438%) and stover (0.875%) of maize. This experiment's findings indicate that using both inorganic and organic fertilizers at the same time increases maize response toward it.

Keywords: Growth, Integrated nutrient management (INM), Nutrient Content, Quality, Yield attributes

INTRODUCTION

Maize (*Zea mays* L.), often known as corn, is a globally important cereal crop that ranks third in cultivation after wheat and rice (Gao *et al*., 2020). Its tolerance to various environmental circumstances and its diverse uses, ranging from food to industrial raw materials, highlight its agronomic significance (Singh *et al*., 2023). Corn is regarded as the "queen of cereals" since it has any cereal's greatest genetic output potential. (Gezahegn *et al*., 2021 and Karnatam *et al*., 2023). It occupies a vital part in the Indian economy, just like rice, wheat, and millets and it has better yield response to chemical or inorganic fertilizers.

Nutrient play a crucial role in maximising the production potential of maize crop (Singh *et al*., 2021). Maize crop have better yield responses to organic fertilizers and inorganic fertilizers. Increased maize production and fertility of soil have been proven when plant nutrients are balanced by combining organic and inorganic fertilizers (Gezahegn *et al.,* 2021). Considering its rapid growth habits and genetic production potential, maize is a crop that requires a lot of nutrients (Ariraman *et al*., 2020). Maize reacts quickly with large amounts of chemical fertilizers, directly increasing growth and yield. Chemical fertilizers are a possible source of large amounts of readily available nutrients, so they cannot be entirely avoided. Overuse and prolonged application of chemical fertilizers degrade soil quality, which has a detrimental effect on the productivity of crop (Pahalvi *et al*., 2021). In addition to enhancing soil health, organic manures fulfil the needs for macro and micronutrients (Antil *et al*., 2020). Thus, a suitable combination of chemical fertilizer and organic manure must be created for corn production.

Integrating different nutrients is a careful and combined use of organic and inorganic nutrients to preserve soil health and productivity (Sharma *et al*., 2022). The application of well-decayed farm yard manure (FYM) in soil management techniques is a well-established method for improving the yield of crops, soil organic matter (SOM), stimulating microbial activity, influencing soil sustainability, and raising the quantity of macronutrients as well as micronutrients in soil that are available to plants (Dhaliwal *et al*., 2021). The application of appropriate and combined nutrients through organic and inorganics can solve problems like rising costs for inorganic fertilizers and declining crop productivity and soil health (Titirmare *et al*., 2023). Therefore, with careful implementation of INM techniques, the soil's production and fertility may be preserved. The aim of this research was to enhance crop yields sustainably while ensuring the preservation of soil health and maintaining its long-term productivity for future generations.

MATERIALS AND METHODS

Location and climatic condition

The field trial was conducted in *kharif* 2023–2024 at Lovely Professional University's Agricultural Farm. The experimental location comes under a sub-tropical region with hot summer and cool winter weather conditions. The temperature ranged from 4-37 ^{0}C and yearly rainfall ranged from 650 mm, with most falling during monsoon season.

Initial soil properties of the experimental field

The experimental soil was taken from 0-30 cm depths from different places of the experimental site. The experimental soil had the following characteristics: Soil pH (7.70), EC (0.09 dSm^{-1}), OC (0.62 %), accessible soil N (175.62 kg ha^{-1}), soil P (19.26 kg ha^{-1}), and soil K (360.08 kg ha^{-1}).

Experimental materials and treatment details

The certified seeds of maize PMH-11 were used for the present study with a seed rate of 20-25 kg ha^{-1}. PMH-11 is a single cross hybrid that matures in 95 DAS and has high yield potential in the Punjab region. The experiment had twelve combinations of treatments consisting of four RDF levels (Control, 50, 75, and 100 % RDF ha^{-1}), three FYM levels (Control, 5 and 10 tonnes ha^{-1}) were replicated thrice, and it was set up using a Split-Plot Design (SPD) assigned to main plot and subplot. The 100 % RDF for maize was 120 kg N, 60 kg P, and 40 kg K ha^{-1}. According to treatments, the well-decayed FYM @ 5, and 10 t ha^{-1} was incorporated 15 days before seeding. A 50% nitrogen and 100% dose of potassium and phosphorus were applied at seeding using urea, single super phosphate (SSP), and murate of potash (MOP). In two equal amounts, the remaining 50% of N was given as urea during the knee-high and tasseling stages.

Nutrient concentration and protein content (%)

Representative plant samples were collected at harvest, oven-dried at 105 ^{0}C for 48 hours, and ground to a fine powder to estimate the contents of nitrogen, phosphorus, and potassium. The method provided by Piper (1966) for nitrogen and potassium, and Jackson (1967) for phosphorus was used to estimate the nutrient concentration in grains and stover. The percentage of protein in the seed was calculated by multiplying its nitrogen content by 6.25 factor, and the result was represented as a percentage of protein content.

Statistical analysis

The experimental data were processed, entered into an MS Excel inventory sheet, and then subjected to statistical analysis using web-based OPSTAT software in the Split-plot (SPD) experimental design. ANOVA was developed to facilitate additional inference. The suitable LSD was acquired for every case at the 0.05 level of probability to compare the mean of treatments.

