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Effect of tillage and nitrogen management on growth, yield and economics of wheat (*Triticum aestivum* L.)

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Abstracts:

During the Rabi season of 2023, a field experiment was conducted at the School of Agricultural Sciences, CPU, Kota (Rajasthan), aiming to evaluate wheat productivity under different tillage systems coupled with efficient nitrogen management practices. The experiment utilized a split-plot design with three replications, where the main plots included four tillage systems (zero tillage, minimum tillage, FIRB, and conventional tillage), and sub-plots consisted of four nitrogen levels (control, RDN, SPAD, and targeted yield of 5 t/ha), resulting in a total of 16 treatment combinations.

Among the tillage systems, conventional tillage showed significant improvements in various parameters such as plant height (95.13 cm), number of tillers per meter row length (372.26), dry matter accumulation per meter row length (109.7 g), tillers per square meter (73.4), seeds per ear (40.4), test weight (39.6 g), seed yield (4220 kg/ha), straw yield (6380 kg/ha), biological yield (10600 kg/ha), net return (60595 /ha), and benefit-cost ratio (1.95) compared to zero tillage and minimum tillage. Moreover, the application of recommended doses of nitrogen (RDN) at 120:80:55 kg/ha NPK significantly enhanced plant height (95.47 cm), number of tillers per meter row length (370.56), dry matter accumulation per meter row length (107.5 g), tillers per square meter (73.6), seeds per ear (40.7), test weight (41.4 g), seed yield (4185 kg/ha), straw yield (6326 kg/ha), biological yield (10511 kg/ha), net return (60715 /ha), and benefit-cost ratio (1.93) compared to control and SPAD

(80:60:50 kg/ha NPK). Overall, the findings underscore the importance of conventional tillage and efficient nitrogen management, particularly through recommended doses, in optimizing wheat productivity and economic returns. These results provide valuable insights for wheat cultivation practices aimed at enhancing yield and profitability in agricultural systems.

Key words: Wheat, Tillage, Nitrogen, Economics.

I Introduction:

Wheat (Triticum aestivum L.) is one of the most important staple crops globally, serving as a primary food source for a significant portion of the world's population. The optimization of wheat production is crucial to ensuring food security and meeting the increasing demands of a growing population. Among the various agronomic practices that influence wheat production, tillage and nitrogen management play pivotal roles. Tillage is a fundamental agricultural practice that involves the mechanical manipulation of soil to prepare seedbeds, control weeds, and incorporate crop residues. Different tillage methods, ranging from conventional plowing to reduced or no-tillage systems, can significantly impact soil structure, moisture retention, and ultimately, crop performance. Understanding the effects of various tillage practices on wheat growth and yield is essential for developing sustainable and efficient farming systems.

Nitrogen is a critical nutrient for wheat, influencing its growth, development, and yield. Effective nitrogen management involves the appropriate application of nitrogen fertilizers to meet the crop's nutritional requirements while minimizing environmental impacts. The rate, timing, and method of nitrogen application can greatly affect wheat productivity and economic returns. Therefore, integrating optimized nitrogen management with suitable tillage practices is key to achieving high yields and maintaining soil health. This study aims to investigate the combined effects of different tillage practices and nitrogen management strategies on the growth, yield, and economic performance of wheat. By evaluating various tillage and nitrogen treatments, the research seeks to identify the most effective combinations that enhance wheat production while promoting sustainable agricultural practices. The findings of this study will provide valuable insights for farmers, agronomists, and policymakers to develop and implement better management practices for wheat cultivation.

II Literature Review:

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Wheat (*Triticum aestivum* L.) is a crucial cereal crop belonging to the Poaceae family, pivotal in meeting around 60 percent of the world's human energy requirements. In India, wheat holds a significant position as one of the primary staple food grains, with the country ranking second globally in wheat production, following China (Usadadiya and Patel, 2013). Covering 30 million hectares of land, India's wheat cultivation yields approximately 107 million tons annually, with an average yield of 3400 kg/ha (IASRI, 2019). This crop is a vital source of protein and calories worldwide, contributing significantly to human dietary needs, with projections indicating a continued rise in demand, especially in developing nations, by 2050 (FAO STAT, 2015; Wageningen FSC, 2016).

Enhancing wheat yield and quality relies heavily on adopting optimal agronomic practices, including efficient tillage methods. Optimum tillage practices are integral in achieving high yields as they facilitate better soil structure, root penetration, and moisture retention. Tillage operations encompass physical soil manipulations aimed at weed control, residue incorporation, improved infiltration, reduced evaporation, seedbed preparation, and soil compaction alleviation. Various forms of tillage such as zero tillage, reduced tillage, and conventional tillage have been utilized, with a recent surge in popularity for zero and reduced tillage techniques. These practices not only conserve moisture but also enhance soil organic matter, reduce CO2 emissions, and address environmental concerns linked to modern agriculture.

Nitrogen stands out as a crucial element for plant growth and productivity, primarily supplied through fertilizers due to widespread soil nitrogen deficiencies. Improving nitrogen use efficiency is vital, achieved by understanding crop peak nitrogen requirement periods and uptake patterns. Efficient nitrogen application during these critical periods optimizes fertilizer utilization, minimizing environmental losses. Nitrogen plays a pivotal role in amino acid and protein synthesis, essential for normal growth and yield. Incorporating nitrogenous fertilizers as starter doses significantly boosts crop growth and productivity.

III Methodology:

The field experiment was conducted at the Research Farm of the School of Agricultural Sciences, CPU, Kota (Rajasthan), specifically during the Rabi season of 2023-24. This section details the experimental techniques, materials, and methods employed for evaluating treatments throughout the investigation.

The experimental soil was characterized as clay loam (vertisols) with a texture consisting of 22.6% silt, 37.1% sand, and 39.9% clay. It exhibited alkaline pH levels at 7.8, medium organic carbon content at 0.56%, and medium available nitrogen (314 kg/ha) and phosphorus (22.1 kg/ha) levels. However, the available potassium content was relatively higher at 298 kg/ha.

The experimental design utilized a split-plot arrangement with three replications. The main plots were divided into four tillage levels: zero tillage, minimum tillage, FIRB (Furrow Irrigated Raised Bed), and conventional tillage. Sub-plots consisted of four nitrogen levels: control, Recommended Dose of Nitrogen (RDN), Soil Plant Analysis Development (SPAD), and targeted yield of 5 t/ha. This design resulted in a total of 16 treatment combinations. Wheat was sown with an inter-row spacing of 22.5 cm and an intra-row spacing of 10 cm, using a seed rate of 100 kg/ha. Seeding was performed using a seed drill in the second week of November, and harvesting took place during the last week of March.

During harvest, data on various growth and yield attributes were collected, including plant height, number of tillers per meter row length, dry matter accumulation per meter row length, tillers per square meter, seeds per ear, test weight, seed yield, straw yield, biological yield, net return, and benefit-cost ratio (BC ratio). To collect data, five randomly selected plants were examined from each plot. Seed and straw yields were measured within the net plot and extrapolated to kg/ha.

Economic analysis involved calculating the costs and returns associated with each treatment. This included assessing input and output costs such as fertilizers, seeds, and labor for crop cultivation. Net income per hectare was determined using the formula: Net income (Rs/ha) = Gross income (Rs/ha) - Cost of cultivation. The benefit-cost ratio was calculated by dividing the net return by the cost of cultivation for each treatment combination.

Statistical analysis of the collected data was conducted using the analysis of variance (ANOVA) method, with significant differences evaluated at a 5% level of significance. This rigorous methodology ensured accurate evaluation and comparison of the different treatments and their impact on wheat productivity and economics.

IV Results and Discussion:

Growth and Yield Attributes:

Upon analyzing the data presented in Table 1, it is evident that different tillage practices significantly influenced various growth and yield attributes of wheat. Conventional tillage exhibited a notable increase in plant height at 90 days after sowing (DAS), recording 95.13 cm, followed by the furrow irrigated raised bed (FIRB) system over zero tillage (73.51 cm) and minimum tillage. Similarly, the number of tillers per meter row length at 90 DAS was maximized with conventional tillage (372.26), followed by FIRB over zero tillage (258.14 cm) and minimum tillage. Dry matter accumulation per meter row length was higher with conventional tillage (109.7 g), followed by FIRB over zero tillage (79.3 g) and minimum tillage. The tillers per square meter were significantly higher in conventional tillage (73.4 tillers/m2), followed by FIRB over zero tillage (53.3 tillers/m2) and minimum tillage. Furthermore, seeds per ear were notably higher in conventional tillage (40.4), followed by FIRB over zero tillage (34.8 cm) and minimum tillage. Similarly, test weight showed higher values in conventional tillage (39.6 g), followed by FIRB over zero tillage (38.1 g) and minimum tillage.

This observed trend can be attributed to the better utilization of nitrogen and other nutrients, facilitating plant height growth and development, as supported by Gupta et al. (2011). The higher dry matter accumulation is likely due to better nutrient availability, higher moisture content, improved plant growth and development resulting from better soil physical conditions, and reduced weed infestation, as confirmed by Kumar et al. (2013).

Similarly, data from Table 1 regarding different nitrogen management practices revealed significant effects on plant height at 90 DAS under the application of Recommended Dose of Nitrogen (RDN) (95.47 cm) treatments, which were statistically comparable with targeted yield 5 t/ha, outperforming the control (72.16 cm) and Soil Plant Analysis Development (SPAD). Similar trends were observed for other parameters like the number of tillers per square meter, dry matter accumulation, seeds per ear, and test weight, where RDN treatments showed promising results compared to other nitrogen management practices.

This improvement in growth attributes under RDN treatments can be attributed to overall enhancement in vigor and crop growth due to the adequate supply of nitrogen during critical growth stages, essential for promoting rapid vegetative growth and biomass, in line with Singh et al. (2017).

Yield and Economics:

The data presented in Table 2 sheds light on the yield and economic aspects of different

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tillage practices and nitrogen management practices. Among the various tillage practices, conventional tillage resulted in significantly higher seed yield (4220 kg/ha) compared to FIRB over zero tillage (2935 kg/ha) and minimum tillage, with conventional tillage exhibiting a 45.8% increase over zero tillage. Similarly, straw yield and biological yield were significantly higher in conventional tillage (6380 kg/ha and 10600 kg/ha, respectively) compared to other tillage practices.

The increase in seed and straw yield under conventional tillage can be attributed to the optimized source-sink relationship, where conventional tillage allows for better dry matter accumulation and partitions a larger proportion to seed, ultimately enhancing seed yield. This finding is supported by Idnani and Kumar (2012) and Soma et al. (2020). Additionally, the biological yield, being a function of grain and straw yields, also showed a significant increase under conventional tillage, indicating improved vegetative growth leading to higher yield attributing characters.

Furthermore, data from Table 2 regarding different nitrogen management practices demonstrated a significant increase in seed yield, straw yield, biological yield, net returns, and benefit-cost ratio under RDN treatments compared to control and SPAD. This improvement in yield and economics can be attributed to the increased utilization of nitrogen, resulting in enhanced growth and yield, as indicated by Maurya et al. (2014) and Singh et al. (2021).

Table 1 Effect of tillage and nitrogen management practices on growth and yield attributes of wheat

Treatments	**Plant height (cm)**	**No. of tiller/m^2**	**Plant dry weight (g/m row length)**	**Effective tillers/m^2**	**No. of seeds/ear**	**Test weight (g)**
Tillage practices						
Zero tillage	73.51	258.14	79.3	53.3	34.8	38.1
Minimum tillage	88.74	272.32	92.4	60.6	37.5	38.8
FIRB	9324	359.17	106.8	68.2	39.2	39.2
Conventional tillage	95.13	372.26	109.7	73.4	40.4	39.6
SEm±	1.69	4.55	2.87	2.07	0.53	0.21

CD (P=0.05)	5.07	13.64	8.62	6.22	1.6	0.62
Nitrogen management practices						
Control	72.16	256.21	78.4	51.2	34.3	38.2
RND (120:80:55 kg/ha NPK)	95.47	370.56	107.5	73.6	40.7	41.4
SPAD (80:60:50 kg/ha NPK)	87.14	342.13	91.7	59.3	37.1	40.7
Targeted yield 5t/ha (150:80:65 kg/ha)	94.29	364.10	103.9	68.8	38.6	40.9
SEm±	**1.68**	**4.47**	**2.62**	**1.91**	**0.47**	**0.19**
CD (P=0.05)	**4.87**	**13.42**	**7.87**	**5.74**	**1.4**	**0.56**

Table 2 Effect of tillage and nitrogen management practices on yield and economics of wheat

Treatments	**Seed yield (kg/ha)**	**Straw yield (kg/ha)**	**Biological yield (kg/ha)**	**Net return (ha.)**	**B:C ratio**
Tillage practices					
Zero tillage	2935	4660	7595	41929	1.94
Minimum tillage	3520	5525	9045	53857	1.83
FIRB	3907	5995	9902	57275	1.91
Conventional tillage	4220	6380	10600	60595	1.95
SEm±	**101.7**	**143.3**	**245**	**1121.7**	**0.09**
CD (P=0.05)	**305**	**430**	**735.1**	**3365**	**0.27**
Nitrogen management practices					
Control	2920	4630	7568	50160	1.63
RND (120:80:55 kg/ha NPK)	4185	6326	10511	60715	1.93
SPAD (80:60:50 kg/ha NPK)	3480	5465	8945	53834	1.81
Targeted yield 5t/ha (150:80:65 kg/ha)	3890	5975	9865	57630	1.89
SEm±	**99.3**	**138.7**	**237.9**	**1091.7**	**0.08**

CD (P=0.05)	**298**	**416**	**713.9**	**3275**	**0.24**

V Conclusion:

The study highlights the importance of optimal agronomic practices like tillage methods and nitrogen management in boosting wheat productivity and profitability. Conventional tillage, especially when coupled with Recommended Dose of Nitrogen (RDN), proved superior in terms of growth attributes, seed yield, and economic returns compared to zero tillage and minimum tillage. This emphasizes the need for farmers to adopt these practices to maximize crop resilience, resource use efficiency, and overall sustainability in wheat cultivation. The results suggest that combining conventional tillage with RDN can be particularly effective in vertisol soils of South-Eastern Rajasthan, leading to higher seed yield, net returns, and Benefit-Cost Ratio (B:C ratio).

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Influence of mustard production through Integrated Nutrient Management in the Southern Humid plains of Rajasthan

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Abstract:

A field experiment was conducted at the Instructional Farm (Agronomy), Career Point University, Alaniya, Kota during 2023-2024. The experiment was laid out in Randomized Block Design with three replications. The experiment consisted of ten treatments combination viz, Control, 100 % RDF, 100% RDF+ 5 ton FYM, 100% RDF + 2 ton FYM + 0.5 ton Vermicompost, 75% RDF + 5 ton FYM, 75% RDF + 1 ton Vermicompost, 125% RDF, 75% RDF + 2.5 ton FYM + 0.5 ton Vermicompost, 75% RDF + 3 ton FYM + 2.5 Kg Zn and 75% RDF + 2 ton FYM + 0.5 ton Vermicompost + 2.5 Kg Zn with Randomized Block Design and three replications. As regard to yield parameters, treatment nitrogen 75% RDF + 2 ton FYM + 0.5 ton Vermicompost + 2.5 Kg Zn had the maximum number of siliquae per plant (214.10), highest number of seeds per siliqua (16.46), highest test weight (5.65 g), maximum seed yield (1786.74 kg ha-1), highest stover yield (3799.89 kg ha-1) as well as maximum oil content (40.81%).

Keywords: Mustard, Vermicompost, nutrient, RDF

I Introduction

Oilseeds crops have important place in Indian agriculture next to cereals. In India, nine oilseeds crops (seven edible oilseeds i.e., rapeseed and mustard, soybean, groundnut, sunflower, sesamum, safflower and niger, and two non-edible oilseeds viz., castor and linseeds) are major source of vegetable oil and fats. Globally, India is the fourth largest oilseed crops producing country after United States, China and Brazil. However, it secures first position in sesame, niger, castor and safflower production and second position in groundnut production after China. In India, the oilseeds are grown on 14.4% of total gross cropped area (25.50 million ha), which produced 32.26 million tonnes oilseeds with 1265 kg/ha productivity.

The basic concept underlying the principle of integrated nutrient management (INM) is the maintenance or adjustment and possibly improvement of soil fertility and plant nutrient supply to an optimum level for sustaining the desired crop productivity through optimization of the benefits from all possible sources of plant nutrients in an integrated manner. The appropriate combination of mineral fertilizers, organic manures, crop residues and biofertilizers varies according to the system of land use, ecological, social and economic conditions. Contrary to low external input (LEI) and organic approaches, the INM involve low to medium external input approach, taking into account a holistic view of soil fertility and plant nutrition requirement for a targeted yield. It should be based not only on cropping and farming system but also on distinct geographical area or village as a dynamic system. The INM approach can be modulated, a factor of targeted yield in any area according to land, water and climatic potentials.

There is great need for research on biological nitrogen fixation and phosphorus solublization for energy conservation. Biofertilzer may help in boosting up atmospheric nitrogen and more solubilization of insoluble phosphorus in the soil. Many scientists revealed that seed inoculation with heterotrophic free living N2-fixer like Azotobacter proved beneficial at different locations. It is a low monetary input, although the response varied depending upon the location, the variety planted and initial inorganic nitrogen status of soil. The FYM as a component of INM favourably affects the physical chemical and biological environments. It is well recognized that neither organic manure alone nor exclusive application of chemical fertilizer can achieve the yield sustainability at an optimum level under modern farming where nutrient turnover in the soil plant system is quite high.

Materials and Methods

Location

Kota district is located at 25.18° N to 75.83° E Latitude in South Eastern Rajasthan. It covers an area of 221.36 km2. Agro-climatically, the district falls in Zone V, known as Humid South Eastern Plain. The average rainfall in the region is 660.6. mm. Maximum temperature range in the summer is 40 to 48°C and minimum 1.0- 2.6°C during winter. Main Rainy season crops of the district are maize, soybean and pulses. While in winter, wheat, mustard, coriander and garlic are main crops.