RESULTS AND DISCUSSION

Morphological parameters

Morphological parameters of maize was significantly influenced by varying levels of inorganic fertilizers and FYM, as shown in Table 1. At 90 DAS, highest plant height (149.35 cm), stem girth (5.97 cm), leaf area plant^{-1} (3692.57 cm^2), leaf area index (3.08), dry matter accumulation (153.26 g plant^{-1}) and chlorophyll index (37.99), was recorded under 100% RDF, which was significantly superior to 50%, 75% RDF and control. While maximum number of leaves plant^{-1} (9.78), was observed in 100% RDF which was significantly greater over 50% RDF and control and found at par with 75%

Table 1. Effect of nutrient and FYM levels on morphological parameters of maize

Treatments	Plant height (cm)	Number of leaves plant^{-1}	Stem girth (cm)	Leaf area per plant (cm^2)	Leaf area index plant^{-1}	Dry matter accumulation per plant (g plant^{-1})	Chlorophyll index
Main Plot Treatments							
N_0 : Control	120.78	6.40	2.86	1804.18	1.50	108.67	30.05
N_1 : 50 % RDF	132.13	7.67	3.99	2491.76	2.08	126.75	32.11
N_2 : 75 % RDF	141.42	9.03	5.04	3132.54	2.61	140.83	34.57
N_3 : 100 % RDF	149.35	9.78	5.97	3692.57	3.08	153.26	37.99
SE (m) ±	1.12	0.23	0.03	21.65	0.02	0.37	0.44
CD 5%	3.87	0.79	0.12	74.92	0.06	1.26	1.52
Sub Plot Treatments							
F_0 : Control	131.28	7.51	4.11	2428.58	2.02	124.84	32.00
F_1 : 5 t ha^{-1} FYM	135.50	8.20	4.48	2794.09	2.33	132.51	33.91
F_2 : 10 t ha^{-1} FYM	140.98	8.96	4.80	3118.12	2.60	139.79	35.12
SE (m) ±	0.38	0.08	0.02	18.80	0.02	0.33	0.19
CD 5%	1.14	0.24	0.07	56.37	0.05	1.00	0.57
Interaction M*S							
SE (m) ±	0.76	0.16	0.05	37.61	0.03	0.67	0.38
CD 5%	2.27	0.47	NS	112.74	0.09	2.00	1.14

Table 2. Effect of nutrient and FYM levels on yield attributes of maize

Treatments	Number of cobs plant^{-1}	Weight of cobs plant^{-1} (g/plant)	Length of Cob (cm)	Number of grain rows cob^{-1}	Number of grains row^{-1}	Number of grains cob^{-1}
Main Plot Treatments						
N_0 : Control	1.20	135.35	13.90	10.83	27.65	300.04
N_1 : 50 % RDF	1.58	143.62	15.50	11.68	29.63	346.09
N_2 : 75 % RDF	1.89	147.98	16.53	12.10	30.87	373.72
N_3 : 100 % RDF	2.18	156.43	17.78	12.72	32.09	408.55
SE (m) ±	0.03	0.73	0.17	0.08	0.23	3.81
CD 5%	0.10	2.52	0.59	0.27	0.80	13.19
Sub Plot Treatments						
F_0 : Control	1.57	142.42	15.22	11.44	29.16	334.83
F_1 : 5 t ha^{-1} FYM	1.70	145.38	15.83	11.79	29.98	354.55
F_2 : 10 t ha^{-1} FYM	1.87	149.75	16.74	12.27	31.04	381.92
SE (m) ±	0.02	0.56	0.13	0.04	0.12	1.70
CD 5%	0.07	1.67	0.39	0.13	0.34	5.09
Interaction M*S						
SE (m) ±	0.05	1.11	0.26	0.09	0.23	3.39
CD 5%	0.14	NS	NS	NS	NS	10.17

RDF. In terms of FYM levels, highest plant height (140.98 cm), number of leaves plant^{-1} (8.96), stem girth (4.80 cm), leaf area plant^{-1} (3118.12 cm^2), leaf area index (2.60), dry matter accumulation (139.79 g plant^{-1}) and chlorophyll index (35.12) was noted under 10 t FYM, which showed significant superiority over 5 t FYM and control.

The study found that interaction between two factors, i.e. RDF and FYM levels was found significant in plant height, leaf area plant^{-1}, leaf area index, dry matter accumulation and chlorophyll index, but it was found non-significant in stem girth (Table 5)

The increased supply of nitrogen, phosphorous, and potassium through inorganics enhanced nutrient availability, which accelerated cell division and enlargement, contributing to the increased maize height at all growth stages (Singh *et al*., 2017; Wailare *et al*., 2017; Raman and Suganya 2018 and Prasad *et al*., 2024). The nitrogen accelerates plant growth by increasing the length and number of internodes, leading to the advancement of taller maize plants (Nagar *et al*., 2022). Organic manures improve the soil's organic matter content, which includes humic compounds that influence nutrient accumulation and encourage root growth. These factors help plants grow more vigorously and develop taller plants of maize (Verma *et al*., 2018). Similar results of plant height of maize with the application of RDF and 10 t FYM ha^{-1} were observed by Desai *et al*. (2017);

Roopashree *et al*. (2019) ; Sharma *et al*. (2020); Adhikari *et al.* (2022); Kaur and Chhatwal. (2022); Nagar *et al*. (2022) and Yadav *et al*. (2022). The maize plants grew faster because of an adequate and timely supply of nutrients, specifically nitrogen, which increases the biochemical activity of maize plant' photosynthesis developing more number of leaves (Kaur and Chhatwal., 2022). This increased growth produced more nodes and internodes and, subsequently, more leaves per plant (Gharge et al., 2020;Naveen et *al*., 2023). The present results of number of leaves plant^{-1} of maize with the application of RDF and 10 t FYM were comparable to the reports of Niranjan and Prakash., 2021; Kaur and Chhatwal., 2022 and Nagar *et al*., 2022. A sufficient amount of nutrients through inorganic and organics aided in the maize plants growth, which in turn produced higher photosynthetic surface and leaf area. Because nitrogen promotes cell proliferation and elongation, the leaf area expand with each increase in the amount of N applied (Naveen *et al*., 2023). Similar findings of leaf area plant^{-1} of maize with application of RDF and 10 t FYM was observed by Roopashree *et al*. (2019). Improved use of the available nutrients from inorganic and organics produce more green leaves, which in turn improved the leaf area index (LAI) and when plants grow taller, they tend to produce more leaves per plant, which raises LAI of maize (Iqbal *et .al*., 2020). The increase in cellular components, primarily protoplasm, and the stimulation of cell division, enlargement, differentiation, and multiplication were the reasons for the rise in LAI of maize with rising fertilizer levels (Singh *et al*., 2017 and Prasad *et al*., 2024). These observation of leaf area index of maize with application of RDF and FYM was corroborate with Sharma *et al*., 2016. Plants require nutrient components to grow to a high height, produce a large number of leaves, and have a high LAI. This enhances interception of light on the crop canopy, which raises the plant's dry matter content. Increases in nutrient dosage result in larger leaf areas, which boost photosynthesis and assimilation of photosynthates and produce more dry matter of maize (Naveen *et al*., 2023). FYM closely associates with greater rate of assimilation and improved partitioning of assimilates which is important for increasing dry matter of maize (Nagar *et al*., 2022). Similar findings of dry matter accumulation of maize with the application of RDF and FYM was noted by Roopashree *et al*., 2019 and Yadav *et al*., 2022. Nitrogen makes up the majority of chlorophyll molecules, an increase in nitrogen availability by RDF results in an rise in the amount of chlorophyll in maize (Lakum *et al*., 2020 and Naveen *et al*., 2023). Under organic manure treatment, a notable rise in the ability of soil to retain water and various nutrients, which increases plant water potential. This led to the leaves opening and expanding quickly, increasing the amount of radiant energy intercepted and possibly increasing the chlorophyll synthesis in the maize leaves (Lakum *et al*., 2020). Similar results of chlorophyll index of maize with the application of RDF and FYM were found by Lakum *et al*. (2020) and Prabhavathi *et al*. (2021).

Yield attributes

Yield attributes of maize were significantly impacted by different inorganic fertilizer levels and FYM, as shown in Table 2. At harvest, maximum number of cobs plant^{-1} (2.18), weight of cob (156.43 g plant^{-1}), length of cob (17.78 cm), number of grain rows cob^{-1} (12.72), number

Table 3. Effect of nutrient and FYM levels on qualitative observations of maize

Treatments	Protein content in grains (%)	Moisture content (%)	Ash content (%)
Main Plot Treatments			
N_0 : Control	8.88	11.53	1.14
N_1 : 50 % RDF	9.58	13.68	1.34
N_2 : 75 % RDF	10.11	14.18	1.45
N_3 : 100 % RDF	10.45	14.50	1.57
SE (m) ±	0.09	0.16	0.01
CD 5%	0.31	0.56	0.04
Sub Plot Treatments			
F_0 : Control	9.50	13.13	1.30
F_1 : 5 t ha^{-1} FYM	9.73	13.47	1.38
F_2 : 10 t ha^{-1} FYM	10.04	13.82	1.45
SE (m) ±	0.04	0.13	0.01
CD 5%	0.12	0.39	0.02
Interaction M*S			
SE (m) ±	0.08	0.26	0.01
CD 5%	0.25	NS	NS

of grains row^{-1} (32.09) and number of grains cob^{-1} (408.55) were noted in 100% RDF which showed significant superiority over 50%, 75% RDF and control. In terms of FYM levels, maximum number of cobs plant^{-1} (1.87), weight of cob (149.75 g plant^{-1}), length of cob (16.74 cm), number of grain rows cob^{-1} (12.27), number of grains row^{-1} (31.04) and number of grains cob^{-1} (381.92) was recorded in 10 t FYM which was significantly superior over 5 t FYM and control.