II Literature Review

Integrated Nutrient Management (INM) has emerged as a crucial strategy for improving mustard production, particularly in the challenging agro-climatic conditions of the Southern Humid Plains of Rajasthan. Research by Singh et al. (2022) underscores the importance of combining organic and inorganic fertilizers to enhance soil fertility and optimize crop yields. This region, with its diverse climatic conditions and soil variability, requires tailored nutrient management practices to achieve optimal results (Sharma & Patel, 2020).

Several studies have highlighted the benefits of integrating bio-fertilizers, organic manures, and chemical fertilizers in mustard cultivation. According to Kumar et al. (2021), balanced nutrient management, including the application of nitrogen, phosphorus, potassium, and essential micronutrients, can significantly boost mustard yield while maintaining soil health. Moreover, the use of organic amendments such as compost and green manure has been reported to improve soil structure, enhance moisture retention, and increase microbial activity, contributing to long-term sustainability (Gupta & Rao, 2019).

The integration of these practices is particularly beneficial in the Southern Humid Plains, where soil degradation and nutrient depletion pose significant challenges to agricultural productivity (Verma & Chauhan, 2023). Overall, the adoption of INM in mustard cultivation not only addresses these challenges but also ensures better crop performance and environmental sustainability in the region (Choudhary et al., 2020).

III Methodology

Experimental Details A field experiment was conducted at the Instructional Farm (Agronomy), Career Point University, Alaniya, Kota during 2023-2024. The experiment was laid out in Randomized Block Design with three replications. The experiment consisted of ten treatments combination viz, Control, 100 % RDF, 100% RDF+ 5 ton FYM, 100% RDF + 2 ton FYM + 0.5 ton Vermicompost, 75% RDF + 5 ton FYM, 75% RDF + 1 ton Vermicompost, 125% RDF, 75% RDF + 2.5 ton FYM + 0.5 ton Vermicompost, 75% RDF + 3 ton FYM + 2.5 Kg Zn and 75% RDF + 2 ton FYM + 0.5 ton Vermicompost + 2.5 Kg Zn.

Measurement of the parameters

The total number of Siliqua was counted in 5 randomly selected plants. The average values of developed pods were expressed as the total no. of Siliqua plant-1. The total number of seeds in each siliqua was counted in 5 randomly selected pods in each treatment. The average values of developed seeds per siliqua were expressed as the number of seeds siliqua-1. Seed yield of each plot was obtained separately by threshing and cleaning the seed and expressed in t ha-1. Stover yield was obtained by subtracting the seed yield from the total weight of the dry plants harvested from 1 m2 area and expressed in t ha-1. Analysis of variance for individual character was done on the basis of mean values as suggested by Panse and Sukhatme (1942).

Results

Data presented in Table 1 indicate that application of vermicompost, FYM and zinc significantly increased number of siliquae per plant over control. The maximum number of siliquae per plant (214.10) was recorded under application of 75% RDF + 2 ton FYM + 0.5 ton Vermicompost + 2.5 Kg Zn (T10) and the minimum (143.17) under control (T1). However, the treatment T4 & T6 and T5 & T7 were found to be statistically at par.

An examination of data (Table 2) establishes that the number of seeds per siliqua at harvest significantly varied from 12.92 to 16.46 per plant among treatments in the experiment. The maximum number of seeds per siliqua (16.46) was recorded under application of 75% RDF + 2 ton FYM + 0.5 ton Vermicompost + 2.5 Kg Zn (T10) and the minimum (12.92) under control (T1). However, the treatment T2 & T3, T4 & T6 and T5 & T7 were found to be statistically at par.

Perusal of data (Table 3) shows that various treatments of vermicompost, FYM and zinc significantly increased test weight over control. The highest test weight (5.65 g) was recorded under application of 75% RDF + 2 ton FYM + 0.5 ton Vermicompost + 2.5 Kg Zn (T10) and the minimum (4.48) under control (T1). However, the treatment T2 & T3, T4 & T5, T4 & T6, T5 & T6, T5 & T7 and T6 & T7 were found to be statistically at par.

A critical examination of data (Table 4) revealed that application of vermicompost, FYM and zinc significantly increased seed yield over control. The maximum seed yield (1786.74 kg ha-1) was recorded under application of 75% RDF + 2 ton FYM + 0.5 ton Vermicompost + 2.5 Kg Zn (T10) and the minimum (984.63 kg ha-1) under control (T1). However, the treatment T4 & T5, T4 & T6, T4 & T7, T5 & T6,T5 & T7 and T6 & T7 were found to be statistically at par.

The perusal of data pertaining to Table 5 revealed that the highest stover yield of mustard (3799.89 kg ha-1) was obtained from the application of 75% RDF + 2 ton FYM + 0.5 ton vermicompost + 2.5 Kg Zn (T10) and the minimum (2021.11 kg ha-1) under control (T1). However, the treatment T4 & T5, T4 & T6, T4 & T7, T5 & T6, T5 & T7 and T6 & T7 were found to be statistically at par.

Discussion

The data about the yield characters (Table 2) indicated that application of all the nutrient viz., soil test recommendation (NPK) along with FYM, Zn and vermicompost treatment showed increase in the yield characters as compared to soil test recommendations of fertilizers and control. The highest seed yield realized with combined application of various plant nutrients could be ascribed to its profound influence on vegetative and reproductive growth of the crop. Hence, marked increase in seed yield with combined application of various plant nutrients seems to be due to more exploitation of crop genetic potential for vegetative and reproductive growth. The best result on seed yield was obtained with application of 75% RDF + 2 ton FYM + 0.5 ton vermicompost + 2.5 Kg Zn (T10). This indicates that mustard responds well to integrated nutrient management which might be owing to the favorable soil condition. Application of FYM with chemical fertilizers improved the physio-chemical condition of the soil, provided favorable environment, stimulated the uptake of nutrients and almost continuous supply of N, P, K, S and micronutrient distributed over the entire crop and batter availability in sufficient amounts of plant nutrients throughout the growth period and especially at critical period of crops growth which has resulted in batter plant vigour and superior yield attributes (Kashved et al. 2010)

Application of zinc sulphute also increased seed yield over the treatments without it. This might be due to the positive influence of sulphur on cell multiplication and elongation and production to deep colour to leaf which favour the chlorophyll synthesis resulting in increased photosynthesis and assimilation rates and zinc on carbohydrates and protein metabolism and promoting growth hormone (Mohapatra and Dixit 2010, Parihar et al. 2012). As yield is the resultant outcome of the effect of various growth and yield parameters, its expression was observed with their integrated influence. With the increment in supply of essential nutrients to mustard, their availability, acquisition, mobilization and influx into the plant tissues increased and thus improved growth attributes and yield components and finally the yield. These results are in agreement with the findings of (Tripathi et al. 2010).

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The highest seed was attained under 75% RDF + 2 ton FYM + 0.5 ton vermicompost + 2.5 Kg Zn. This was attributed to improved availability of essential nutrient and growth hormones that led to enhanced N metabolism and protein synthesis. Similar findings have also been made by Singh and Pal, (2011).

Data presented in Table 2 show that effect of fertilizers with FYM, Zn and seed treatment on stover yield of mustard which shows similar result to seed yield of mustard. Higher stover yield was obtained with application 75% RDF + 2 ton FYM + 0.5 ton vermicompost + 2.5 Kg Zn. The significant increase in stover yield due to integrated application of chemical fertilizers with FYM and Zn. The greater stover yield at higher fertility was attributed to increased plant height and leaf area and finally dry matter accumulation plant-1 and this was also concluded by (Singh and Pal, 2011). This could be due to FYM incorporated with chemical fertilizers and seed treatment, FYM improved the physio-chemical condition of the soil, provided favorable environment, stimulated the uptake of nutrients and enhanced major as well as secondary and micronutrients to the mustard and seed inoculants increased the seed germination, plant growth, plant stands, and vegetative growth of plants increased the stover yield of mustard over the treatments where chemical fertilizers applied. As stover yield is the resultant outcome of the effect of various growth and yield parameters, its expression was observed with their integrated influence. These results corroborate the finding of others (Tripathi et al. 2010). Application of FYM increased the seed and stover yield. It was due to improved physic-chemical properties of soil and provides a better soil environment for the biological activity and improved microbial population of the experiment soil, fixing the atmospheric nitrogen in soil and also supplies micronutrient beneficial to the crop growth and productivity. Similar results were reported by Das, et al. (2010), Khafi et al. (2010), Saha et al.(2010) Arya et al. (2007), Chand, et al. (2007) and Nagdive, et al. (2007).

Table 1 Effect of nutrient management on number of siliquae per plant of mustard

Treatments	**Number of siliquae per plant**
Control	143.17
100 % RDF	156.23
100% RDF+ 5 ton FYM	162.91

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100% RDF + 2 ton FYM + 0.5 ton vermicompost	169.92
75% RDF + 5 ton FYM	181.66
75% RDF + 1 ton vermicompost	171.70
125% RDF	183.32
75% RDF + 2.5 ton FYM + 0.5 ton vermicompost	198.55
75% RDF + 3 ton FYM + 2.5 Kg Zn	208.30
75% RDF + 2 ton FYM + 0.5 ton vermicompost + 2.5 Kg Zn	214.10
S.Em+	2.90
CD (P=0.05)	6.32

Table 2 Effect of nutrient management on number of seeds per siliqua of mustard

Treatments	**Number of seeds per siliqua**
Control	12.92
100 % RDF	13.83
100% RDF+ 5 ton FYM	14.04
100% RDF + 2 ton FYM + 0.5 ton vermicompost	14.49
75% RDF + 5 ton FYM	14.93
75% RDF + 1 ton vermicompost	14.53
125% RDF	15.03
75% RDF + 2.5 ton FYM + 0.5 ton vermicompost	15.51
75% RDF + 3 ton FYM + 2.5 Kg Zn	16.33
75% RDF + 2 ton FYM + 0.5 ton Vermicompost + 2.5 Kg Zn	16.46
S.Em+	1.11
CD (P=0.05)	3.33

Table 3 Effect of nutrient management on number of seeds test weight (g) of Mustard.

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Treatments	**Test weight (g)**
Control	4.48
100 % RDF	4.73
100% RDF+ 5 ton FYM	4.81
100% RDF + 2 ton FYM + 0.5 ton Vermicompost	5.03
75% RDF + 5 ton FYM	5.12
75% RDF + 1 ton Vermicompost	5.05
125% RDF	5.15
75% RDF + 2.5 ton FYM + 0.5 ton Vermicompost	5.32
75% RDF + 3 ton FYM + 2.5 Kg Zn	5.58
75% RDF + 2 ton FYM + 0.5 ton Vermicompost + 2.5 Kg Zn	5.65
S.Em+	1.06
CD (P=0.05)	3.17

Table 4 Effect of nutrient management on number of seeds Yield (Kg/ha) of Mustard.

Treatments	**Seed Yield (Kg/ha)**
Control	984.63
100 % RDF	1128.75
100% RDF+ 5 ton FYM	1269.17
100% RDF + 2 ton FYM + 0.5 ton Vermicompost	1409.48
75% RDF + 5 ton FYM	1449.83
75% RDF + 1 ton Vermicompost	1413.54
125% RDF	1458.27
75% RDF + 2.5 ton FYM + 0.5 ton Vermicompost	1596.84
75% RDF + 3 ton FYM + 2.5 Kg Zn	1764.10
75% RDF + 2 ton FYM + 0.5 ton Vermicompost + 2.5 Kg Zn	1786.74
S.Em+	50.90
CD (P=0.05)	150.32

Table 5 Effect of nutrient management on number of seeds test weight (g) of mustard

Treatments	**Stover Yield (Kg/ha)**
Control	2021.11
100 % RDF	2380.89
100% RDF+ 5 ton FYM	2744.43
100% RDF + 2 ton FYM + 0.5 ton Vermicompost	3105.79
75% RDF + 5 ton FYM	3197.44
75% RDF + 1 ton Vermicompost	3114.66
125% RDF	3215.87
75% RDF + 2.5 ton FYM + 0.5 ton Vermicompost	3496.34
75% RDF + 3 ton FYM + 2.5 Kg Zn	3777.60
75% RDF + 2 ton FYM + 0.5 ton Vermicompost + 2.5 Kg Zn	3799.89
S.Em+	61.15
CD (P=0.05)	182.04

Conclusion:

The field experiment conducted at the Instructional Farm (Agronomy), Career Point University, Alaniya, Kota during 2023-2024 provided valuable insights into the efficacy of various nutrient management practices for mustard cultivation. The experiment, laid out in a Randomized Block Design with three replications, included ten treatment combinations aimed at optimizing yield parameters. This study contributes valuable insights into optimizing mustard cultivation practices through integrated nutrient management. The identified treatment combination can serve as a practical guideline for mustard growers, helping them enhance productivity and profitability while ensuring sustainable agricultural practices. Further research and extension efforts in this direction are warranted to promote the adoption of integrated nutrient management practices for oilseed cultivation, thereby contributing to agricultural sustainability and food security in India.

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Comparative Analysis of Organic and Inorganic Fertilizers on Wheat (Triticum aestivum L.) Yield Attributes

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Abstracts:

The present investigation entitled "Effect of organic and inorganic sources on yield attributing traits of wheat (*Triticum aestivum* L.)" was conducted at Agronomy Research Farm of Career Point University, Kota, Rajasthan during Rabi 2023-24. The 15 treatment combinations comprised with three fertility sources [50+50% inorganic +organic (F_1), 100% organic (F_2), and 100% inorganic (F_3)] with five varieties (Raj 3765 (V_1), Raj 1482 (V_2), Raj 3777 (V_3), Raj 4037 (V_4) and Raj 4120 (V_5) were arranged in Randomized Block Design (RBD) with three replications. Yield contributing characters like number of ear heads m^{-1}, length of ear (cm), number of spikelet ear^{-1}, number of grain ear^{-1} etc. were increased significantly with 100% inorganic fertilizers (F_3). Application of 100% inorganic fertilizers (F_3) significantly increased the grain and straw yield over 100% organic sources of nutrients (F_2). The highest value with 100% inorganic fertilizers (F_3). Raj 4120 increased the grain and straw yield significantly 32.77 q ha^{-1} and 42.67 q ha^{-1}, respectively over rest of varieties. All the yield contributing characters like number of ear heads m^{-1}, Length of ear (cm), number of spikelet's ear^{-1} and number of grain ear^{-1} were also higher in Raj 4120 and lowest were recorded in Raj 4037 (V_4).

Key Word: Wheat, Organic, Inorganic, Variety, Growth, Quality

I Introduction:

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Wheat (Triticum aestivum L.) is one of the most vital cereal crops worldwide, playing a crucial role in global food security and nutrition. Enhancing wheat production is essential to meet the demands of a growing population and to ensure a stable food supply. Among the various agronomic factors influencing wheat productivity, nutrient management is particularly significant. The sources of nutrients—whether organic or inorganic—can profoundly impact the growth, yield, and overall performance of wheat crops. Organic nutrient sources, such as compost, manure, and bio-fertilizers, are derived from natural materials and contribute to improving soil health, structure, and microbial activity. These sources often release nutrients slowly, providing a sustained supply over time and enhancing the long-term fertility of the soil. On the other hand, inorganic nutrient sources, primarily synthetic fertilizers, are designed to deliver precise and immediate nutrient availability, which can lead to quick and substantial improvements in crop growth and yield.

Balancing the use of organic and inorganic nutrient sources is crucial for optimizing wheat production. Organic sources can improve soil quality and sustainability, while inorganic fertilizers can provide the necessary nutrients at critical growth stages to boost yield. Understanding the effects of these different nutrient sources on yield-attributing traits of wheat, such as grain number, grain weight, and overall biomass, is essential for developing integrated nutrient management strategies. This study aims to evaluate the impact of organic and inorganic nutrient sources on the yield-attributing traits of wheat. By examining various combinations of organic and inorganic treatments, the research seeks to identify the most effective nutrient management practices that enhance wheat yield and contribute to sustainable agriculture. The findings of this study will offer valuable insights for farmers, agronomists, and policymakers to implement balanced and efficient nutrient management strategies for wheat cultivation.

II Literature Review:

Wheat (*Triticum aestivum* L.) is the world's most important cereal crop both the respect of acreage (215 m ha) and production (584 mt). It is the second most important grain crop after rice in India. Anonymous, 2022. Balance fertilization through organic & inorganic sources collectively improves the quality of grain and boosts the productivity of wheat as well as improves the soil health. Organic matter is the substrate for a large number of soil, beneficial organisms that are essential to keep the plant healthy, improves nutrient availability and increases crop yield. Organic matter improves physical condition of the soil for better performance of microorganisms Zhou *et al*., 2022.

Although increased level of production can be achieved by increased use of fertilizers but continuous use of chemical fertilizers alone may lead to some detrimental effect on physico-chemical properties of soil and also may not be so remunerative unless the fertility of soil is maintained at sustainable level by the application of organic manure. Therefore, to maintain fertility and productivity of soil at sustainable level for long duration, use of organic manure is quite essential. Organic manures are considered to be an integral component of sustainable system, as they improve soil fertility and physical properties of the soil. Soil physical problems such as surface hardening and crusting are also removed due to ameliorative effect of organic manures. Among organic manures, FYM is a well-known source, which contains Macro and Micronutrients in appropriate proportion, and its use helps in improving the physical condition and moisture retentive capacity of soil. It also serves as a source of energy for the development of beneficial microorganisms in the soil. However, organic manures cannot substitute total N requirement of crop since the nitrogen requirement is very high and the availability of organic manure (FYM etc.) is not sufficient. Therefore, there is need to evaluate the utilization of both organic as well as inorganic sources in a rational way to achieve suitable production of wheat.

Fertilizer use has become a key factor for increasing agricultural production. Amongst various agricultural inputs considered necessary for higher crop yields, fertilizer has been and will continue to be king input in achieving the food production targets in the country (Patra *et al.* (1999). Though fertilizer doses estimated on the basis of soil test are usually considered enough but the results obtained from All India Coordinated Research Project on Long Term Fertilizer Experiment have indicated that the yields under 1.5 times of the optimum rates of NPK fertilization were substantially higher than the yields under soil test based 100% NPK as optimum dose. Hence there is a need for the application of higher dose of fertilizers to obtain higher yields.