The study found that interaction between two factors i.e. RDF and FYM levels was found significant in the number of cobs plant^{-1}, grain numbers cob^{-1} and test weight but it was found non-significant in cob weight, cob length, number of grain rows cob^{-1}, number of grains row^{-1} (Table 6)

The favourable effect on the growth, development, and cob's number of maize may have been caused by greater production of photosynthates and their effective translocation to the productive parts of maize due to appropriate accessible nutrients (Sudhakar., 2018). Inorganic fertilizer and Farmyard manure application improved the rhizosphere environment, improving availability of nutrients within the root zone and enhancing absorption and translocation of nutrients from source to sink, which plays a crucial role in cob and yield formation of maize (Jayanthi *et al*., 2020). Present findings of number of cobs of maize with the application of RDF and FYM was similar with Desai *et al*., 2017; Roopashree *et al*., 2019 and Getaneh *et al*., 2024. Application of both inorganic fertilizers and FYM together helps to increase vegetative growth, photosynthetic production, flowering time, fertility, and ultimately the quantity of grains per cob of maize (Kaur and Chhatwal., 2022). Similar results of grains per cob of maize with RDF and FYM application were found by Kaur and Chhatwal., 2022; Yadav *et al*., 2022 and Meena *et al*., 2023.

Qualitative observations

Qualitative observations of maize were notably affected by different levels of inorganic fertilizers and FYM, as shown in table 3. Highest protein content in grains (10.45%) and ash content of grains (1.57%) was recorded in 100% RDF, which was significantly better over 50%, 75% RDF and control. While highest moisture content of maize grains (14.50%) was observed in 100% RDF which showed significant superiority over 50% RDF and control but found at par with 75% RDF. In terms of FYM levels, highest protein content in grains (10.04%) and ash content of grains (1.45%) was recorded in 10 t FYM which was significantly superior over 5 t FYM and control. While highest moisture content of maize grains (13.82%) was observed under 10 t FYM which was significantly greater over control and found at par with 5 t FYM.The study found that interaction between two factors i.e. RDF and FYM levels was significant in protein content in grains but not in moisture content and ash content of maize grains (Table 6).

Crude protein content increased as a result of the steady rise in NPK dosages, which was linked to an increase in accessible nitrogen content (Mamatha *et al*., 2024). The enhanced protein content may result from increased nitrogen availability, which in turn led to increased N intake and accumulation of N content in plants, extending the advantage with favourable biochemical reactions at increased FYM levels. Increased intake of N is a component of amides, amino acids, and proteins (Nagar *et al*., 2022). Combined application of chemical fertilizers and FYM significantly and favourably increased the crude protein content, which may be

Table 4. Effect of nutrient and FYM levels on nutrient content of maize

Treatments	Nitrogen content (%)		Phosphorus content (%)		Potassium content (%)	
	Grain	Stover	Grain	Stover	Grain	Stover
Main Plot Treatments						
N_0 : Control	1.421	0.415	0.278	0.108	0.299	0.716
N_1 : 50 % RDF	1.533	0.472	0.315	0.136	0.363	0.783
N_2 : 75 % RDF	1.618	0.509	0.332	0.157	0.378	0.803
N_3 : 100 % RDF	1.672	0.543	0.358	0.191	0.399	0.826
SE (m) ±	0.014	0.008	0.007	0.003	0.003	0.004
CD 5%	0.049	0.028	0.023	0.011	0.010	0.015
Sub Plot Treatments						
F_0 : Control	1.520	0.461	0.306	0.133	0.320	0.743
F_1 : 5 t ha^{-1} FYM	1.557	0.485	0.320	0.146	0.364	0.780
F_2 : 10 t ha^{-1} FYM	1.606	0.509	0.346	0.165	0.395	0.823
SE (m) ±	0.007	0.003	0.002	0.002	0.003	0.003
CD 5%	0.020	0.008	0.006	0.005	0.008	0.009
Interaction M*S						
SE (m) ±	0.013	0.005	0.004	0.003	0.005	0.006
CD 5%	0.040	0.016	0.012	0.009	0.016	0.018

Table 5. Interaction effect of nutrient and FYM levels on morphological parameters of maize

Plant height (90 DAS)				**Number of leaves plant^{-1} (90 DAS)**				**Leaf area per plant (cm^2)**			
Interaction M*S	F_0	F_1	F_2	**Interaction M*S**	F_0	F_1	F_2	**Interaction M*S**	F_0	F_1	F_2
N_0	115.30	121.59	125.44	N_0	5.50	6.59	7.11	N_0	1625.81	1843.55	1943.19
N_1	127.18	130.65	138.56	N_1	7.23	7.34	8.44	N_1	2129.00	2423.02	2923.25
N_2	137.20	140.01	147.04	N_2	8.37	8.82	9.91	N_2	2694.53	3102.07	3601.00
N_3	145.44	149.74	152.88	N_3	8.94	10.03	10.37	N_3	3264.97	3807.72	4005.03
SE (m) ±	0.76			SE (m)	0.16			SE (m)	37.61		
CD 5%	2.27			CD 5%	0.47			CD 5%	112.74		

Leaf area index plant^{-1} (90 DAS)				**Dry matter accumulation (g plant^{-1}) (90 DAS)**				**Chlorophyll index (90 DAS)**			
Interaction M*S	F_0	F_1	F_2	**Interaction M*S**	F_0	F_1	F_2	**Interaction M*S**	F_0	F_1	F_2
N_0	1.35	1.54	1.62	N_0	104.43	109.77	111.81	N_0	29.14	30.25	30.76
N_1	1.77	2.02	2.44	N_1	120.22	124.05	135.98	N_1	31.22	31.93	33.17
N_2	2.25	2.59	3.00	N_2	128.53	140.54	153.42	N_2	32.49	34.84	36.38
N_3	2.72	3.17	3.34	N_3	146.18	155.67	157.94	N_3	35.13	38.64	40.18
SE (m) ±	0.03			SE (m)	0.67			SE (m)	0.38		
CD 5%	0.09			CD 5%	2.00			CD 5%	1.14		