Almost the organic manures, FYM are a traditional to the soil such as, farmyard manure help in maintaining soil fertility and productivity. It increases soil microbiological activities, plays key role in transformation, recycling and availability of nutrients to the crop (Chouhan *et al.*, 2001). It also improves the physical properties like soil structure, porosity, reduces compaction and crusting and increases water-holding capacity of the soil. The

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availability of phosphorus and micronutrients from native source are also increased with incorporation of organic matter, which might be due to release of organic acids (Singh *et al.*, 1990). Because of aforesaid positive impact of organic matter and ever increasing cost of chemical fertilizers coupled with their limited availability, organic manuring through locally available source is again regaining importance in crop production and for maintenance of soil productivity on sustainable basis. As the nutrient needs of the crops to keep pace with nutrient removed by crop cannot be met either through mineral fertilizers or through organics, efficient and judicious use of all the major sources of plant nutrients viz. Soil mineral organic and biological material in an integrated manner would be essential and inevitable. From the results of the long term fertilizer experiments conducted in different part of the country, it has been well established that under high input production system where crop productivity cannot be further increased with incremental use of fertilizer alone, addition of organic sources could again increase the yield through increased soil productivity and fertilizer use efficiency. Thus sustainable agriculture in years to come should ideally be based on integrated plant nutrient supply.

Land degradation and environmental pollution can be minimized for sustainable agriculture. It will reduce the use of inorganic fertilizers increasing their use efficiency, saves farmers money, increases organic matter in soil, enhances the quality of environment and increases the crop yield and profitability. Integrated nutrient management is an old age concept but its importance was not realized earlier due to low nutrient turn over in soil plant system and almost all the required nutrients were met through organic sources. Integrated nutrient management has now assumed great significance mainly because of two reasons firstly the need for continuous increase in per hectare yield requires growing application on nutrients and the present level of fertilizer production in India is not enough to meet the requirement of total plant nutrients. Secondly the results of a large number of experiments on manures and fertilizers conducted in the country revealed that neither the chemical fertilizer alone nor the organic sources exclusively can achieve the sustainability in production of wheat under intensive cropping system.

III Methodology:

Experimental site:

The experiment was conducted at Agronomy Research Farm of Agronomy Research Farm, Career Point University, Kota, Rajasthan. The experimental site was situated about on

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Faizabad-Raibareilly road at 26.47^{0}N latitude, 82.12 ^{0}E longitude and on altitude of 113 meters above mean sea level.

Weather conditions:

Geographically Kota falls under semi-arid sub-tropical climate of Indo-Gangetic plains having alluvial calcareous soil. The average annual precipitation is about 1194 mm. of which 80-90 per cent received during monsoon period i.e. between June to September. The temperatures reach to its peak (40-45^{0}C) during May and June while the mercury is quite low during December and January (5-8^{0}C).

Field preparation:

The field was ploughed once with tractor drawn soil turning plough after receiving a pre-sowing irrigation, followed by subsequent two cultivators. The planking was in variably done after each ploughing and also after sowing of the seeds. After the preparation of field the lay out was done in the field.

Application of FYM:

FYM 12 and 24 t ha^{-1} as per treatment was applied one week prior to pre-sowing irrigation. Quantity was calculated on oven dry basis.

Application of fertilizers:

Fertilizer nitrogen, phosphorus and potassium were applied in the form of urea, SSP and muriate of potash at @ 120, 60 and 60 kg ha^{-1}, respectively. Full dose of phosphorus and potassium and half dose of nitrogen was applied at the time of sowing and rest half dose of nitrogen was applied as two split doses @ time of first irrigation and second irrigation.

IV Results and Discussion:

The observations recorded on growth, development, yield attributes, yield, quality of grain etc and economics of different treatments have been subjected to statistical analysis and presented in tables depictions wherever necessary. The treatment effects have been described in the light of statistical interpretations.

Result and Discussion

Days taken to 50% flowering and Maturity:

Data pertaining to days taken to 50% flowering have been presented in Table 1. It shows that RAJ 4120 (V_5) took 80.60 days to flowering, days taken to maturity (122 days) was maximum in which was application of 100% inorganic fertilizer (F_3), delayed 50 per cent

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flowering by 2-3 days as compared to 100% organic (F_2) and 50 +50% inorganic + organic (F_1) plots.

Economically Characters:

An analysis of data presented in Table-1 reveal that number of ear heads increased significantly by the application of 100% inorganic fertilizer (F_3). Treatment (F_3) recorded highest number of ear heads which was significantly superior over 100% organic (F_2) and 50% +50% inorganic +organic sources.

Among varieties, the highest number of ear heads (116.67 m^{-1}), Length of panicle (8.20), cm, Number of spikelets per ear (29.67), Numbers of grain per ear (51.89), grain yield (32.77) g. and straw yield (42.67) g were recorded in RAJ 4120 (V_5) being at par with RAJ 3765 and Raj 3777 and significantly superior over RAJ 4037 (V_4) RAJ 1482 (V_2) . Saharan *et al*. (2023) Reported that the application of 75 % RDF+5 t FYM ha^{-1}+*Azotobacter*+PSB in wheat, significantly enhanced all growth (dry matter, total tillers, CGR, RGR and others) & yield attributes (Effective tillers, test weight and others), Tiwari *et al*. (2022) Observed that the treatment combination 50% RDF + FYM 6 ton /ha + 1.875 ton / ha. was registered significantly superior in terms of number of tillers, dry weight, test weight, grain yield, straw yield, respectively over rest of the treatments.

The interaction effect of fertility sources and varieties was found to be non-significant. The values of yield contributing characters like number of ear heads per running meter, Length of ear cm, number of spiklets ear^{-1}, number of grain ear^{-1} (Table 1) were increased with 100 % inorganic fertilizer (F_3) followed by 50+50% inorganic +organic (F_1). This might be due to the better development of source and sink capacity of the plant, which ultimately resulted in the higher yield contributing characters with inorganic fertility sources. Similar results were also obtained by Mauriya and Yadav (1997), Bajpati (1987), and Premi and Kalia (2003).

Grain and straw yields of wheat were affected significantly due to different fertility sources (Table 1). The highest grain (35.74 q ha^{-1}) and straw yields (46.84 q ha^{-1}) were recorded with 100% inorganic (F_3) followed by 50+50% inorganic +organic (F_1). Increase in yield with application of 100% inorganic fertilizers might be attributed to more number of ear heads m^{-1}, number of grains ear^{-1} and also test weight. Higher yield under 100% inorganic fertilizer was due to adequate nutrients supply which contributed to increased dry matter production. Better vegetative growth coupled with higher yield attributes resulted in higher grain and

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straw yield of wheat. Similar result were also reported by Bajpai (1997), Nayak and Gupta (2000), Siddique *et al*. (1999) and Raju and Devi (2005).

Table 1. Yield attributes as influenced by fertility sources and wheat varieties

Treatments	Days taken to 50% flowering	Days taken to maturity	No. of ear heads (m^1)	Length of ear (cm)	No. of spikelets (ear^{-1})	No. of grain (ear^{-1})	Yield	
Fertility sources							Grain	Straw
F_1	80.0	117.00	114.40	7.58	27.13	51.67	29.77	37.56
F_2	79.60	115.30	94.0	6.28	18.13	39.67	26.84	33.02
F_3	82.90	118.60	129.20	9.51	37.67	56.63	35.74	46.84
SEm±	**1.86**	**2.13**	**1.585**	**0.136**	**1.085**	**1.240**	**0.60**	**0.79**
CD (P=0.05)	**3.13**	**4.63**	**4.589**	**0.395**	**3.144**	**3.590**	**1.75**	**2.30**
Varieties								
V_1	74.34	113.60	114.67	8.03	28.67	51.22	31.62	40.38
V_2	78.00	118.30	110.33	7.56	26.89	48.83	29.57	37.30
V_3	78.30	120.10	112.67	7.79	28.00	50.00	30.71	38.58
V_4	75.00	114.26	108.33	7.37	25.00	46.67	29.25	36.77
V_5	80.60	122.00	116.67	8.20	29.67	51.89	32.77	42.67
SEm±	**2.06**	**2.34**	**2.046**	**1.176**	**1.401**	**1.600**	**0.77**	**1.03**
CD (P=0.05)	**3.46**	**4.78**	**5.925**	**0.510**	**NS**	**NS**	**2.25**	**2.98**

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Table 2 Effect of tillage and nitrogen management practices on yield and economics of wheat

Treatments	Seed yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	Net return (ha.)	B:C ratio
Tillage practices					
Zero tillage	2935	4660	7595	41929	1.94
Minimum tillage	3520	5525	9045	53857	1.83
FIRB	3907	5995	9902	57275	1.91
Conventional tillage	4220	6380	10600	60595	1.95
SEm±	**101.7**	**143.3**	**245**	**1121.7**	**0.09**
CD (P=0.05)	**305**	**430**	**735.1**	**3365**	**0.27**
Nitrogen management practices					
Control	2920	4630	7568	50160	1.63
RND (120:80:55 kg/ha NPK)	4185	6326	10511	60715	1.93
SPAD (80:60:50 kg/ha NPK)	3480	5465	8945	53834	1.81
Targeted yield 5t/ha (150:80:65 kg/ha)	3890	5975	9865	57630	1.89
SEm±	**99.3**	**138.7**	**237.9**	**1091.7**	**0.08**
CD (P=0.05)	**298**	**416**	**713.9**	**3275**	**0.24**

V Conclusion:

Wheat remains a crucial cereal crop globally and in India, where it holds the second position after rice. Effective fertilization strategies, integrating both organic and inorganic sources, are essential to enhance wheat productivity, grain quality, and soil health. While chemical fertilizers alone can increase yields, their continuous use may degrade soil properties. Organic manures, such as farmyard manure (FYM), play a vital role in maintaining soil fertility and physical properties, contributing to sustainable agricultural practices. Long-term studies highlight that a combination of organic and inorganic fertilizers can lead to better crop yields and improved soil conditions. FYM, in particular, improves soil structure, enhances nutrient availability, and supports beneficial microorganisms. However, organic sources alone cannot meet the high nitrogen demands of wheat crops, necessitating a balanced approach to fertilization. Integrated nutrient management (INM) emerges as a sustainable solution, combining soil mineral, organic, and biological materials to optimize nutrient supply. This approach not only boosts crop yields but also enhances fertilizer use efficiency and reduces environmental impact. As the demand for higher per hectare yields increases and fertilizer production remains insufficient, INM offers a viable path forward. Experimental results demonstrate that 100% inorganic fertilization yields the highest grain and straw outputs, but integrating organic sources also significantly improves various yield attributes. Therefore, the adoption of INM practices, leveraging both organic and inorganic fertilizers, is crucial for achieving sustainable wheat production and long-term soil health.

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Effect of fertility levels and bio-fertilizers on growth and yield attribute of field pea (*Pisum sativum*) in South Eastern plain Zone of Rajasthan

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Abstracts:

A field experiment entitled "Effect of fertility levels and bio-fertilizers on growth and yield attribute of fieldpea (*Pisum sativum*) in South Eastern plain zone of Rajasthan" have been conducted on clay loam soil of Research Farm, Department of Agronomy, Career Point University, Kotaduring rabi 2023-2024. The treatments comprising four fertility levels (F0: Control, F2: 50% RDF, F3: 75% RDF and F2: 100% RDF) and four bio-fertilizer levels (B0: Control, B1: Rhizobium, U2: PSB and B3: Rhizobium + PSB assigned respectively to plots and those were replicated three times in FRBD. For such experiment field pea was used. Results revealed that under 100% RDF and rhizobium + PSB crop was obtained highest value of growth parameters (plant height, number of primary branches plant^{-1}, periodic dry matter accumulation, yield attributes viz., number of pod plant^{-1}, number of grains pod^{-1} and 100g weight of grains.

Key words: Field pea, Rhizobium, Bio-fertilizer, Fertility

I Introduction:

Field pea (Pisum sativum) is a crucial leguminous crop, known for its high nutritional value and significant role in sustainable agriculture through nitrogen fixation. In the South Eastern Plain Zone of Rajasthan, optimizing the growth and yield of field peas is essential to enhance food security and promote sustainable farming practices. The region's unique climatic and soil conditions present both challenges and opportunities for field pea cultivation, necessitating tailored agronomic strategies. Soil fertility and the use of bio-fertilizers are critical components that influence the growth and yield of field peas. Soil fertility levels, which refer to the availability of essential nutrients, are fundamental in determining the plant's developmental success and productivity. Ensuring optimal nutrient availability through appropriate fertility management can lead to improved plant growth, higher yields, and better-quality produce. Bio-fertilizers, which consist of beneficial microorganisms such as nitrogen-fixing bacteria, phosphate-solubilizing bacteria, and mycorrhizal fungi, play a vital role in sustainable agriculture. These bio-fertilizers enhance nutrient availability, improve soil health, and promote robust plant growth by facilitating nutrient uptake and stimulating root development. In the context of the South Eastern Plain Zone of Rajasthan, bio-fertilizers offer a sustainable solution to maintain soil fertility and achieve high crop yields, especially in challenging environmental conditions.

The interplay between different fertility levels and bio-fertilizers in influencing the growth and yield attributes of field peas is a significant area of research. Understanding how these factors interact can help develop integrated nutrient management strategies that maximize crop productivity while maintaining soil health. This is particularly important for the South Eastern Plain Zone of Rajasthan, where sustainable farming practices are essential for the long-term sustainability of agriculture. This study aims to investigate the effects of varying fertility levels and bio-fertilizers on the growth and yield attributes of field pea in the South Eastern Plain Zone of Rajasthan. By evaluating different combinations of fertility treatments and bio-fertilizers, this research seeks to identify the most effective strategies for enhancing field pea productivity in this region. The findings will provide valuable insights for farmers, agronomists, and policymakers, contributing to the development of sustainable and efficient agricultural practices for field pea cultivation in Rajasthan.

II Literature Review:

Field pea [*Pisum sativum* (L.)] or matar is one of the important cool season's crops of the India cultivated over an area of about 0.64 mha with a production of about 0.88m tonnes. (FAO 2021). In Rajasthan the area occupied by field pea was 14 thousand hectares and the production was 35 thousand tonnes during 2020-21 (Anonymous 2021).

Pea is commonly used in human diet throughout the world and it is rich in protein (21-25 %), carbohydrates, vitamin A and C, calcium, phosphorous and has high levels of

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amino acids lysin and tryptophan (Bhat *et al*. 2013). It provides variety of vegetarian dishes and hence it is liked throughout the world. Unripe pods are used as green vegetable and dry seeds are used for dal and chat after boiling. It contains protein (19.2-22.5%), fat (1.8%), carbohydrate (60- 65%), calcium (64 mg), iron (4.8 mg), riboflavin (0.15 mg), thiamine (0.72 mg) and niacin (2.4 mg).

Field pea is highly responsive to nitrogenous fertilizer application especially in early stage. Nitrogen promotes the leaf, stem and other vegetative growth. It also increases the protein content in pea. It is an integral constituent of proteins and chlorophyll and is present in many other compounds of great physiological importance in plant metabolism, such as nucleotides, phosphatised, alkaloids, enzymes, hormones, vitamins etc. It imparts dark-green colour to plants, hastens rapid early growth and improves capacity to fix atmospheric nitrogen symbiotically. Nitrogen application to legumes at lower doses in the initial stage is essential for vigorous start. Growing of pulses without application of phosphatic fertilizer is an important factor for low yield. An adequate supply of phosphorus has been reported by various workers to be beneficial for better growth and yield, better quality in legumes (Sammauria *et al*., 2009). It acts as a structural component of membrane system of cells, chloroplasts and mitochondria. It is a constituent of energy phosphates like ADP and ATP, nucleic acid, nucleo proteins, purines, pyrimidine, nucleotides and several co-enzymes. It is involved in the basic reaction of photosynthesis. It plays an important role in cell division, carbohydrate break down for energy release, transfer of inherited characteristics and hastening the maturity of plants. Use of bio-fertilizers plays an important role in increasing fertilizers use efficiency. When the seeds of pulses are inoculated with Rhizobium and sown in such soils, it increases their number in the rhizosphere, thereby increasing the amount of microbiologically fixed nitrogen for the plant growth.

III Methodology:

Materials and methods : The field experiment was conducted at Research Farm, Career Point University, Kota(Rajasthan) which is situated at 29° 10´ N latitude and 75° 46´ E longitude with an elevation of 215.2 m above mean sea level in Rajasthan state of India. Effect of fertility levels and bio-fertilizers on growth and yield attribute of field pea (*Pisum sativum*) in South Eastern plain zone of Rajasthan” have been conducted on clay loam soil of Research Farm, Department of Agronomy, Career Point University, Kota during Rabi 2023-2024. The treatments comprising four fertility levels (F0: Control, F2: 50% RDF, F3: 75%

RDF and F2: 100% RDF) and four bio-fertilizer levels (B0: Control, B1: Rhizobium, U2: PSB and B3: Rhizobium + PSB assigned respectively to plots and those were replicated three times in FRBD. For such experiment field pea was used. Observation was recorded as growth and yield attributes of field pea.

IV Result and Discussion

Effect of fertility Growth Parameters Fertility levels had significant effect on plant height, number of primary branches plant^{-1} and periodic dry matter accumulation. The maximum plant height (18.10, 25.63, 42.76 and 55.90cm), number of primary branches plant^{-1}(1.35, 1.83, 2.45 and 2.91),dry matter accumulation (0.449, 5.05, 15.30 and 23.41 g plant^{-1}) at 30, 60, 90 DAS and at harvest was recorded under the application of 100% RDF and minimum was recorded under control (no fertilizer)(Table 1). Water is an elementary constituent of plant protoplasm and their adequate supplies enhance cell division and as well as cell elongation. Therefore, optimum availability of fertilizer with 100% RDF to field pea might have improved the photosynthetic area of plants that cumulatively contributed to higher growth parameters. All the treatments resulted in increasing available nutrient in soil over control. These results are in agreement with those of Zhao *et al*., (2009), Yadav and Kumar (2009) and Chesti and Ali (2012).

Yield Attributes

The analysis of data indicates that different fertility levels had significant effect on yield attributes *viz*., number of pod plant^{-1}, number of grains pod^{-1} and 100g weight of grains. The maximum number of pod plant^{-1} (21.52), number of grains pod^{-1} (5.12) and 100g weight of grains (15.68 g) were registered under 100% RDF (Table 2).An overall increase in yield attributes and yield of field pea crop due to combined application of chemical fertilizers with bio-fertilizers have also been reported by Mishra *et al*. (2010), Rajput and Kushwah (2005), Bhat *et al*. (2013), Erman *et al*. (2009), Negi *et al*. (2006), Dass *et al*. (2005) and Kumari *et al* (2012).

Effect of bio-fertilizer

Growth Parameters

An analysis of data indicated that various bio-fertilizer levels caused significant increment in the growth parameters of field pea *i.e*., plant height, number of primary branches plant^{-1} and periodic dry matter accumulation. The maximum plant height (15.48, 23.01, 40.14 and 53.28cm), number of primary branches plant^{-1}(1.26, 1.65, 2.28 and 2.73),dry matter

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accumulation (0.430, 4.84, 14.70 and 22.50 g plant^{-1}) at 30, 60, 90 DAS and at harvest was recorded under the application of Rhizobium + PSB but statistically higher over control (Table 1). Different studies have shown that bio-fertilizer application affects crop growth, plant metabolism and physiology. Increased nodulation under Rhizobium + PSB inoculation might be to due to close association of both the microbial population and their activities resulting in improving soil fertility status. These finding are similar to the results obtained by Singh *et al*., (2012), Khandelwal *et al*., (2012) and Kumari *et al*., (2012).

Yield Attributes

Bio-fertilizer application caused a significant increase in yield attributes *viz*., number of pod plant^{-1}, number of grains pod^{-1} and 100g weight of grains. The maximum number of pod plant^{-1} (20.55), number of grains pod^{-1} (4.71) and 100g weight of grains (15.23 g) were registered under rhizobium + PSB as compare to control (Table 2).Rhizobium or PSB application may enhance crop yield by several indirect action such as decreased shading due to greater leaf erectness. Erectness of leaves as a result of Rhizobium or PSB application could account for about 10 per cent in the photosynthesis, there by indirectly increasing yield. Similar results were also noticed by Sharma *et al.* (1999).

Table 1. Effect of fertility level and bio-fertilizer on number of pods plant^{-1}, number of grains pod^{-1} and 100 grain weight and grain yield

Treatment	Number of pods plant^{-1}	Number of grains pod^{-1}	100 grain wt. (g)
Fertility level			
Control	14.04	3.36	13.89
50 % RDF	15.81	3.75	14.27
75 % RDF	17.96	4.31	14.83
100 % RDF	21.52	5.12	15.64
SEm±	**0.454**	**0.148**	**0.148**
CD (P=0.05)	**1.311**	**0.426**	**0.426**
Bio-fertilizer level			
Control	11.84	3.01	13.53
Rhizobium	17.91	4.32	14.84
PSB	19.03	4.50	15.02
Rhizobium + PSB	20.55	4.71	15.23
SEm±	**0.454**	**0.148**	**0.148**
CD (P=0.05)	**1.311**	**0.426**	**0.426**

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Table 2. Effect of fertility level and bio-fertilizer on plant height, number of primary branches plant^{-1} and dry matter accumulation at 30, 60, 90 DAS and at harvest.

Treatment	Plant height (cm)				Number of primary branches plant^{-1}				Dry matter accumulation (g plant^{-1})			
	30 DAS	**60 DAS**	**90 DAS**	**At harvest**	**30 DAS**	**60 DAS**	**90 DAS**	**At harvest**	**30 DAS**	**60 DAS**	**90 DAS**	**At harvest**
Fertility level												
Control	9.73	17.27	34.39	47.53	0.49	0.88	1.50	1.96	0.382	4.12	11.75	17.60
50 % RDF	12.20	19.74	36.86	50.00	0.81	1.39	2.01	2.47	0.408	4.42	13.06	19.66
75 % RDF	15.85	23.53	40.51	53.65	1.07	1.58	2.21	2.66	0.434	4.76	14.10	21.66
100 % RDF	18.10	25.63	42.76	55.90	1.35	1.83	2.45	2.91	0.449	5.08	15.30	23.41
SEm±	**0.640**	**0.636**	**0.640**	**0.640**	**0.054**	**0.064**	**0.064**	**0.064**	**0.003**	**0.074**	**0.246**	**0.227**
CD (P=0.05)	**1.848**	**1.836**	**1.848**	**1.848**	**0.15**	**0.184**	**0.184**	**0.184**	**0.010**	**0.213**	**0.711**	**0.657**
Bio-fertilizer level												
Control	11.83	19.39	36.49	49.63	0.39	0.90	1.53	1.98	0.397	4.24	11.73	17.70
Rhizobium	13.82	21.48	38.48	51.63	0.99	1.51	2.14	2.59	0.415	4.55	13.34	20.18
PSB	14.75	22.29	39.41	52.55	1.08	1.61	2.24	2.69	0.427	4.78	14.43	21.95
Rhizobium + PSB	15.48	23.01	40.14	53.28	1.26	1.65	2.28	2.73	0.430	4.84	14.70	22.50
SEm±	**0.640**	**0.636**	**0.640**	**0.640**	**0.054**	**0.064**	**0.064**	**0.064**	**0.003**	**0.074**	**0.246**	**0.227**
CD (P=0.05)	**1.848**	**1.836**	**1.848**	**1.848**	**0.15**	**0.184**	**0.184**	**0.184**	**0.010**	**0.213**	**0.711**	**0.657**

V Conclusion:

On the basis of one year investigation titled "Effect of fertility levels and bio-fertilizers on growth and yield of field pea (*Pisum sativum*) in South Eastern plain zone of Rajasthan" it can be concluded that, maximum growth and yield attribute was recorded under 150 kg ha^{-1} and rhizobium + PSB compared to other treatments.

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Evaluating the Effects of Organic and Inorganic Fertilizers on Lentil (Lens culinaris) Growth and Nodulation

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Abstracts:

The present investigation was conducted at Agronomy research farm, School of Agriculture, Career point University Alniya Kota, during *rabi* seasons of 2023-24. The field experiment was laid out with 14 treatment combinations comprising of one varietal treatments (Kota Masoor-1) with Randomized Block Design and three replications. Various nutrient management treatments had significant impact on growth parameters of lentil *viz.*, plant height, number of branches per plant, at all crop growth stages. The aforesaid characters were significantly superior under the treatment NPKS (20:17:20:20 kg/ha) + FYM @ 5 t/ha over rest of the treatments. Although, application of NPKS (20:17:20:20 kg/ha) + Vermicompost @ 2 t/ha, 50% NPKS + FYM @ 5 t/ha and 50% NPKS + Vermicompost @ 2 t/ha was found comparable with former treatment in respect of all growth characters. The minimum values of all these parameters were recorded in the control. Various nutrient management treatments had significant impact on the number of root nodules per plant and increased significantly higher in all the fertility treatments over control in both the observations recorded at 30 and 60 days after sowing stages. The maximum root nodules per plant and maximum dry weight of root nodules 6.88 and 10.12, 4.15 and 8.95 were recorded with the application of NPKS(20:17:20:20kg/ha)+ R*hizobium* culture + PSB at both the stages of crop growth respectively.

Key words: Lentil, Rhizobium, Vermicompost, Nutrients

I Introduction:

Lentil (Lens culinaris) is a highly valued leguminous crop, known for its rich protein content and significant contribution to human diets across the world. Besides its nutritional benefits, lentil plays a crucial role in sustainable agriculture due to its ability to fix atmospheric nitrogen through a symbiotic relationship with rhizobium bacteria, a process called nodulation. Optimizing both the growth and nodulation of lentils is essential for improving crop yield and soil health, making it a vital area of study.

Effective nutrient management is key to enhancing the growth and nodulation of lentils. Organic nutrient sources, such as compost, manure, and green manure, contribute to soil health by improving its structure, increasing organic matter content, and promoting microbial activity. These improvements in soil quality can lead to better root development and enhanced nodulation, resulting in a more robust crop. On the other hand, inorganic nutrient sources, primarily synthetic fertilizers, offer immediate nutrient availability, which can accelerate plant growth and increase yields. However, the long-term effects of these fertilizers on soil health and microbial populations can vary significantly from those of organic sources.

The interaction between organic and inorganic fertilizers in influencing the growth and nodulation of lentils presents a compelling area of research. While organic sources support sustainable agricultural practices by improving long-term soil fertility, inorganic fertilizers can provide the necessary nutrients during critical growth periods. Understanding how these different nutrient sources affect lentil growth and nodulation can help in developing integrated nutrient management strategies that optimize both crop production and environmental sustainability.

This study aims to investigate the effects of organic and inorganic nutrient sources on the growth and nodulation of lentil. By evaluating various combinations of organic and inorganic treatments, the research seeks to determine the most effective strategies for enhancing lentil productivity. The outcomes of this study will offer valuable insights for farmers, agronomists, and policymakers, guiding them in implementing balanced and sustainable fertilization practices for lentil cultivation.

II Literature Review:

Pulses are a staple food around the world, playing a key role in many traditional cuisines. In India, it is an important group of food crops that can play a vital role to address national food and nutritional security and also tackle environmental challenges. From the nutritional point of view, pulses have been an important source of plant-based protein which are usually lacking in animal-based proteins. Pulses contribute about 10 per cent of the daily protein intake and 5 per cent of energy intake and hence are of particular importance for food security in low income countries. Pulses contain 22–34.6 per cent protein on dry-seed basis, which is almost 2-3 times higher as in cereals. In addition, pulses are important to fulfill the nutritional needs of the human body and importantly health-conscious consumers as pulses are free from gluten, sodium and cholesterol. The positive impact of pulses on soil health is very well known, in particular their ability to naturally fix atmospheric nitrogen, which fertilizes the soil for both intercropped crops and crops to be cultivated subsequently. This in turn lowers the need to use chemical nitrogenous fertilizers. Reducing the production and application of these fertilizers in agriculture decreases GHG emissions and thus, plummeting their degrading / threatening impacts on environment, ecology and sustainability overall. Pulses can enhance the aggregation and structure of the soil, which can improve the water retaining capacity of soil and consequently water-use efficiency of crops as well. Globally, in 2017, pulses accounted for 85.40 million hectares of global crop area producing 87.40 million tonnes of grain with an average productivity of 1023 kg ha-1. However, still the production of pulses is not keeping pace with a minimum requirement of 60 g of protein per day. India is the world‟s largest grower, producer and consumer of pulses accounting 34 per cent of total acreage, 26 per cent of the total production and about 30 per cent (23-24 million tonnes) of the total consumption in the world. In India, the area under pulses was >29 million ha with the total production of 25.23 million tonnes at a productivity of 841 kg ha-1 during 2021-22 (MoA & FW, 2022). The integrated nutrient management (INM) has assumed greater significance in the recent past. Work on INK as a whole is very less. Besides, the prohibitive cost of chemical fertilizers often compels to use organic and bio-fertilizers. Therefore, INM involving inorganic, biological and organic sources has potential to improve soil fertility on sustainable basis, since it supplies almost all the nutrients besides increasing nutrient use efficiency and improving physio-chemical properties of soil. The application bio-fertilizer mixed with FYM saved 50 % recommended dose of chemical fertilizer. (Rajkhowa et al., 2003, Rajput and Pandy 2004 and Rajput and Kushwah, 2005). Growing fertilizer need of the country and increasing fertilizer prices have emphasized on the use of bio-fertilizer in Indian agriculture.

III Methodology:

Materials and Methods Location Kota district is located at 25.18° N to 75.83° E Latitude in South Eastern Rajasthan. It covers an area of 221.36 km^2. Agro-climatically, the district falls in Zone V, known as Humid South Eastern Plain. The average rainfall in the region is 660.6. mm. Maximum temperature range in the summer is 40 to 48°C and minimum 1.0- 2.6°C during winter. Main Rainy season crops of the district are maize, soybean and pulses. While in winter, wheat, mustard, coriander and garlic are main crops.

Experimental Details The experiment was carried out with the following standard procedure regarding treatments, replications and experimental design etc. were used to achieve the objectives. Further details are as follows

T1 : Control (no fertilizers)
T2 :NPK+S (20:17:20:20) kg/ha
T3 : 50% NPK + S
T4 : FYM @ 5t/ha
T5 :Vermicompost @ 2 t/ha
T6 :NPK+S (20:17:20:20 kg/ha) + FYM @5 t/ha
T7 :NPK+S (20:17:20:20kg/ha)+Vermicompost @2t/ha
T8 : 50% NPK+S+ FYM@ 5 t/ha
T9 :50% NPK+S+Vermicompost @ 2t/ha
T10 : Rhizobium culture + PSB.
T11 :NPK+S (20:17:20:20 kg/ha)+(Rhizobiumculture+PSB)
T12 : 50% NPK+S + (Rhizobium culture + PSB)
T13 :FYM @ 5t/ha+(*Rhizobium*culture+PSB)
T14 :Vermicompost @ 2t/ha.+(*Rhizobium*culture+PSB)

Measurement of the growth parameters

The plant population was recorded at 30 days after sowing and at maturity of the crop. The number of plant were counted in one-meter row length from randomly selected three rows in each plot and there average were calculated. The plant height was measured in cm at 30, 45, 60 days after sowing and at maturity from the soil surface to the main apical bud up to last foliate. Five plant s selected randomly from each plot and their average height were measured

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in cm with the help of measuring scale. The total number of branches per plant were counted at 30, 60, 90 days after sowing and at maturity along with main shoot of randomly selected five tagged plants and the mean was calculated. The numbers of root nodules of five randomly selected plants were counted in each plot after uprooting the plant with the help of Ganti at 30 and 60 days after sowing using second rear rows. The roots were carefully washed with water and healthy root nodules. Dry weight of root nodules were recorded from five randomly selected plants in each plot at 30 and 60 DAS. Healthy and effective root nodules kept in thermostatically controlled oven at 800C for 20 hours to obtain constant dry weight and finally their weight was recorded in mg.

IV Results and Discussion

Plant population:

The statistical analysis of data pertaining to plant population per meter row length at 30 days stage as well as at maturity has been summarized, where it is reviewed that the experimental variable did not affect plant population significantly. The study of Table-1 revealed that the plant population was uniform for all practical purpose under various nutrient management treatments. At 30 DAS, it ranged from 11.96/m row length in absolute control treatment to 12.20/m row length in T_6 (NPKS (20:17:20:20 kg/ha) + FYM @ 5 t/ha) treatment. It is apparent from these plant counts that the sowing was done properly and uniformly using healthy and viable seeds of Kota Masoor 1 (RKL 607-1) variety to give rise to the better seed germination and emergence. Secondly, plant count at maturity stage indicated that there was no any adverse influence of weather conditions such as maximum and minimum temperature, relative humidity and rainfall on crop. At maturity stage, plant population ranged from 11.66 to 11.86/m row length.

The plant population is the most important character, which directly influenced the crop yield. Uniform plant density is an important pre requisite for obtaining higher precision when it is not a variable factor as treatment. The data in Table-1 indicated that the plant population remained almost uniform in all the treatments without giving any definite trend. It is obviously reflected that sowing of experimental crop was done properly and uniformly in each treatment using healthy and viable seed of lentil variety Kota Masoor-1 (RKL 607-1) for better germination. Thus, the crop stand remained almost uniform in all the integrated nutrient management treatments. There was no harmful effect of the treatment applied to the same furrow in which seed were hand drilled.

Plant height

Data regarding effect of organic, inorganic and bio-fertilizers on plant height of lentil at various growth stages have been summarized in Table- 2. Plant height was recorded from 30 days after sowing (DAS) to maturity. An examination of data embodied in Table-2 revealed that plant height was, in general, enhanced by multi-fold with the advancement of plant growth till maturity stage under all treatments. The different treatments of nutrient management significantly influenced the plant height at all growth stages. The data (Table-2) revealed that treatment NPKS (20:17:20:20 kg/ha) + FYM @ 5 t/ha attained significantly more height (10.36, 15.15, 23.43 and 33.91 cm) among all treatments at 30, 60, 90 DAS and maturity, respectively. However, it was found at par with NPKS (20:17:20:20 kg/ha) + Vermicompost @ 2 t/ha at all crop growth stages; 50% NPKS + FYM @ 5 t/ha, 50% NPKS + Vermicompost @ 2 t/ha and NPKS (20:17:20:20 kg/ha) + *Rhizobium* culture + PSB at 30, 60 DAS and maturity; FYM @ 5 t/ha + *Rhizobium* culture + PSB at 30 DAS and maturity; and with 50% NPKS + *Rhizobium* culture + PSB at maturity. Minimum plant height was recorded in control closely followed by 50% NPKS, *Rhizobium* culture + PSB, Vermicompost @ 2 t/ha, Vermicompost @ 2 t/ha + *Rhizobium* culture + PSB, FYM @ 5 t/ha, NPKS (20:17:20:20 kg/ha) and 50% NPKS + *Rhizobium* culture + PSB.

Number of branches per plant:

The number of branches per plant was recorded at different growth intervals and the mean data have been presented in Table 3. The formation of branches was, in general, fast up to maturity, which resulted in more than four-fold rise in the branches per plant. Analysis of variance (Appendix III) indicated that different treatments of nutrients management exerted significant influence upon this growth character at all stages of observation. Application of 100% of the recommended dose of NPKS (20:17:20:20 kg/ha) in combination with 5 t FYM/ha (T6) brought about maximum branches range from 2.03 at 30 DAS to 5.15 per plant at maturity. This treatment proved significantly superior to rest of the treatments except the treatment NPKS (20:17:20:20 kg/ha) + Vermicompost @ 2 t/ha, 50% NPKS + FYM @ 5 t/ha, 50% NPKS + Vermicompost @ 2 t/ha,NPKS (20:17:20:20 kg/ha) + *Rhizobium* culture + PSB and FYM @ 5 t/ha + *Rhizobium* culture + PSB at all crop growth stages. The minimum number of branches i.e. 1.00, 1.33 and 3.47 per plant was recorded in control at 30, 60, 90 DAS and maturity, respectively.

The morphological parameters *viz.*, plant height and number of branches per plant recorded periodically, have exhibited many interesting architectural variations due to dual inoculation of *Rhizobium* culture and PSB under the application of NPKS at 100 and 50% rates with or without FYM and vermicompost incorporation. Both these parameters, in general, increased by multi-fold in all the treatments with the successive growth and development stages. At maturity stage, plant height ranged from 30.71 to 33.91 cm and branches 3.82 to 5.15 per plant under the various treatments.