Table 6. Interaction effect of nutrient and FYM levels on yield attributes and protein content of maize

Number of cobs plant^{-1}				**Number of grains cob^{-1}**				**Protein content in grains (%)**			
Interaction M*S	F_0	F_1	F_2	**Interaction M*S**	F_0	F_1	F_2	**Interaction M*S**	F_0	F_1	F_2
N_0	1.13	1.20	1.27	N_0	273.22	300.33	326.56	N_0	8.74	8.88	9.02
N_1	1.47	1.53	1.73	N_1	334.90	341.34	362.03	N_1	9.19	9.46	10.10
N_2	1.60	1.93	2.13	N_2	350.69	370.31	400.15	N_2	9.79	10.15	10.40
N_3	2.07	2.13	2.33	N_3	380.50	406.23	438.93	N_3	10.27	10.44	10.64
SE (m) ±	0.05			SE (m)	3.39			SE (m)	0.08		
CD 5%	0.14			CD 5%	10.17			CD 5%	0.25		

explained by the ample availability of necessary and advantageous nutrient elements, especially nitrogen from fertilizers and FYM (Thakur *et al*., 2021). This finding of protein content in maize grains with application of RDF and FYM was similar to the work of Lakum *et al*., 2020.

Nutrient content

Nitrogen, phosphorus and potassium content in grains and stover were considerably affected by different levels of inorganic fertilizers and FYM, as shown in Table 4. Highest N content (1.672%), P content (0.358%) and K content (0.399%) in grains and highest N content (0.543%), P content (0.191%) and K content (0.826%) in stover was observed in 100% RDF which showed significant superiority over 50% and 75% RDF and control. In terms of FYM levels, highest N content (1.606%), P content (0.346%) and K content (0.395%) in grains and highest N content (0.509%), P content (0.165%) and K content (0.823%) in stover was noted under 10 t FYM which showed significant superiority over 5 t FYM and control. The study found that interaction between two factors i.e. RDF and FYM levels was found significant in nitrogen, phosphorus and potassium content of grains and stover of maize (Table 7).

The concentrations of nutrients in plant tissue increase with the administration of sufficient fertilizers (Gezahegn., 2021). Grain and stover N between the increased urea and manure treatments show that seasonal mineralization rates was adequate to meet the crop nitrogen requirements (Miner *et al*., 2020). One possible explanation for a rise in content of N due to consistent and steady supply of N from FYM, which improved nitrogen absorption and transformation (Nagar *et al*., 2022 and Mamatha *et al*., 2024). The similar findings of N conent in grains and stover of maize with the application of RDF and FYM were noted by Lakum *et al*. (2020) and Yadav and Singh., (2022). The combination of NPK fertilizers and farm yard manure resulted in a much higher P content in maize and this occurred by improved root growth, supply of nutri-

Table 7. Interaction effect of nutrient and FYM levels on nutrient content

Nitrogen content in grains (%)				Phosphorus content in grains (%)				Potassium content in grains (%)			
Interaction M*S	F_0	F_1	F_2	**Interaction M*S**	F_0	F_1	F_2	**Interaction M*S**	F_0	F_1	F_2
N_0	1.399	1.420	1.443	N_0	0.264	0.283	0.286	N_0	0.276	0.304	0.317
N_1	1.471	1.513	1.616	N_1	0.309	0.314	0.321	N_1	0.311	0.369	0.409
N_2	1.567	1.624	1.663	N_2	0.313	0.328	0.354	N_2	0.339	0.380	0.417
N_3	1.644	1.670	1.702	N_3	0.337	0.357	0.382	N_3	0.354	0.403	0.438
SE (m) ±	0.013			SE (m)	0.004			SE (m)	0.005		
CD 5%	0.040			CD 5%	0.012			CD 5%	0.016		
Nitrogen content in stover (%)				**Phosphorus content in stover (%)**				**Potassium content in stover (%)**			
Interaction M*S	F_0	F_1	F_2	**Interaction M*S**	F_0	F_1	F_2	**Interaction M*S**	F_0	F_1	F_2
N_0	0.398	0.408	0.439	N_0	0.099	0.102	0.123	N_0	0.697	0.708	0.743
N_1	0.453	0.475	0.487	N_1	0.126	0.135	0.147	N_1	0.732	0.789	0.829
N_2	0.481	0.505	0.542	N_2	0.138	0.157	0.177	N_2	0.765	0.801	0.845
N_3	0.510	0.553	0.567	N_3	0.168	0.192	0.213	N_3	0.780	0.823	0.875
SE (m) ±	0.005			SE (m)	0.003			SE (m)	0.006		
CD 5%	0.016			CD 5%	0.009			CD 5%	0.018		

ents to the soil by organic manure increases the availability of native nutrients (Thakur *et al*., 2021). This findings of P content in maize grain and stover with RDF and FYM were similar to Lakum et al. (2020) and Yadav and Singh (2022). Application of organic manure to the crop may result in a higher potassium content because of enhanced nutrient absorption and effective translocation into the plant system during vegetative growth (Nagar *et al*., 2022). The fibrous cells tend to react to the supply of potassium and are typically found in sclerenchyma cells. Supply of potassium leads to high hemicellulose and cellulose and comparatively greater turgidity, which associates with high K content in stalk (Mishra *et al*., 2022). The results of K content in grains and stover of maize with the application of RDF and FYM were found to be similar to the works of Lakum *et al*. (2020) and Yadav and Singh. (2022).