The morphological parameters, plant height and number of branches per plant were significantly influenced by nutrient management treatments at all crop growth stages. Application of NPKS (20:17:20:20 kg/ha) + FYM @ 5 t/ha (T_6) resulted in significantly tallest plants and highest branches per plant over rest of the treatments. However, this treatment was found at par with NPKS (20:17:20:20 kg/ha) + Vermicompost @ 2 t/ha, 50% NPKS + FYM @ 5 t/ha, 50% NPKS + Vermicompost @ 2 t/ha and NPKS (20:17:20:20 kg/ha) + *Rhizobium* culture + PSB. The increase in plant growth was attributed to the increase availability of nutrients with application of inorganic fertilizer, continuous supply of nutrients due to the action of biofertilizers and release of nutrients from organic fertilizer. NPK plays pivotal role in several physiological and biochemical processes, viz., root development, photosynthesis, energy transfer reaction and symbiotic biological N-fixation process. Sulphur influences the formation of protein and chlorophyll, is a constituent of plant‘s structural material and increases root development. FYM and vermicompost improved the physical property of soil and activities of *Rhizobium* culture, which fixed the atmospheric nitrogen as well as soil nitrogen made available to the plant and PSB, which made available phosphorus from insoluble to soluble form. Beneficial effect of FYM, vermicompost and biofertilizer singly or jointly along with NPKS on growth characters of lentil have also been reported by Pathak *et. al.* (2003), Singh *et al.* (2003), Hossain and Suman (2005), Singh *et al.* (2007), Zeidan (2007), Singh *et al.* (2008) and Kumar *et al.* (2009).

Number of root nodules per plant:

The data in Table 4 revealed that the number of root nodules was augmented steadily with the increase of plant growth till 60 days stage. Application of NPKS (20:17:20:20 kg/ha) + *Rhizobium* culture + PSB (T11) brought about maximum number of root nodules i.e. 6.88 at 30 DAS and 10.62 per plant at 60 days stage. This treatment (T11) found to be

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significantly superior to most of the treatments except 50% NPKS + *Rhizobium* culture + PSB at both stages of observation.

Dry weight of root nodules per plant:

The dry weight of root-nodules exhibited the same result trend as observed in case of root-nodule numbers per plant because both were interrelated to each other (Table-5 The applied treatments exerted their significant influence upon this parameter at both the stages of plant growth. Application of hundred percent dose of NPKS (20:17:20:20 kg/ha) along with *Rhizobium* culture + PSB (T11) gave the maximum dry weight of root nodules i.e. 4.15 mg/plant at 30 days stage and 8.95 mg/plant at 60 days stage of plant growth. It was closely followed by Vermicompost @ 2t/ha + *Rhizobium* culture+PSB and 50% NPK+ S + *Rhizobium* culture+PSB at 30 DAS and 60 DAS. Absolute control treatment resulted in the lower dry weight of root-nodules. Lentil, being a legume, fixes atmospheric nitrogen and improves the soil fertility. Integrated nutrient management in legumes is of great importance as it encourages the root nodulation, growth and productivity per unit is in addition to soil health on the sustainable basis.

Root-nodulation study indicated that the combined application of NPKS (20:17:20:20 kg/ha) + *Rhizobium* culture + PSB, resulted to increase maximum number of root-nodules per plant as well as their dry weight of root nodules per plant at 30 and 60 days stages. This was at par with 50% NPKS + *Rhizobium* culture + PSB in case of number of root nodules and their dry weight per plant and with FYM @ 5 t/ha + *Rhizobium* culture + PSB, Vermicompost @ 2 t/ha + *Rhizobium* culture + PSB, *Rhizobium* culture + PSB, NPKS (20:17:20:20 kg/ha) + FYM @ 5 t/ha and NPKS (20:17:20:20 kg/ha) + Vermicompost @ 2 t/ha in case of dry weight of root nodules per plant only. Biological nitrogen fixation by the symbiotic bacteria (*Rhizobium sp*.) in root-nodules of legume plants, lentil is one of them, is quantitatively one of the most important ways in which atmospheric nitrogen enters the biosphere. Biosphere is that parts of the earth's envelope in which living organisms exist in their natural state. The combination of organic and inorganic sources of nutrients in treatments like NPKS (20:17:20:20 kg/ha) + *Rhizobium* culture + PSB, 50% NPKS + *Rhizobium* culture + PSB, FYM @ 5 t/ha + *Rhizobium* culture + PSB, Vermicompost @ 2 t/ha + *Rhizobium* culture + PSB, *Rhizobium* culture + PSB, and NPKS (20:17:20:20 kg/ha) + FYM @ 5 t/ha encouraged the formation of increased number and dry weight of root nodules per plant up to the significant level. This may be because of the increase number of nitrogen fixing bacteria in the rhizosphere (root-zone) and the sufficient supply of nutrients to plant for development of root nodules. These results corroborate with those of many workers, viz., Jain *et al* (1995), Singh and Kumar (1996), Chandra and Pareek (2002), Sharma and Sharma (2004), Balyan and Singh (2005), Hossain and Suman (2005), Karmakar *et al.* (2006), Khanna *et al.* (2006) and Kumar and Chandra (2008).

Table 1. Yield attributes as influenced by fertility sources and wheat varieties

Treatments	Days taken to 50% flowering	Days taken to maturity	No. of ear heads (m^1)	Length of ear (cm)	No. of spikelets (ear^{-1})	No. of grain (ear^{-1})	Yield	
Fertility sources							Grain	Straw
F_1	80.0	117.00	114.40	7.58	27.13	51.67	29.77	37.56
F_2	79.60	115.30	94.0	6.28	18.13	39.67	26.84	33.02
F_3	82.90	118.60	129.20	9.51	37.67	56.63	35.74	46.84
SEm±	**1.86**	**2.13**	**1.585**	**0.136**	**1.085**	**1.240**	**0.60**	**0.79**
CD (P=0.05)	**3.13**	**4.63**	**4.589**	**0.395**	**3.144**	**3.590**	**1.75**	**2.30**
Varieties								
V_1	74.34	113.60	114.67	8.03	28.67	51.22	31.62	40.38
V_2	78.00	118.30	110.33	7.56	26.89	48.83	29.57	37.30
V_3	78.30	120.10	112.67	7.79	28.00	50.00	30.71	38.58
V_4	75.00	114.26	108.33	7.37	25.00	46.67	29.25	36.77
V_5	80.60	122.00	116.67	8.20	29.67	51.89	32.77	42.67
SEm±	**2.06**	**2.34**	**2.046**	**1.176**	**1.401**	**1.600**	**0.77**	**1.03**
CD (P=0.05)	**3.46**	**4.78**	**5.925**	**0.510**	**NS**	**NS**	**2.25**	**2.98**

Table 2 Effect of tillage and nitrogen management practices on yield and economics of wheat

Treatments	Seed yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	Net return (ha.)	B:C ratio
Tillage practices					
Zero tillage	2935	4660	7595	41929	1.94
Minimum tillage	3520	5525	9045	53857	1.83
FIRB	3907	5995	9902	57275	1.91
Conventional tillage	4220	6380	10600	60595	1.95
SEm±	**101.7**	**143.3**	**245**	**1121.7**	**0.09**
CD (P=0.05)	**305**	**430**	**735.1**	**3365**	**0.27**
Nitrogen management practices					
Control	2920	4630	7568	50160	1.63
RND (120:80:55 kg/ha NPK)	4185	6326	10511	60715	1.93
SPAD (80:60:50 kg/ha NPK)	3480	5465	8945	53834	1.81
Targeted yield 5t/ha (150:80:65 kg/ha)	3890	5975	9865	57630	1.89
SEm±	**99.3**	**138.7**	**237.9**	**1091.7**	**0.08**
CD (P=0.05)	**298**	**416**	**713.9**	**3275**	**0.24**

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Table 3: Effect of nutrient management on number of branches of lentil at different growth stages

Treat.	Combination	Number of branches at			
		30 DAS	60 DAS	90 DAS	Maturity
T_1	Control (No fertilizers)	1.23	1.62	3.78	3.82
T_2	NPK+S (20:17:20:20kg/ha)	1.66	2.42	4.44	4.48
T_3	50% NPK+S	1.3	1.92	3.98	4.02
T_4	FYM @ 5t/ha	1.56	2.16	4.38	4.42
T_5	Vermicompost @ 2t/ha	1.63	2.36	4.04	4.08
T_6	NPK+S (20:17:20:20kg/ha)+ FYM @ 5t/ha	2.03	3.36	5.11	5.15
T_7	NPK+S(20:17:20:20kg/ha)+Vermicompost @ 2t/ha	2	3.22	5.04	5.08
T_8	50%NPK + S + FYM @5t/ha	1.93	2.92	4.84	4.88
T_9	50%NPK + S+Vermicompost @2t/ha	1.96	2.98	4.71	4.75
T_{10}	*Rhizobium* culture+PSB	1.5	1.96	4.01	4.05
T_{11}	NPKS(20:17:20:20kg/ha)+ R*hizobium* culture + PSB	1.9	2.89	4.64	4.68
T_{12}	50% NPK+ S + *Rhizobium* culture+PSB	1.7	2.62	4.48	4.52
T_{13}	FYM@5t/ha + *Rhizobium* culture+PSB	1.73	2.89	4.58	4.62
T_{14}	Vermicompost @ 2t/ha + *Rhizobium* culture+PSB	1.6	2.22	4.24	4.28
	S.E.m±	**0.12**	**0.22**	**0.24**	**0.26**
	C.D.(at 5%)	**0.33**	**0.63**	**0.72**	**0.69**

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Table 4. Effect of nutrient management on number of root nodules /plant of lentil at different growth stages.

Treatment	Combination	Number of root nodules/plant at	
		30 DAS	**60 DAS**
T_1	Control (No fertilizers)	3.68	4.62
T_2	NPK+S (20:17:20:20kg/ha)	4.35	6.02
T_3	50% NPK+S	4.02	5.82
T_4	FYM @ 5t/ha	3.88	5.42
T_5	Vermicompost @ 2t/ha	3.75	5.02
T_6	NPK+S (20:17:20:20kg/ha)+ FYM @ 5t/ha	4.82	9.02
T_7	NPK+S(20:17:20:20kg/ha)+Vermicompost @ 2t/ha	4.62	8.55
T_8	50%NPK + S + FYM @5t/ha	4.42	7.28
T_9	50%NPK + S+Vermicompost @2t/ha	4.38	7.15
T_{10}	*Rhizobium* culture+PSB	5.35	9.08
T_{11}	NPKS(20:17:20:20kg/ha)+ R*hizobium* culture + PSB	6.88	10.62
T_{12}	50% NPK+ S + *Rhizobium* culture+PSB	5.82	9.88
T_{13}	FYM@5t/ha + *Rhizobium* culture+PSB	5.75	9.22
T_{14}	Vermicompost @ 2t/ha + *Rhizobium* culture+PSB	5.68	9.08
	S.E.m±	**0.29**	**0.37**
	C.D. (at 5%)	**0.68**	**0.86**

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Table No.5: Effect of nutrient management on dry weight of root nodules /plant (mg) of lentil at 30 and 60 days after sowing.

Treatment	Combination	Dry weight of root nodules /plant (mg)	
		30 DAS	60 DAS
T_1	Control (No fertilizers)	2.22	4.07
T_2	NPK+S (20:17:20:20kg/ha)	2.88	6.93
T_3	50% NPK+S	2.82	6.75
T_4	FYM @ 5t/ha	2.55	5.96
T_5	Vermicompost @ 2t/ha	2.28	4.8
T_6	NPK+S (20:17:20:20kg/ha)+ FYM @ 5t/ha	3.48	6.95
T_7	NPK+S(20:17:20:20kg/ha)+Vermicompost @ 2t/ha	2.95	7.81
T_8	50%NPK + S + FYM @5t/ha	3.28	7.85
T_9	50%NPK + S+Vermicompost @2t/ha	3.85	7.8
T_{10}	*Rhizobium* culture+PSB	3.08	7.56
T_{11}	NPKS(20:17:20:20kg/ha)+ R*hizobium* culture + PSB	4.15	8.95
T_{12}	50% NPK+ S + *Rhizobium* culture+PSB	3.89	7.05
T_{13}	FYM@5t/ha + *Rhizobium* culture+PSB	3.55	7.04
T_{14}	Vermicompost @ 2t/ha + *Rhizobium* culture+PSB	3.95	7.95
	S.E.m±	**0.29**	**0.37**
	C.D.(at 5%)	**0.68**	**0.86**

V Conclusion:

The study conducted at the Agronomy Research Farm, School of Agriculture, Career Point University Alniya Kota, during the rabi season of 2023-24, demonstrated the significant impact of various nutrient management treatments on the growth parameters of lentil (Kota Masoor-1). The findings indicated that the combined application of NPKS (20:17:20:20 kg/ha) with FYM @ 5 t/ha notably enhanced plant height, number of branches per plant, and overall growth at all crop stages compared to other treatments. Additionally, treatments incorporating vermicompost and

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Rhizobium culture, alongside NPKS and FYM, showed comparable results, highlighting their potential as effective nutrient management strategies. The experiment revealed that the application of NPKS (20:17:20:20 kg/ha) + Rhizobium culture + PSB produced the maximum number and dry weight of root nodules per plant, signifying improved root health and nutrient uptake. The study underlined the importance of integrated nutrient management (INM) in enhancing soil fertility, crop growth, and sustainable agricultural practices. The results support the notion that combining inorganic, organic, and biological fertilizers can optimize nutrient availability, improve plant physiological and biochemical processes, and ultimately increase lentil productivity.

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Effect of sulphur and bio-fertilizers on growth parameters of fenugreek (*Trigonella foenum-graecum* L.) in South-East Rajasthan

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Abstract:

A field experiment was conducted at the Instructional Farm (Agronomy), Career Point University, Alaniya, Kota during 2023-2024. The experiment was conducted in Factorial RBD. The treatment consisted of four levels of sulphur viz., 0, 15, 30 and 45 kg ha-1 and four combinations of biofertilizers viz., control, Rhizobium, PSB and Rhizobium + PSB thereby making 16 treatment combinations replicated thrice. The results revealed that application of 45 kg sulphur ha-1 registered significantly higher growth characters i.e., plant height, dry matter at successive growth stages, number of primary and secondary branches The fenugreek raised with 45 kg sulphur ha-1 significantly improved yield attributes i.e., Pods plant-1, pod length, seeds pod-1 and test weight thereby enhanced seed, haulm and biological yield by over application of 15 and 30 kg sulphur ha-1. The crop accumulated highest quantum of total uptake of N, P, K and S over application of 15 and 30 kg sulphur ha-1, respectively. The crop under the influence of 45 kg sulphur ha-1 fetched highest net return of and B-C ratio of over rest of sulphur levels However, Rhizobium + PSB rcorded maximum plant height, dry matter, primary and secondary branches plant-1. Inoculation of Rhizobium + PSB of fenugreek seeds proved significantly higher pods plant-1, pod length, seeds pod-1 and test weight with concomitant increase in seed and haulm yield over control. The fenugreek seed inoculated with Rhizobium + PSB increased total uptake of N, P, K and S over control. The maximum net return and the higher B-C ratio was also recorded when seeds were inoculated with Rhizobium + PSB.

Keywords: Fenugreek, Rhizobium, Sulphur, nutrients

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I Introduction:

Fenugreek (Trigonella foenum-graecum L.), a widely cultivated leguminous crop, holds significant agronomic and medicinal value in India, particularly in Rajasthan. This region, known for its diverse climatic conditions, presents unique challenges and opportunities for crop cultivation. Among the various factors influencing the growth and productivity of fenugreek, soil fertility plays a crucial role. In recent years, there has been a growing interest in sustainable agricultural practices that not only enhance crop yield but also maintain soil health. This has led to an increased focus on the use of bio-fertilizers and micronutrients like sulphur, which are essential for plant growth. Sulphur, a secondary macronutrient, is vital for the synthesis of amino acids, proteins, and enzymes in plants. It plays a pivotal role in nitrogen metabolism, chlorophyll formation, and overall plant development. Despite its importance, sulphur is often overlooked in traditional fertilization practices, leading to deficiencies that can severely impact crop yield and quality. In fenugreek, sulphur deficiency can manifest as reduced growth, delayed maturity, and lower seed production. Given the sandy and loamy soils of South-East Rajasthan, which are often low in organic matter and prone to nutrient leaching, the application of sulphur could be particularly beneficial.

Bio-fertilizers, on the other hand, are living organisms that enhance nutrient availability in the soil. They include various strains of bacteria, fungi, and algae that form symbiotic relationships with plant roots, facilitating the uptake of nutrients like nitrogen, phosphorus, and potassium. The use of bio-fertilizers not only improves soil fertility but also contributes to sustainable agriculture by reducing the dependency on chemical fertilizers. In fenugreek cultivation, bio-fertilizers such as Rhizobium, Azotobacter, and phosphorus-solubilizing bacteria (PSB) have shown promising results in enhancing growth parameters and yield. The synergistic effect of sulphur and bio-fertilizers on the growth and development of fenugreek has been a subject of research in various agro-ecological zones. However, limited studies have been conducted in the specific context of South-East Rajasthan, where the agro-climatic conditions and soil characteristics differ from other regions. This study aims to fill this gap by investigating the combined effect of sulphur and bio-fertilizers on the growth parameters of fenugreek in this region.

The research will focus on key growth parameters such as plant height, number of branches per plant, leaf area, biomass production, and root nodulation. These parameters are critical indicators of plant health and productivity, and their response to different fertilization regimes can provide valuable insights into the optimal nutrient management practices for fenugreek. By conducting field experiments and analyzing the data, this study will contribute to the development of more efficient and sustainable fertilization strategies that can enhance fenugreek cultivation in South-East Rajasthan. In addition to improving crop yield, the findings of this study have broader implications for sustainable agriculture in the region. As the demand for organic and sustainably produced crops continues to grow, the use of bio-fertilizers and micronutrients like sulphur offers a viable alternative to conventional chemical fertilizers. By promoting soil health and reducing environmental impacts, these practices align with the principles of sustainable farming and contribute to the long-term resilience of agricultural systems.