The results of the present work on integrated nutrient management (INM) with Recommended doses of fertilizers (RDF) and FYM align with findings from previous studies. Its uniqueness lies in providing critical insights into region-specific interactions between nutrient sources and crop responses under specific agro-climatic conditions. This study goes beyond confirming existing knowledge by addressing gaps in understanding the combined long-term effects of RDF and FYM on nutrient dynamics and sustainable productivity for maintaining ecological balance. Moreover, it highlights innovative management practices and optimized nutrient combinations tailored to enhance resource-use efficiency and crop performance. These contributions are practical and valuable for refining localized nutrient management strategies, making the study a significant addition to the existing body of knowledge.

Conclusion

The study concluded that under integrated nutrient management strategies, the application of a recommended dose of inorganics and FYM i,e., 100% RDF + 10 tonnes of FYM had a beneficial effect on plant height (152.88 cm), number of leaves plant^{-1} (10.37), leaf area plant^{-1} (4005.03 cm^2), leaf area index plant^{-1} (3.34), Dry matter accumulation (157.94 g plant^{-1}), chlorophyll index (40.18), number of cobs plant^{-1} (2.33), number of grains cob^{-1} (438.93), protein content in grains (10.64%), nitrogen content in grains (1.702%) and stover (0.567%), phosphorous content in grains (0.382%) and stover (0.213%), and potassium content in grains (0.438%) and stover (0.875%) of maize. This integrated approach optimizes nutrient use efficiency, balances short-term crop productivity with long-term soil sustainability, and reduces reliance on synthetic fertilizers, making it a sustainable agricultural practice.

Conflict of interest

The authors declare that they have no conflict of interest.

REFERENCES

1. Adhikari, P., Sharma, R. & Pokharel, B. B. (2022). Effect of organic manures and chemical fertilizers on maize productivity and soil properties in the Winter season. *Journal of Nepal Agricultural Research Council*, *8*, 53 -63. DOI: https://doi.org/10.3126/jnarc.v8i.44861
2. Antil, R. S. & Raj, D. (2020). Integrated nutrient manage-

ment for sustainable crop production and improving soil health. *Nutrient Dynamics for Sustainable Crop Production*, 67-101. DOI:10.1007/978-981-13-8660-2_3

3. Ariraman, R., Kumar, A. P., Selvakumar, S., Sowmya, S. & Mansingh, M. D. I. (2020). Effect of sulphur nutrition on growth parameters, yield parameters, yield, nutrient uptake, quality and economics of maize: A review. *Journal of Pharmacognosy and Phytochemistry*, *9*(6), 1632-1636. DOI: 10.22271/phyto.2020.v9.i6x.13181
4. Desai, A. J., Patel, K. P., Chaudhari, M. P. & Patel, R. N. (2017). Effect of irrigation level and integrated nutrient management on growth and yield of Rabi maize (Zea mays L.). *Journal of Pharmacognosy and Phytochemistry*, *6*(6S), 990-992.
5. Dhaliwal, S. S., Sharma, S., Sharma, V., Shukla, A. K., Walia, S. S., Alhomrani, M., Gaber, A., Toor, A. S., Verma, V., Randhava, M.K., Pandher, L.K., Singh, P. & Hossain, A. (2021). Long-term integrated nutrient management in the maize–wheat cropping system in alluvial soils of North-Western India: Influence on soil organic carbon, microbial activity and nutrient status. *Agronomy*, *11* (11),2258.DOI:https://doi.org/10.3390/agronomy11112258
6. Gao, C., El-Sawah, A. M., Ali, D. F. I., Alhaj Hamoud, Y., Shaghaleh, H. & Sheteiwy, M. S. (2020). The integration of bio and organic fertilizers improve plant growth, grain yield, quality and metabolism of hybrid maize (Zea mays L.). *Agronomy*, 10(3), 319. DOI: https://doi.org/10.3390/agronomy10030319
7. Getaneh, S., Molla, E. & Abera, D. (2024). Effects of integrated fertilizer application on soil properties and yield of Maize (Zea mays L.) on Nitisols in Pawe District, Northwestern Ethiopia. *Journal of Agriculture and Environmental Sciences*, *9*(1), 13-32. DOI: 10.4314/jaes.v9i1.2
8. Gezahegn, A. M. (2021). Role of integrated nutrient management for sustainable maize production. *International Journal of Agronomy*, *2021*(1), 9982884. DOI: https://doi.org/10.1155/2021/9982884
9. Gharge, P. V., Karpe, A. H. & Patil, P. R. (2020). Effect of split nitrogen application on growth parameters of maize. *International Journal of Chemical Studies*, *8*(3), 1030-1033. DOI: https://doi.org/10.22271/chemi.2020.v8.i3m.9332
10. Iqbal, S., Rashid, Z., Ganai, M., Saad, A. A., Kanth, R. H. & Bhat, R. (2020). Response of Growth, Yield and Yield Attributes of Popcorn (Zea mays everta) to Organic and Inorganic Sources of Nutrients. *Int. J. Curr. Microbiol. App. Sci*, *9*(7), 4024-4034. DOI: https://doi.org/10.20546/ijcmas.2020.907.472
11. Jackson, M. L. (1967). Soil Chemical Analysis, Prentice Hall of India. *Pvt. Ltd., New Delhi*, *498*.
12. Jayanthi, D., Malarkodi, M., Gokila, B. & Shanmugasundaram, R. (2020). Long term fertilizer impact on crop biomass, microbial biomass carbon, microbial biomass nitrogen and nutrient uptake of swell-shrink soil in maize under finger millet-maize cropping sequence. *Journal of Pharmacognosy and Phytochemistry*, *9*(1), 644-649.
13. Karnatam, K. S., Mythri, B., Un Nisa, W., Sharma, H., Meena, T. K., Rana, P., Vikal, Y., Gowda, M., Dhillon, B. S. & Sandhu, S. (2023). Silage maize as a potent candidate for sustainable animal husbandry development—perspectives and strategies for genetic enhancement. *Frontiers in Genetics*, *14*, 1150132. DOI: https://doi.org/10.3389/fgene.2023.1150132
14. Kaur Bal, K. & Chhatwal, N. (2022). Evaluation of integrated nutrient management on soil health, maize productivity and grain quality. *Journal of Soil, Plant and Environment*, *1*(2), 44-60. DOI: https://doi.org/10.56946/jspae.v1i2.71
15. Lakum, Y. C., Patel, H. K., Patel, K. C., Patel, G. G. & Patel, P. D. (2020). Effect of organic manures and inorganic fertilizers on maize yield, chemical composition and seed quality under maize: Chickpea cropping sequence. *International Journal of Chemical Studies*, *8*(4), 145-48. DOI: https://doi.org/10.22271/chemi.2020.v8.i4b.9683
16. Mamatha, B., Kadalli, G. G., Manjunath, R., Mudigiri, C. & Vilakar, K. (2024). Effect of Longterm Fertilization and Manuring on Nutritional Quality of Maize Grain. *International Journal of Plant & Soil Science*, *36*(6), 749-762. DOI: https://doi.org/10.9734/ijpss/2024/v36i64680
17. Meena, R., Meena, S. C., Meena, S. N. & Jat, G. (2023). Effect of chemical nitrogen fertilizer and organic manure on yield attributes, productivity and profitability of maize (Zea mays L.). *Current Advances in Agricultural Sciences* 15(2): 129-134. DOI : 10.5958/2394-4471.2023.00022.9
18. Miner, G. L., Delgado, J. A., Ippolito, J. A., Stewart, C. E., Manter, D. K., Del Grosso, Floyd, B. A. & D'adamo, R. E. (2020). Assessing manure and inorganic nitrogen fertilization impacts on soil health, crop productivity, and crop quality in a continuous maize agroecosystem. *Journal of Soil and Water Conservation*, *75*(4), 481-498. DOI: https://doi.org/10.2489/jswc.2020.00148
19. Mishra P., Sharma S., Tiwari US., Panday HP., Pathak RK. & Sachan Ak. (2022). Response of INM on nutrient concentration and their uptake of maize (*Zea mays* L.) crop. *The Pharma Innovation Journal*, 11(4), 1669-1676.
20. Nagar, K.,Patel, H.K.,Raval,C.H.,Badi, A.R., Lakshman. & Chaudhary N. (2022). Response of FYM and Split Application of Nitrogen on Growth and Green Yield of Fodder Maize (*Zea mays* L.). *International Journal of Plant & Soil Science, 34*(23), 245-253. DOI: https://doi.org/10.9734/ijpss/2022/v34i2331585
21. Naveen, P., Lakshmi, Y. S., Rekha, K. B. & Anjaiah, T. (2023). Effect of Tillage, Crop Residue Management and Nutrient Levels on Growth and Yield of Maize (Zea mays L.). *International Journal of Environment and Climate Change*, *13*(11), 2191-2199. DOI: https://doi.org/10.9734/ijecc/2023/v13i113381
22. Niranjan, B. N. & Prakash, S. S. (2021). Effect of Integrated Nitrogen Management on Growth and Yield of Maize and Soil Properties (Zea mays L.). *Mysore Journal of Agricultural Sciences*, *55*(4).
23. Pahalvi, H. N., Rafiya, L., Rashid, S., Nisar, B. & Kamili, A. N. (2021). Chemical fertilizers and their impact on soil health. *Microbiota and Biofertilizers, Vol 2: Ecofriendly tools for reclamation of degraded soil environs*, 1-20. DOI:10.1007/978-3-030-61010-4_1
24. Piper, C. S. (1966). Soil and Plant analysis.Asia publishing house, Bombay and New Delhi.
25. Prabhavathi, N., Nagaraju, K., Madhuri, K. N. & Prasad, P. R. (2021). Effect of INM on growth and physiological parameters of maize in maize-groundnut cropping sys-

tem. *The pharma innovation Journal*, *10*(5), 250-253.