II Literature Review:

Fenugreek (*Trigonella foenum-graecum* L.) popularly known by its vernacular name "methi" has been in culinary and medicinal uses due to its restorative and nutraceutical properties for more than 2500 years. The seed contain an alkaloid trigonellin (0.12-0.38%) is thought to reduce glycosuria in diabetes. Fenugreek seed helps not only in reducing blood sugar levels due to its high phytochemicals concentration, but it also reduce low density cholesterols and triacylglycerols. Seeds are used in treatments of slatulene, dysentery, diarrhea, tisdyspepsia, chronic cough, dropsy, enlargement of liver spleen, rickets, gout diabetes and arthri. The important steroid "Diosgenin" is used in synthesis of sex hormone and makes ovule contraceptive. The sapogenin, is an estrogen precursor and helps in managing menopause. The concentration of diosgenin varies from 0.86 to 2.2% in seed (Bochalia et al., 2011). Fenugreek leaves and seed have been used extensively to prepare extracts and powder for medicinal uses. Fenugreek is reported to have anti- diabetic, anti-fertility, anticancer, anti-microbial, anti-parasitic and hypocholesterolaemic effects (Al-Habori and Raman, 2002).

In the recent years, continuous and imbalance application of chemical fertilizers with little or no use of organic manure is leading to poor nutrient use efficiency, low yield of crop and poor physical and biological property of soil. At the same time increasing cost of production due to more and more use of costly nutrient sources is becoming unaffordable to the most of farmers. Hence, it has become imperative to search for other complementary and alternative sources of nutrients, among which use of bio-fertilizers of biological origin for integrated nutrient management in fenugreek is an important avenue. In this approach, microbial fertilization with Rhizobium as well as PSB and KSB has been found promising to improve soil health and crop production. Bio-fertilizer such as Rhizobium, PSB and KSB play an important role in increasing the availability of nitrogen, phosphorus and potassium.

Inoculation with Rhizobium will not only improve nitrogen availability in soil by biological nitrogen fixation but also ensure prolonged and adequate supply of this vital nutrient with minimum loss in light texture soil. Therefore, the introduction of efficient strain of rhizobium may be helpful in boosting greater nitrogen fixation and crop production. Inoculation of seeds with Rhizobium culture is low cost input in legume and has been found beneficial by many workers (Subba Rao, 1976). Similarly, inoculation with Phosphate solubilizing bacteria (PSB) converts the unavailable form of phosphorus into soluble or available form to the plant. Microbial fertilization along with Rhizobium and PSB has been found promising to improve soil health and crop production (Meena et al., 2014). Rhizobium + PSB help to maintain soil fertility and eliminate the pollution hazards to increase the productivity. A large number of soil micro-organisms have capacity to solubilize mineral phosphate. The PSB help in improving phosphate uptake in plants. Potassium is an essential nutrient required by crops. Most of the K in soil exists in the form of silicate minerals (microcline, muscovite, biotite etc.). The KSB are commonly known as potassium dissolving bacteria or silicate dissolving bacteria. NPK consortia is a mixture of Rhizobium + PSB +

KSB, Inoculation with NPK Consortia provide nutrients such as N, P and K through their activities in the soils or rhizosphere and makes them readily available to the plants.

III Methodology

Materials and Methods

Kota district is located at 25.18° N to 75.83° E Latitude in South Eastern Rajasthan. It covers an area of 221.36 km2. Agro-climatically, the district falls in Zone V, known as Humid South Eastern Plain. The average rainfall in the region is 660.6. mm. Maximum temperature range in the summer is 40 to 48°C and minimum 1.0- 2.6°C during winter. Main Rainy season crops of the district are maize, soybean and pulses. While in winter, wheat, mustard, coriander and garlic are main crops.

Experimental Details

The experiment was carried out with the following standard procedure regarding treatments, replications and experimental design etc. were used to achieve the objectives. The experiment was conducted in Factorial RBD. The treatment consisted of four levels of sulphur viz., 0, 15, 30 and 45 kg ha-1 and four combinations of biofertilizers viz., control, Rhizobium, PSB and Rhizobium + PSB thereby making 16 treatment combinations replicated thrice.

Measurement of the growth parameters

The number of plants metre-1 row length were counted after complete germination at 20 DAS and harvest from five randomly selected locations in each experimental plot. These were averaged to work out number of plants m-1 length. At 30, 60, 90 DAS and at harvest, the height of five randomly selected plants from each plot was measured from cotyledonary node to the apex of the shoot. The mean plant height for each treatment was computed and expressed in cm. The plant sample for Dry matter accumulation were taken at 30, 60, 90 DAS and at harvest. For this purpose, the plant from 50 cm row length were cut close to the ground level and put in the paper bags. The samples were sun dried and thereafter kept in electric oven at 720C ± 0.50C for 72 hours or till the constant weigh were achieved. The dry matter was expressed in gram m-1 row length. Total number of primary and secondary branches were counted from five randomly selected plants from each experimental unit. These were averaged to workout number of primary and secondary branches plant-1. The growth efficiency parameters mainly CGR and RGR were estimated between 30-60 DAS, 60-90 DAS and 90 DAS to harvest by the following formula as given by Radford (1967).

CGR (g m-2 day-1) = 1 × W2−W1

P t2−t1

Where, W1 and W2 are dry weight plant-1 at time t1 and t2, respectively. P represents the ground area.

RGR (g g-1 day-1) = (loge W2− loge W1)

t2−t1

Where, W1 and W2 are dry weight plant-1 at time t1 and t2, respectively.

IV Results and Discussion

A perusal of data (Table 1) reveals that application of sulphur levels and bio-fertilizers to fenugreek crop did not significantly influence number of plants m-1 row length recorded after full germination (15 DAS) and at harvest.

Plant height

Sulphur: An examination of data (Table 2) shows that increasing levels of sulphur application significantly influenced plant height recorded at harvest. The maximum plant height at harvest was recorded with the application of 45 kg sulphur ha-1.

Bio-fertilizers: The plant height at harvest was significantly influenced due to inoculation of fenugreek seed with bio-fertilizers over control. The crop attained highest plant height at harvest when seeds were inoculated with Rhizobium + PSB however both these treatments significantly enhanced plant height at harvest.

Dry matter accumulation

Sulphur: It is explicit from data (Table 3) that increasing levels of sulphur application significantly influenced DMA plant-1 at harvest. The highest DMA plant-1 at harvest was estimated with the application of sulphur 45 kg ha-1.

Bio-fertilizers: Data show that inoculation of fenugreek seed with bio-fertilizers alone or in combination brought about significant influence on DMA plant-1 at harvest over control. The maximum DMA plant-1 at harvest was estimated when seeds were inoculated with Rhizobium + PSB.

Branches plant-1 at harvest Primary branches

Sulphur: It is explicit from data (Table 4) that increasing levels of sulphur application significantly influenced number of primary branches plant-1 at harvest. The highest number of primary branches plant-1 at harvest were estimated with the application of 45 kg sulphur ha-1.

Bio-fertilizers: Inoculation of fenugreek seed with bio-fertilizers alone or in combination significantly increased number of primary branches plant-1 at harvest over control. Amongst bio-fertilizers, inoculation with Rhizobium + PSB recorded highest number of primary branches plant-1 at harvest significantly.

Secondary branches

Sulphur: It is apparent from data (Table 4) that increasing levels of sulphur significantly increased number of secondary branches plant-1 at harvest. The highest number of secondary branches plant-1 were recorded with the application of 45 kg sulphur ha-1.

Bio-fertilizers: It is explicit from data that inoculation of fenugreek seed with bio-fertilizers alone or in combination brought about significant variation on number of secondary branches plant-1 at harvest over control. Amongst bio-fertilizers, inoculation of seed with Rhizobium + PSB produced highest number of secondary branches plant-1 at harvest significantly.

Growth efficiency

Crop growth rate

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Sulphur: Data presented in Table 5 indicate that application of sulphur at varying levels brought about significant effect on CGR estimated between 90 DAS- at harvest. The application of 45 kg sulphur ha-1 registered highest CGR between 90 DAS- at harvest.

Bio-fertilizers: Inoculation of fenugreek seed with bio-fertilizer alone or in combination significantly improved CGR between 90 DAS -at harvest over control. Amongst bio-fertilizers, inoculation of seed with Rhizobium + PSB recorded highest CGR between 90 DAS- at harvest which remained at par with co-inoculation of PSB however both these treatments significantly increased CGR between 90 DAS –at harvest over control.

Relative growth rate

Sulphur: An examination of data (Table 5) reveals that application of sulphur at varying levels failed to bring about significant variation on RGR estimated between 90 DAS–at harvest of fenugreek.

Bio-fertilizers: Data reflects that inoculation of fenugreek seed with bio-fertilizers alone or in combination failed to exert perceptible variation on RGR estimated between 90 DAS-at harvest.

Discussion

It is evident from the results that application of sulphur up to 45 kg ha-1 significantly improved morphological component of growth i.e. plant height, primary and secondary branches plant-1. These increases ultimately reflected in overall improvement of crop growth estimated in terms of biomass accumulation plant-1 at various growth stages. In general, the overall improvement in growth of fenugreek with the addition of sulphur could be ascribed to its pivotal role in several physiological and biochemical processes which are of vital importance for development of the plants. It is well established that sulphur in the form of sulphate (SO4-2 – S) is involved in synthesis of sulphur containing amino acids (methionine and cystine), various enzymatic processes and variety of oxidation - reduction reactions in the plants (Nelson and Tisdale, 2013). Besides these, the recent advancement in hormonal regulation of plant growth and development has clearly demonstrated that alike environmental factors, plant nutrients are not only substrate and catalyst of plant growth but can be considered as stimulii for certain steps for the development to which plant responds through oriented growth (Michael and Beringer, 1980). It has been reported that micro-acidification of calcareous soils under the influence of sulphur fertilization results in greater availability of phosphorus and micronutrients especially Fe, Zn and Mn (Nelson and Tisdale, 2013). Further they opined that sulphur fertilizers are transformed to sulphuric acid by soil microorganisms which in turn reduces soil pH and improves soil structure alongwith availability of macro and micro nutrients. On the other hand, as a consequence of lower hydration of SO4-2 sulphur ions, the plant cell colloids get swollen which reduce turgor pressure, thereby, increases transportation and led to higher extraction of nutrients from soil environment towards plant system (Rawal, 2020). Thus, the concomitant influence of sulphur fertilization on availability of nutrients from soil and their extraction by the plants seems to have provided congenial nutritional environment in the plants. This is also evince from the estimates of nutrient concentration and their uptake which showed significant increase in concentration of nutrients (N and S) and their accumulation (N, P, K and S) at harvest. These improvements under sulphur fertilization might have increased metabolic processes in plants resulting in greater meristamatic activities and apical growth, thereby, improvement in plant height. Thus greater availability of nutrients during vegetative phase might have enhanced meristamatic activities thereby increased division, enlargement and elongation of cells thus improving production of branches plant-1. Likewise significant improvement in branches production could be attributed to enhanced growth of lateral buds due to higher availability of nutrients and assimilates. Besides this, improvement in nodulation under the influence of sulphur subscribe to the view that it increased the activity of enzyme ferredoxin which might have resulted in higher biological nitrogen fixation and photosynthesis. Further, significant improvement in nodulation, plant height and number of branches plant-1 might have resulted in better interception, absorption and utilization of radiant energy leading to higher photosynthetic rate and finally more accumulation of dry matter plant-1. The overall improvement in growth of fenugreek with the application of sulphur under the present study in cognizance with the results obtained by (Godara et al., 2013; Choudhary et al., 2014; Boori et al., 2017; Verma et al., 2019).

Table 1 Effect of sulphur and bio-fertilizers on plant population of fenugreek.

Treatments	**Plant population (m^{-1} row length)**	
	15 DAS	**At harvest**
Sulphur (kg ha^{-1})		
Control	12.17	10.58
15	12.35	10.73
30	12.59	10.85
45	12.73	10.94
S.Em.±	0.17	0.16
C.D.(P=0.05)	NS	NS
Bio-fertilizers		
Control	12.08	10.49
Rhizobium	12.43	10.81
PSB	12.63	10.87
Rhizobium + PSB	12.69	10.92
S.Em.±	0.17	0.16
C.D.(P=0.05)	NS	NS

Table 2 Effect of sulphur and bio-fertilizers on plant height at successive growth stages of fenugreek.

Treatments		**Dry matter accumulation (g $plant^{-1}$)**	

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	30 DAS	60 DAS	90 DAS	At harvest
Sulphur (kg ha^{-1})				
Control	0.422	4.26	11.92	17.77
15	0.448	4.56	13.23	19.83
30	0.474	4.90	14.27	21.83
45	0.489	5.22	15.47	23.58
S.Em.±	0.003	0.05	0.25	0.23
C.D.(P=0.05)	0.010	0.21	0.71	0.66
Bio-fertilizers				
Control	0.437	4.38	11.90	17.87
Rhizobium	0.455	4.69	13.51	20.35
PSB	0.467	4.92	14.60	22.12
Rhizobium + PSB	0.470	4.98	14.87	22.67
S.Em.±	0.003	0.07	0.25	0.23
C.D.(P=0.05)	0.010	0.21	0.71	0.66

Table 4 Effect of sulphur and bio-fertilizers on growth characters of fenugreek.

Treatments	**Branches plant^{-1} at harvest**	
	Primary	**Secondary**
Sulphur (kg ha^{-1})		
Control	6.59	8.15
15	7.40	8.84
30	7.97	9.41
45	8.52	9.97
S. Em. ±	**0.14**	**0.18**
C.D.(P=0.05)	**0.41**	**0.52**
Bio-fertilizers		
Control	6.72	8.24
Rhizobium	7.42	8.92

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PSB	8.01	9.48
Rhizobium + PSB	8.09	9.61
S.Em.±	**0.14**	**0.18**
C.D.(P=0.05)	**0.41**	**0.52**

Table 5 Effect of sulphur and bio-fertilizers on growth efficiency at successive crop duration of fenugreek

Treatments		**CGR (g m^{-2} day^{-1})**		**RGR (g g^{-1} day^{-1})**		
	Between 30 - 60DAS	**Between 60 – 90DAS**	**Between 90 DAS at harvest**	**Between 30 - 60DAS**	**Between 60 – 90DAS**	**Between 90 DAS at harvest**
Sulphur kg ha^{-1}						
Control	4.24	8.57	6.58	0.619	0.576	0.553
15	4.54	9.69	7.43	0.619	0.576	0.554
30	4.89	10.77	7.47	0.620	0.576	0.554
45	5.24	11.44	9.10	0.621	0.577	0.554
S.Em.±	**0.08**	**0.29**	**0.16**	**0.0006**	**0.0009**	**0.0007**
C.D.(P=0.05)	**0.24**	**0.84**	**0.46**	**NS**	**NS**	**NS**
Bio-fertilizers						
Control	4.32	8.53	6.22	0.619	0.575	0.553
Rhizobium	4.68	9.94	7.69	0.620	0.576	0.554
PSB	4.93	10.89	8.44	0.620	0.577	0.554
Rhizobium + PSB	4.99	11.12	8.23	0.621	0.577	0.554
S.Em.±	**0.08**	**0.29**	**0.16**	**0.0006**	**0.0009**	**0.0007**
C.D.(P=0.05)	**0.24**	**0.84**	**0.46**	**NS**	**NS**	**NS**

V Conclusion:

The field experiment conducted at Career Point University, Kota, demonstrated the significant impact of sulphur application and bio-fertilizer inoculation on the growth, yield, and nutrient uptake of fenugreek. The application of 45 kg sulphur ha-1 resulted in the highest growth parameters, including plant height, dry matter accumulation, and the number of primary and secondary branches. This sulphur level also enhanced yield attributes, such as the number of pods per plant, pod length, seeds per pod, and test weight, leading to increased seed, haulm, and biological yields compared to lower sulphur levels. Inoculation with the combination of Rhizobium and PSB (Phosphate Solubilizing Bacteria) significantly improved plant growth metrics, yield attributes, and nutrient uptake over the control. The combined inoculation also resulted in the highest net returns and benefit-cost ratio, highlighting the economic viability of this practice for fenugreek cultivation. The study underscores the importance of balanced sulphur fertilization and the synergistic effect of bio-fertilizers in enhancing fenugreek growth and productivity. These findings can inform integrated nutrient management strategies aimed at improving crop performance and sustainability in agricultural practices.

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Effect of fertility levels and bio-fertilizers on growth and yield of wheat (*Triticum aestivum* L.)

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Abstract

In Rabi 2023-24, a field trial titled "Influence of Fertility Levels and Biofertilizers on the Growth and Yield of Wheat (*Triticum aestivum* L.)" took place at the Instructional Farm of Agriculture, Career Point University, Kota. This experiment tested 16 treatment combinations, varying in fertility levels (ranging from Control to 120% RDF) and liquid biofertilizers (including Azotobacter, PSB, and Azotobacter + PSB), using a factorial randomized block design replicated three times. The wheat variety Lok-1 was employed as the test crop, with the recommended dose of fertilizer (RDF) set at 100:60:40 kg ha-1 of N: P_2O_5: K_2O. Notably, the combination of 100% RDF and Azotobacter + PSB significantly enhanced plant height, total tillers per meter of row length, effective tillers per meter of row length, test weight, grain, straw, and biological yield.

Key Words: Fertilizer, Bio-fertilizer, Wheat

Introduction

Wheat, a key cereal crop in India, holds a prominent position in the country's agricultural landscape. It serves as a vital source of energy during the winter season and constitutes a significant portion, accounting for 35%, of the nation's grain production. While India has transitioned from a state of wheat scarcity during its independence to one of surplus today, there remains a pressing need for continued efforts to ensure sustained growth in production. This is essential to meet the nutritional demands of the ever-expanding population, maintain sufficient buffer stocks for food security, and cater to the requirements

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of wheat-based food processing industries. Wheat plays a crucial role in the dietary intake, contributing approximately 55% of the carbohydrates and 20% of the calories consumed. Globally, it holds the largest cultivated area, spanning around 215 million hectares, and yields a staggering 765.4 million tonnes of produce.

The Integrated Nutrient Management (INM) approach aims to optimize crop yields while preserving the agro-ecosystem through efficient and economical utilization of various plant nutrient sources. Organic sources supplement chemical fertilizers by providing essential trace elements that enhance soil fertility. Combining organic materials with inorganic fertilizers ensures proper nutrition and soil fertility maintenance in wheat cultivation. Comparative studies between different combinations of organic and chemical inputs are necessary to determine the most effective approach. Additionally, integrating farmyard manure (FYM) with inorganic nitrogen sources has been shown to boost wheat productivity, increase monetary returns, and enhance soil fertility.

Material and Method

The experiment took place at the Instructional Farm of Agriculture, Career Point University, Kota, located in the hadouti region of Rajasthan at coordinates 24°85' N latitude and 73°42' E longitude, with an altitude of 582.17 meters above sea level. This area falls within agro-climatic zone V of Rajasthan. During the wheat cropping period in the Rabi season of 2019, the weekly temperature ranged from 20.8 °C to 37.3 °C, while the maximum and minimum relative humidity ranged from 86.7% to 16.7%, respectively. The total rainfall recorded during the crop season was 42.6 mm, with a maximum evaporation of 9.9 mm. Soil analysis revealed that the experimental field's soil is sandy loam, with a neutral alkaline pH, medium levels of available nitrogen and phosphorus, and high levels of available potassium.

The experiment comprised 16 treatment combinations, including four fertility levels (Control, 60%, 90%, and 120% RDF) and four liquid biofertilizer levels (Control, Azotobacter, PSB, and Azotobacter + PSB). It was arranged in a factorial randomized block design with three replications. For the wheat crop, the required nitrogen dose was calculated by subtracting the nitrogen supplied through DAP from the total, with the remaining nitrogen supplied through urea. P2O5 from DAP and K2O from MOP were applied at sowing, with half the nitrogen, full phosphorus, and potassium doses applied before sowing and the remaining nitrogen split into two equal doses during the first and third irrigation. Seed treatment with liquid biofertilizers involved placing 1 kg of seeds in a plastic bag and adding the required amount of biofertilizers (5 to 10 ml kg-1 seed for each biofertilizer). The bag

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was closed and squeezed to ensure even coating of the seeds, then opened and left to dry in the shade for 20 to 30 minutes. Some plots received treatment with Azotobacter and PSB individually, while others received treatment with both.

Result and discussion

The growth parameters of wheat, particularly plant height at 30 days after sowing (DAS), 60 DAS, and at harvest, were significantly influenced by the inoculation of seeds with various liquid biofertilizers, including Azotobacter, PSB, and a combination of Azotobacter + PSB, as compared to the control group. The combined inoculation of Azotobacter + PSB resulted in the highest plant heights across all observed stages compared to both the control and single inoculation treatments. The enhanced growth attributed to biofertilizers may stem from their role in increasing the availability of essential plant nutrients. Inoculating seeds with nitrogen-fixing bacteria, such as Azotobacter, led to an increase in their concentration in the rhizosphere, where they fix atmospheric and organic nitrogen, subsequently converting it into nitrate form. This process, in turn, promotes root development and overall plant growth, potentially facilitated by the secretion of vitamins, auxins, and amino acids by Azotobacter. Additionally, PSB was found to produce organic acids that enhance the mineralization of insoluble organic phosphorus into soluble phosphorus, thus increasing its availability in the soil. Previous studies have also highlighted the beneficial effects of Azotobacter and PSB on wheat, attributed to their nitrogen-fixing ability, phosphate solubilization, and secretion of plant growth hormones. The combined inoculation of Azotobacter and PSB further promoted lateral root proliferation and the development of root hairs, facilitating increased nutrient and water absorption due to the expanded surface area. Consequently, the observed increase in plant height can be attributed to enhanced photosynthesis and assimilate production resulting from the stimulated growth. These findings align with previous research by Bai*et al.* (2003) and Wu *et al.* (2005).

Yield attributes and Yield

The investigation results presented in Table 2 revealed significant impacts on yield attributes and overall yield, except for the harvest index, when seeds were inoculated with various liquid biofertilizers such as Azotobacter, PSB, and a combination of Azotobacter + PSB, in comparison to the control group. While there was no significant effect observed on the harvest index due to biofertilizer inoculation, prior research by Jnawali*et al.* (2015) indicated that Azotobacter seed inoculation enhances yield by supplying more nitrogen to the crop. The chelating effect of PSB reduces phosphorus fixation, thereby increasing phosphorus uptake and promoting better growth attributes such as total tillers per meter of row length, effective tillers per meter of row length, and test weight. This enhanced uptake of micronutrients and secondary nutrients, facilitated by increased phosphorus availability, likely leads to greater root expansion, enhanced photosynthesis, and improved partitioning of photosynthates among vegetative and reproductive plant parts, ultimately resulting in improved yield attributes and seed yield. Additionally, the combined inoculation of N+P-fixer bacteria may have a synergistic effect on the production of growth-promoting hormones such as auxin, gibberellins, and cytokinins, further enhancing yield attributes and overall yield, as suggested by Kaushik*et al.* (2012). The combination of Azotobacter + PSB notably increased stover yield, possibly due to increased biomass production. Previous studies by Kumawat and Khangarot (2002), Brahmaparkash*et al.* (2004), Ram and Mir (2006), Singh *et al.* (2008), and Bhavya*et al.* (2017) also support the cumulative positive effects of biofertilizer inoculation on growth and yield attributes.

Table 1: Effect of different treatments on plant height of wheat.

Treatments	**Plantheight (cm)**				**Number of grains spike^{-1}**	**Tillers m^{2}at Harvest**
	DAS			**At Harvest**		
	30	**60**	**90**			
Control	24.6	40.3	84.8	85.8	38.00	226
T2: 60 kg N + 20 kg P_2O_5 + 20 kg K_2O ha^{-1}	28.1	48.8	97.2	97.8	45.00	322
T3: 90 kg N + 30 kg P_2O_5 + 30 kg K_2O ha^{-1}	26.7	44.8	91.5	91.9	48.00	351
T4: 120 kg N + 40 kg P_2O_5 + 40 kg K_2O ha^{-1}	26.4	44.6	91.0	91.5	49.67	387
T5: Azatobacter	27.2	44.9	94.2	94.9	48.67	356
T6: PSB	27.3	45.3	93.0	93.2	50.00	388
T7: Azatobacter + PSB	27.5	44.9	94.2	96.8	50.00	405
T8: Azatobacter+60 kg N + 20 kg P_2O_5	26.1	43.2	89.4	89.9	50.67	425

+ 20 kg K_2O ha^{-1}						
T9: PSB+60 kg N + 20 kg P_2O_5 + 20 kg K_2O ha^{-1}	26.1	43.0	87.9	89.0	50.54	424
T10: Azatobacter + PSB+60 kg N + 20 kg P_2O_5 + 20 kg K_2O ha^{-1}	26.1	43.2	89.4	89.9	45.00	327
T11: Azatobacter+90 kg N + 30 kg P_2O_5 + 30 kg K_2O ha^{-1}	26.4	43.0	87.9	89.0	46.67	333
T12: PSB+90 kg N + 30 kg P_2O_5 + 30 kg K_2O ha^{-1}	26.7	43.2	89.9	90.8	50.00	388
T13: Azatobacter + PSB+90 kg N + 30 kg P_2O_5 + 30 kg K_2O ha^{-1}	35.5	32.5	71.7	107.6	50.00	405
T14: Azatobacter+120 kg N + 40 kg P_2O_5 + 40 kg K_2O ha^{-1}	37.6	32.8	72.9	102.2	50.67	425
T15: PSB+120 kg N + 40 kg P_2O_5 + 40 kg K_2O ha^{-1}	38.13	33.6	73.1	103.4	47.00	344
T16: Azatobacter + PSB+120 kg N + 40 kg P_2O_5 + 40 kg K_2O ha^{-1}	38.1	34.2	74.2	104.0	47.00	346
S.Em.±	**0.49**	**0.52**	**0.42**	**0.30**	**0.07**	**0.08**
C.D.=(P=0.05)	**NS**	**1.50**	**1.20**	**0.85**	**6.53**	**7.35**

Table 2. Effect of different treatments on yield of wheat.

Treatments	Biological yield (kg/ha^{-1})	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)
T1: Control	7754	2499	5254	32.2

T2: 60 kg N + 20 kg P_2O_5 + 20 kg K_2O ha^{-1}	10370	4412	5957	42.6
T3: 90 kg N + 30 kg P_2O_5 + 30 kg K_2O ha^{-1}	9503	3728	5775	39.2
T4: 120 kg N + 40 kg P_2O_5 + 40 kg K_2O ha^{-1}	9595	3742	5853	39.0
T5: Azatobacter	9682	3806	5876	39.3
T6: PSB	9660	3771	5890	39.0
T7: Azatobacter + PSB	10279	4373	5906	42.5
T8: Azatobacter+60 kg N + 20 kg P_2O_5 + 20 kg K_2O ha^{-1}	9306	3523	5783	37.9
T9: PSB+60 kg N + 20 kg P_2O_5 + 20 kg K_2O ha^{-1}	9301	3490	5811	37.5
T10: Azatobacter + PSB+60 kg N + 20 kg P_2O_5 + 20 kg K_2O ha^{-1}	9416	3598	5818	38.2
T11: Azatobacter+90 kg N + 30 kg P_2O_5 + 30 kg K_2O ha^{-1}	10541	3460	4078	43.62
T12: PSB+90 kg N + 30 kg P_2O_5 + 30 kg K_2O ha^{-1}	10618	4816	4992	48.00
T13: Azatobacter + PSB+90 kg N + 30 kg P_2O_5 + 30 kg K_2O ha^{-1}	10661	5034	5391	46.01
T14: Azatobacter+120 kg N + 40 kg P_2O_5 + 40 kg K_2O ha^{-1}	10800	5146	5500	45.95
T15: PSB+120 kg N + 40 kg P_2O_5 + 40 kg K_2O ha^{-1}	9345	3505	5840	37.5
T16: Azatobacter + PSB+120 kg N + 40 kg P_2O_5 + 40 kg K_2O ha^{-1}	9474	3532	5943	37.3
S.Em.±	**34.4**	**26.6**	**38.5**	**0.41**
C.D.=(P=0.05)	**98.7**	**76.5**	**110.6**	**1.16**

Conclusion:

Based on the results, it can be concluded that the use of a combination of 100% Recommended Dose of Fertilizers (RDF), Azotobacter, and Phosphate - Solubilizing Bacteria (PSB) significantly improves various aspects of wheat cultivation. This includes enhanced plant growth, improved yield attributes, and increased overall yield. Therefore, I recommend the application of this treatment regimen comprising 100% RDF, Azotobacter, and PSB to maximize wheat productivity. By adopting this approach, farmers can achieve optimal returns under the current agro-climatic conditions.

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Effect of different irrigation and mulch levels on growth and yield of barley (*Hordeum vulgare* L.)

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Abstract

A field experiment was conducted to assess the improving barley productivity under different irrigation and mulching practices at School of Agricultural Sciences, CPU, Kota (Rajasthan) during *Rabi*, 2023-24. The experiment was laid out in a split plot design with three replications. The experiment consisting of 12 treatments combinations with irrigation levels in main plot *viz.*, one irrigation at active tillering stage (30-35 DAS), two irrigation at active tillering and milking stage and three at active tillering, boot stage (60-65 DAS) and milking stage (80-85 DAS) and four mulching levels in sub plot No mulch, 2 t/ha, 4 t/ha and 6 t/ha. Growth and yield parameters were significantly increased with application of three irrigation at active tillering stage, boot stage (60-65 DAS) and milking stage (80-85 DAS) over one irrigation at active tillering stage (30-35 DAS). The maximum plant height (114.6 cm and 112.1 cm), number of tillers/m^2 (365.32 and 351.34), dry matter accumulation (320.3 and 307.14 g/meter row length) and effective tillers/m^2 (84.2 and 78.9), no. of grains/ear (40.2 and 37.4), test weight (41.37g and 40.27g) highest seed yield (4320 and 4180 kg/ha), straw yield (6530 and 6355 kg/ha) and biological yield (10850 and 10535 kg/ha) fetched net return (₹49972 and ₹ 47910) and benefit cost ratio (1.46 and 1.43) of barley were recorded under application of three at active tillering, boot stage (60-65 DAS) and milking stage (80-85 DAS) and application of 4 t/ha mulch followed by application of two irrigation at active tillering and milking stage and 6 t/ha mulch application over one irrigation at active tillering stage (30-35 DAS) and no mulch.

Key words: Barley, Irrigation, Mulch, Growth, Yield and Economics

Introduction:

Barley (*Hordium vulgare* L.) is one of the first domesticated plant species in the world, belong to family Poaceae. The hulled and awned type barley is believed to be originated from Abyssinia, considering this place as principle centre of origin, whereas, south eastern Asia is the centre of origin for hull-less, six rowed varieties with short or no awn. With a share of 7 per cent of the global cereal production barley is considered fourth largest cereal crop in the world (Pal *et al*., 2012). It has been traditionally considered as poor man's crop because it is one of the most input efficient crops and can be cultivated in adverse climatic conditions like drought, salinity, alkalinity and marginal lands etc. Among the cereals, it ranks fourth with respect to area and production after wheat, rice and maize. Barley grain is also valuable for smothering and cooling effect on the body for easy digestion. Besides these conventional uses, it is an important industrial crop as it is used as raw material for beer, whisky and brewing industries. In India, barley is mainly grown in the northern plains and concentrated in the states of Utter Pradesh, Haryana and Rajasthan. In India, barley was cultivated on 453 thousand ha area with 1371 thousand tons of production at an average productivity of 33.04 q/ha. In India, Rajasthan is the largest state having more than 52% in production and 46 % area followed by Uttar Pradesh. In Rajasthan, barley was cultivated on 408 thousand ha area with 1399.6 thousand tons of production at an average productivity of 29.16 q/ha (IIWBR, 2022-23). In the recent years it has been observed that because of severe drought in drier part of northern plains, there is an acute shortage of green fodder in the months of November to January. Since the common forage crops, Berseem, Oats and Sugarcane require frequent irrigation and cannot be grown under water scarcity condition. Barley can be an option, both for grain as well as fodder. However its industrial demand as raw material has also increased. Malt extracted from barley grain is used as a source of fermentable material for beer and certain distilled beverages like whisky, brandy etc. As a food barley is mixed with gram or wheat and then ground to flour for preparing better quality „*chapatis*‟. Roasted grains of barley after grinding can be used as „*Sattu*‟. Apart from this barley is used as a component of various health foods. Barley grain contains approximately 12.5 per cent moisture, 11.5 per cent albuminoids, 74 per cent carbohydrates, 1.3 per cent fats, 3.9 per cent crude fibre and 1.5 per cent ash (Singh *et al.*, 2018). The barley water helps in better urine filtration, increased kidney efficiency due to its high enzymatic constitution. Regular consumption of barley lowers the plasma blood cholesterol content because of its high beta glucan content and thus helps in prevention of high blood pressure and related heart problems (Truswell, 2002). The other important property of barley is its potential use in diabetic problems. The soluble fiber from barley improves glucose utilization and insulin sensitivity in acute and chronic studies of normal-weight and overweight adults, and individuals with the metabolic syndrome (Rimm *et al.* 2002).

Water is the most crucial input in agriculture as major share of water resources is used in agriculture and food requirements are increasing while water resources are shrinking. The global water crisis has drawn worldwide attention to the urgency of achieving a more efficient use of water resources particularly, to increase crop production and national food security. Since agriculture uses infiltrated water that forms soil moisture in the root-zone of the crops and subsequently loss through evaporation and transpiration (ET), water conservation is the most important for sustaining food and livelihood security of people practicing agriculture. In this context mulching is one of the important agronomic practices in conserving the soil moisture and modifying the soil physical environment.

Mulching is a common practice to cover soil surface and it not only conserves moisture but also moderates temperature besides effectively controlling the weeds. It creates congenial conditions for the growth and ameliorates various environmental stresses (Macilwain, 2004). It exerts decisive effects on earliness, yield and quality of the crop. Straw mulching has a major effect on soil water and thermal regimes. The mulch probably acts as an insulator, resulting in smaller fluctuations in soil temperature in mulched treatments as compared to without mulch. Mulches can be more effective under extreme weather conditions as compared to normal conditions. Mulching is a common practice recommended for tropical small farming holder, due to its ability to conserve soil and moisture and also suppress weeds (Sah 2015). Mulching increased soil moisture content, improved the soil structure and decreased the weed growth, and thereby enhanced yield in crops (Govindappa 2014). The yield and water productivity gains were due to greater root proliferation which was the result of moderation of soil temperature and water conservation with straw mulching (Arora *et al.* 2011).

Material and Methods

A field experiment was conducted at Research farm, School of Agricultural Sciences, CPU, Kota (Rajasthan) during *Rabi* season 2023-24. The details of experimental techniques, materials used and methods adopted for treatment evaluation during the course of investigation are described in this chapter.The soil of the experimental field was sand (22.6%

silt, 37.1% and 39.9% clay) in texture clay loam (vertisols), was alkaline in reaction(pH 7.8), medium in organic carbon (0.56%), medium in available nitrogen (314 kg/ha), phosphorus (22.1 kg/ha) but higher in available potassium (298 kg/ha).

The experiment was laid out in a split plot design with three replications. The experiment consisting of 12 treatments combinations with irrigation levels in main plot *viz.*, one irrigation at active tillering stage (30-35 DAS), two irrigation at active tillering and milking stage and three at active tillering, boot stage (60-65 DAS) and milking stage (80-85 DAS) and four mulching levels in sub plot No mulch, 2 t/ha, 4 t/ha and 6 t/ha. Barley is sown at 20 cm as inter row spacing and 10 cm is followed as intra row spacing using 100 kg/ha seed rate. Seeding was done by seed drill in the second week of November and reaped during the last week of March. At the time of harvest, information on growth and yield attributes such as plant height, no. of tillers/meter row length, dry matter accumulation/meter row length, tiller/m^2, seeds/ear, test weight, seed yield, straw yield and biological yield, net return, B:C ratio of barley. The data collected on different parameters was statistically analyzed using the analysis of variance approach, and the significant differences were assessed at 5% level of significance.