26. Prasad, G., Rinwa, R. S. & Kumar, P. (2024). Impact of Manures and Nitrogen Levels on Growth and Productivity of Spring Maize (L.) Zea mays. *Indian Journal of Ecology*, *51*(2), 370-373. DOI: https://doi.org/10.55362/IJE/2024/4244
27. Raman, R. & Suganya, K. (2018). Effect of integrated nutrient management on the growth and yield of hybrid maize. *Journal of Agricultural Research*, *3*(2), 1-4.
28. Roopashree, D. H., Nagaraju, Y. M., Ramesha, B. T. & Raghavendra, S. (2019). Effect of integrated nutrient management on growth and yield of baby corn (Zea mays L.). *International Journal of Current Microbiology and Applied Sciences*, *8*(6), 766-772. DOI: https://doi.org/10.20546/ijcmas.2019.806.091
29. Sharma, P. K., Kalra, V. K. & Tiwana, U. S. (2016). Effect of farmyard manure and nitrogen levels on growth, quality and fodder yield of summer maize (Zea mays L.). *Agricultural Research Journal*, *53*(3), 355-59. DOI: 10.5958/2395-146X.2016.00068.5
30. Sharma, T., Arya, V. M., Sharma, V., Sharma, J., Gulshan, T., Bera, A. & Laskar, Y. A. (2022). Integrated nutrient management: A long-term approach towards sustainability. *International Journal of Plant & Soil Science*, *34*(20), 433-446. DOI: https://doi.org/10.9734/ijpss/2022/v34i2031171
31. Sharma, V., Singh, M. J. & Khokhar, A. K. (2020). Productivity, nutrient uptake and soil properties as influenced by integrated nutrient management in maize-wheat cropping system under rainfed conditions of sub-montane Punjab. *Agricultural Research Journal*, *57*(6). DOI: 10.5958/2395-146X.2020.00123.4
32. Singh, A. P., Pandey, P. K. & Joshi, R. P. Harnessing Genetic Diversity for Climate-Resilient Maize: A Comprehensive Review. DOI: https://DOI:10.47509/JABAS.2023.v02i02.02
33. Singh, L., Kumar, S., Singh, K. & Singh, D. (2017). Effect of integrated nutrient management on growth and yield attributes of maize under winter season (Zea mays L.). *Journal of Pharmacognosy and Phytochemistry*, *6*(5), 1625-1628.
34. Singh, S. P., Dutta, S. K., Jha, S., Prasad, S. S., Chaudhary, S. K., Sahi, V. & Majumdar, K. (2021). Nutrient management in calcareous soil improves rice–maize sustainable yield index, performance indicators. *Journal of Plant Nutrition*, *44*(11),1571-1586.DOI: https://doi.org/10.1080/01904167.2020.1867740
35. Sudhakar, C. (2018). Effect of organic manures and inorganic sources of nitrogen on growth, grain yield and its attributes in Rabi maize (Zea mays L.) of rice-maize cropping system. *IJCS*, *6*(6), 1543-1549.
36. Thakur, A., Sharma, R. P., Sankhyan, N. K. & Kumar, R. (2021). Maize grain quality as influenced by 46 years' continuous application of fertilizers, farmyard manure (FYM), and lime in an Alfisol of North-western Himalayas. *Communications in Soil Science and Plant Analysis*, *52*(2), 149-160. DOI: https://doi.org/10.1080/00103624.2020.1854289
37. Titirmare, N. S., Ranshur, N. J., Patil, A. H., Patil, S. R. & Margal, P. B. (2023). Effect of Inorganic Fertilizers and Organic Manures on Physical Properties of Soil: A Review. *International Journal of Plant & Soil Science*, *35*(19), 1015-1023. DOI: https://doi.org/10.9734/ijpss/2023/v35i193638
38. Verma, K., Bindra, A. D., Singh, J., Negi, S. C., Datt, N., Rana, U. & Manuja, S. (2018). Effect of integrated nutrient management on growth, yield attributes and yield of maize and wheat in maize-wheat cropping system in mid hills of Himachal Pradesh. *Int. J. Pure Appl. Biosci*, *6*, 282-301. DOI: http://dx.doi.org/10.18782/2320-7051.6379
39. Wailare, A. T. & Kesarwani, A. (2017). Effect of Integrated Nutrient Management on Growth and Yield Parameters of Maize (zea maysl.) As well as Soil Physico-chemical Properties.
40. Yadav A. & Singh A.(2022). Impact of organic and inorganic nutrient sources on nutrient concentration and their uptake by maize (*Zea mays* L.). *The Pharma Innovation Journal*, 11(2), 556-560.
41. Yadav, R. C., Niwas, R., Yadav, A. S. & Sachan, R. (2022). Effect of integrated nutrient management on growth, yield and economics of maize (Zea mays L.) under central plain zone of Uttar Pradesh. *The Pharma Innovation Journal*, *11*(7), 1795-17.