Results and discussion

Growth and yield attributes

Effect of irrigation levels

The results showed that irrigation levels had significant influence on growth and yield attributes (table 1). Plant height at harvest (114.6 cm), no. of tillers/m^2 (365.32), Dry matter accumulation/meter row length (320.32 g), number of effective tillers/m^2 (84.2), number of grain/ear (40.2) and test weight (41.37 g) were recorded under the application of three irrigation at active tillering, boot stage (60-65 DAS) and milking stage (80-85 DAS) followed by two irrigation at active tillering and minimum recorded under one irrigation at active tillering stage (30-35 DAS), respectively. This might due to all growth attributing parameters of experimental crop of barley were influenced significantly due to irrigation levels as supported by Singh *et al.* (2022). Increased effective tillers under more irrigations *i.e.* up to three may be attributed to the fact that the loamy sand soil had limited water holding capacity and increased moisture content in the soil might have resulted in better nutrient use efficiency thereby leading to profuse plant growth. Similar results have been reported by Singh *et al.*

(2021). The reason is obvious that adequate supply of water might have kept all the nutrient ions in proper available form. Similar results have been reported by Jan *et al*. (2001).

Effect of mulching levels

The results showed (table 1) that mulching levels had significant influence on growth and yield attributes (table 1). Plant height at harvest (112.1 cm), no. of tillers/m^2 (351.34), Dry matter accumulation/meter row length (307.14 g), number of effective tillers/m^2 (78.9), number of grain/ear (37.4) and test weight (40.27 g) were recorded significantly maximum under the application of 4 t/ha mulch which was statistically at par with 6 t/ha mulch over no mulch and 2 t/ha mulch, respectively. This might due to all growth attributing parameters of experimental crop of barley were influenced significantly due to mulching has double actions; controlling weeds and providing soil cover, both of which reduce water loss through decreased transpiration and evaporation and increased availability of soil moisture contents improves plant height (Khurshid *et al.*, 2006 and Ahmed *et al.*, 2007). dry matter accumulation under mulching in combination with irrigation can be explained in light of role of soil water in increasing nutrient availability and its transport for utilization in cell growth and its differentiation in production of tillers, leaves and therefore, dry matter accumulation (reported by Kar *et al.* 2007).

Yield and economics

Effect of irrigation levels

Data presented in Table 2 concluded that among the irrigation levels significantly increased seed, straw and biological yield was obtained significantly higher seed, straw and biological yield from application of three irrigation (4320, 6530 and 10850 kg/ha) at active tillering, boot stage (60-65 DAS) and milking stage (80-85 DAS) which was statistically at par with two irrigation at active tillering at active tillering and milking stage and minimum over one irrigation (3620, 5525 and 9145 kg/ha) at active tillering stage (30-35 DAS). Application of three irrigation increased seed, straw and biological yield 19.33, 18.19 and 18.64 per cent as compared to one irrigation at active tillering stage (30-35 DAS). However, different irrigation levels did not significant influence the harvest index. This might due to source-sink relationship (sink components - test weight and source components – dry matter accumulation). An optimally green crop, accumulate more dry matter and partitions large proportion of it to seed. Dry matter accumulation and its partition to seed yield is a function of crop growth. As seed yield is primarily a function of cumulative effect of yield determining characters, significantly higher values of these characters might be ascribed as the most probable reason of getting higher seed yield of barley. The biological yield is a function of grain and straw yields, thus significant increase in biological yield with the three irrigation increased seed and straw yield. The effect of irrigation levels on grain yield of barley was significant. Similar results have been reported by Jan *et al*. (2001). The reason is obvious that adequate supply of water might have kept all the nutrient ions in proper available form. Similar results have been reported by Singh *et al.* (2021). The economics of treatments was affected with numbers of irrigations levels and presented in Table 2. The maximum net return (₹ 49972/ha) were calculated under the treatment of three irrigation) at active tillering, boot stage (60-65 DAS) and milking stage (80-85 DAS). The data on B: C ratio revealed that irrigation levels at three irrigation at active tillering, boot stage (60-65 DAS) and milking stage (80-85 DAS) has been noticed more remunerative in terms of benefits of Rs 1.46 by investing ₹ 1.00 compared to one irrigation at active tillering stage (30-35 DAS) similarly reported by Pandey *et al.* (2017) and Singh *et al.* (2022).

Effect of mulching levels

The yield of barley presented in Table 2 concluded that among the mulching levels significantly increased seed, straw and biological yield, it was obtained significantly higher seed, straw and biological yield from application of 4 t/ha mulch (4180, 6355 and 10535 kg/ha) which was statistically at par with application of 6 t/ha mulch and over no mulch application (3320, 5126 and 8446 kg/ha). Application of 4 t/ha mulch increased seed, straw and biological yield 25.90, 23.97 and 24.73 per cent as compared to no mulch application. However, various mulch levels did not significant influence the harvest index. Mulching might have reduced the fluctuation of soil temperature and increased the soil moisture and resulted in more rapid crop growth and produced more number of tillers. The result was partially similar to the findings of Mishra (1996). These results are in line with those of Khurshid *et al*. (2006), who reported that mulch increases the soil moisture and nutrients availability to plant roots, in turn, leading to higher grain yield Hingonia *et al.* (2016). Economics of different levels of mulch and presented in Table 2. The maximum net return (₹ 47910/ha) were calculated under the treatment of three irrigation). The data on B:C ratio revealed that mulch levels at M_3 (4 t/ha) has been noticed more remunerative in terms of benefits of Rs 1.43 by investing ₹ 1.00 compared to no mulch similarly results finding by Hingonia *et al.* (2016) and Singh *et al.* (2021).

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Table 1 Effect of irrigation and mulching levels on growth and yield attributes of barley

Treatments	Plant height (cm)	No. of tiller/m^2	Plant dry weight (g/m row length)	Effective tillers/m^2	No. of seeds/ear	Test weight (g)
Irrigation levels						
One irrigation	105.2	268.17	285.17	63.3	36.8	39.12
Two irrigation	109.8	357.41	303.41	72.8	38.5	40.81
Three irrigation	114.6	365.32	320.32	84.2	40.2	41.37
SEm$\pm$	1.2	4.21	4.21	2.17	0.53	0.21
CD (P=0.05)	3.6	12.63	12.63	6.51	1.6	0.62
Mulching levels						
No mulch	102.4	259.46	282.43	56.2	34.3	38.12
2 t/ha	106.2	336.21	293.26	72.6	35.9	39.43
4 t/ha	112.1	351.34	307.14	78.9	37.4	40.27
6 t/ha	113.8	359.17	311.45	82.8	38.6	40.72
SEm$\pm$	1.3	3.95	3.80	2.13	0.47	0.19
CD (P=0.05)	3.9	10.85	11.40	6.39	1.4	0.56

Table 2 Effect of irrigation and mulching levels on yield and economics of barley

Treatments	Seed yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	Net return (₹/ha)	B:C ratio
Irrigation levels					
One irrigation	3620	5525	9145	40745	1.37
Two irrigation	4007	6095	10102	45999	1.43
Three irrigation	4320	6530	10850	49972	1.46
SEm$\pm$	101.9	143.5	245.4		
CD (P=0.05)	305.7	430.5	736.2		

Mulching levels					
No mulch	3320	5126	8446	36802	1.32
2 t/ha	3785	5770	9555	42758	1.38
4 t/ha	4180	6355	10535	47910	1.43
6 t/ha	4250	6442	10692	48925	1.44
SEm±	99.4	138.9	238.3		
CD (P=0.05)	298.2	416.7	714.9		

Conclusion

On the basis of one year field experimentation, it seems quite logical to indicate that higher production, net return and B: C ratio was observed under the application of three irrigation at active tillering, boot stage (60-65 DAS) and milking stage (80-85 DAS) along with 4 t/ha mulch has been found most effective and profitable in grain, straw and biological yield of barley.

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Performance of wheat varieties (*Triticum aestivum* L.) under different fertility levels on growth and yield

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Abstract
A field experiment on "Performance of wheat varieties (*Triticum aestivum* L.) Under different fertility levels" was conducted at Career Point University during Rabi 2023-24 to investigate the effect of different levels of farmyard manure on yield and quality of wheat varieties. The soil of experimental field was loamy sand having normal pH and medium organic carbon. The available nitrogen and potassium were in medium range and available phosphorus status was high. The experiment was laid out in split plot design with five nutrition treatments fertilizer to supply 60, 90 and 120 kg N ha^{-1}, recommended chemical fertilizers and unfertilized control) in main plots and three varieties (Raj 3077, Lok 1 and DBW302) in sub plots. A significant improvement in growth and yield attributing characters was recorded with the application of recommended chemical fertilizers over rest of the treatments. The highest level of fertilizer (M3), supposed to supply 1.5 times higher nitrogen over the recommended nitrogen, resulted in significantly lower grain yield (43.1 q ha^{-1}) than the recommended chemical fertilizers (55.6 q ha^{-1}) and the decrease was 22.5 per cent. However the highest level of fertilizer was significantly better than the other two levels of fertilizer and unfertilized control. The grain yield of varieties did not differ significantly among themselves with the varying levels of nutrition. Protein content and sedimentation value were significantly higher in Raj 3077.

Keywords: Chemical fertilizers, Grain yield, Quality, Variety, Wheat

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I Introduction

Wheat is a rabi season crop and is the main cereal crop of India. It is mainly grown in the north and northwestern states of India like Uttar Pradesh, Madhya Pradesh, Punjab, and Haryana. The wheat in India is majorly soft to medium hard, has medium protein, and is white bread wheat. The cultivation of wheat crop requires a moist and cool climate and can be grown in any soil type. India is divided into 6 major wheat growing zones, namely, Northern Hill Zone, Northwestern Plains Zone, Northeastern Plains Zone, Central Zone, Peninsular Zone, and Southern Hill Zone. In this blog, we will discuss the current scenario of wheat production and the benefits of wheat production and discuss the largest wheat producing states in India. Before that, let's discuss the importance of wheat in India and the factors responsible for wheat production in India. Rajasthan has made significant strides in wheat production in recent years. Its wheat production stands at 9484 thousand hectares and covers an area of 3118 thousand tonnes. Despite its arid and semi-arid climate, the state has successfully adopted water-efficient techniques, improved farming practices, and introduced drought-tolerant wheat varieties. Key wheat-growing districts in Rajasthan include Sikar, Jaipur, Jodhpur, and Nagaur. In the study region, the productivity of wheat is much lower as compared to average state productivity. The basic and prime reasons for lower productivity in the region identified are viz; cultivation of the crop under rainfed conditions, poor knowledge of drought tolerant improved varieties, and poor adoption of production practices. Further, low productivity in the region has also been ascribed to improper management of irrigation water to the crop, especially at critical stages of growth for the proper growth and development (Joshi *et al.*, 2007). Moreover, in the recent past it has also been noticed that owing to late harvesting of preceding kharif crops, more than 50% sowing of wheat gets delayed till December or early January. The delayed sowing leads to substantial loss in grain yield, due to unavailability of sufficient irrigation water at the later stages. Furthermore, poor agronomic practices such as seed rate, selection of suitable varieties, nutrient management, weed management and irrigation management etc. are also responsible for low productivity of wheat in India (Tiwari*et al.*, 2014). It is evident from the findings, that there is no scope for area expansion, hence additional production has to added to the national food basket by increasing the per hectare productivity (Nagarajan, 1997). Keeping these in view, FLDs of improved production technology on wheat were conducted to enhance the productivity, economic returns and convincing the farmers for adoption of improved production technologies.

Improvement in wheat production can be achieved by enhancing through the development of new cultivars having wider genetic base and manage from integrated use of resources, as the land area under wheat is not expected to expand further. Balanced fertilizer through organic and inorganic sources improves the soil health as well as boosts the productivity of wheat. Organic matter is the substrate for a large number of soil living beneficial organisms which are essential to keep the plant healthy. Enriched fertilizer improves the nutrient availability and increases wheat yield. Organic matter in soil increases the water holding capacity, cation exchange capacity as well as improves the soil structure for better performance of microorganisms. The soil which enriched in organic matter has been found to respond better to the application of nitrogenous fertilizers (Subbiah and Bajaj, 1968). About 40% of cattle dung is available for manuring, rest being wasted or used as fuel (White, 1957). Thus, a good amount of organic waste is lost which is an important input for agricultural production. In the event of widespread energy crisis and deterioration of soil fertility due to intensive agriculture and imbalance use of fertilizers, it is highly desirable for making massive efforts to adopt organic matter recycling as a source of bioenergy and to supplement the demand gap of N, P, K as well as to enrich the soil in respect to micronutrients. Thus, the combination of fertilizer with inorganic fertilizers may be highly effective for increasing the yield under late sown wheat as well as better quality of produce in addition to sustaining biological health and maintaining balanced C: N ratio of the soil. Thus present study was undertaken to assess the performance of wheat varieties under various fertility levels. Fertilizer is the single most important input in modern agriculture to raise the crop productivity. The combined use of NPK fertilizers plays an important role in wheat production. Application of NPK in balanced share at proper time has great impact on wheat yield. Plant species, even varieties within species vary in their behaviors to obtain and utilize NPK for grain production. Nutrients play an important role in boosting the crop production. Crop species of wheat requires higher amount of nitrogen, phosphorus and potassium fertilizers. For maximizing production per unit area, growing of high yielding varieties with higher doses of fertility level is necessary. The chemical fertilizers are under wide recommendation to fulfill the nutrient need of this crop (Kumari*et al.*, 2013).

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II Literature Review:

Material and Method : The present investigation entitled "**Performance of wheat varieties (*Triticumaestivum* L.) under different fertility levels**." was carried out during rabi season of 2023-24.The experiment was conducted at the Agriculture Research Farm, Career Point University, Kota situated in South-East part of Rajasthan at an altitude of 579.5 metre above mean sea level and at 24º35 N latitude and 73º42 E longitude. The region falls under agro-climatic zone V (humid South eastern Plain) of Rajasthan. The experiment was laid out in split plot design with nutrition sources in main plots and wheat varieties in sub plots.**Treatments**, **Varieties (3) :**V_1 : Raj 3077, V_2 : Lok 1and V_3 : DBW 303 **doses of Fertilizers application :**M_1 : Control, M_2 : 60kg N + 20 Kg P_2O_5 + 20 kg K_2O Kg/ha, M_3 : 90kg N + 30 Kg P_2O_5 + 30 kg K_2O Kg/ha and M_4 : 120kg N + 40 Kg P_2O_5 + 40 kg K_2O Kg/ha. Observations recorded was five plants per plot were selected randomly to measure the height from ground level to the base of top most fully opened leaf up to 60 DAS, up to the base of flag leaf at 90 DAS and up to base of the ear at 120 DAS and at harvest. The germination plants in one square meter area were from three randomly selected locations with quadrate in each plot after 15 DAS of crops. The average was taken and finally plant population was expressed.Above ground plant samples from 50 cm row length were taken periodically at 30, 60, 90, 120 DAS and at harvest. The samples were first sun dried. Thereafter, these were kept in an oven at a temperature of 65±10C to achieve constant weight. The dry weight thus obtained was recorded and expressed as quintal ha-1.The numbers of tillers were recorded from five places in each plot at 30, 60, 90 days after sowing and at harvest stage of crop growth by using quadrate. Then average value was worked out in per meter square. Effective tillers per metre row length from two spots in each plot were counted at harvest and were converted to per metre square area. Five ears were selected at random from each plot and their length excluding awns was measured and then average values were calculated. The average length was expressed in cm. Randomly selected five ears were taken from each plot and threshed manually. The number of grains were counted and averaged for number of grains ear-1.Length of ten selected spikes from each plot and length measured carefully by scale from the neck node to the tip of last grain and average value was worked out to find out the length of single spike.One thousand grains from produce of each plot were taken and their weight was recorded. The thousand grain weight was expressed in grams. The total produce was weighed in bundles after harvesting and threshed thereafter. The weight of grains was recorded. The straw weight was obtained after deducting the weight of grains from total bundle weight. Grain and straw yield were computed and expressed as quintals per hectare.

III Methodology

Plant height : Plant height is an important index of the plant development. It gives an idea to predict the growth rate and yield of the crop. The perusal of data on periodic plant height indicates a progressive increase in plant height with the advancement in age of crop. The periodic plant heights at 30, 60, 90, 120 days after sowing (DAS) and at harvest are presented in Table 1.The plant height at 30 DAS was not significantly affected by the nutrition treatments but the application of fertilizer and chemical fertilizers increased plant height significantly at 60, 90, 120 DAS and at harvest than the control (unfertilized). The non-significant differences at 30 DAS might be due to less demand of nutrients at initial stage that might have been available in all the treatments. However, Kaur (2010) reported that at 30 DAS the plant height had non-significant differences as at initial growth stage plants were unable to utilize the applied nutrients.The maximum plant height (34.6 cm) at 60 DAS was obtained with the higher level of fertilizer (M4) which was statistically at par with recommended chemical fertilizers (32.9 cm). M4 gave significantly higher plant height than the other levels of fertilizer (M3 and M2) and unfertilized control. The plant height (31.1cm) recorded with the M3 (equivalent to recommended nitrogen) was statistically at par with the chemical fertilizers (RDF) and lower level of fertilizer (M2). All the treatments resulted in significantlyhigher plant height than the unfertilized control (24.8 cm). At 90 DAS the maximum plant height was recorded with the application of chemical fertilizers (67.8 cm) but it was statistically at par with M4 (65.3 cm).The similar results at 90 DAS were observed by **Channabasana gowda *et al*** (2008) who compared 12.5t fertilizer ha^{-1} with RDF. The plant height with chemical fertilizers (RDF) at 120 DAS and at harvest (97.4 cm and 104.9 cm, respectively) was significantly higher than all the fertilizer levels and unfertilized control. The similar results were reported by **Kharub and Chander (2010)** and **Tanveer *et al* (2010).** The higher mineralization rate of nutrients from decomposing fertilizer might have supplied high amount of nutrients to the plant initially but it might have not sustained after 90 DAS due to slow release of nutrients from fertilizer. Whereas, inorganic fertilizer might have supplied readily available nitrogen throughout the growing period. Though M3 at 120 DAS and at harvest resulted in significantly lower plant height (86.6 cm and 94.3 cm, respectively) than M4 , but it was statistically at par with M2 (85.7 cm and 93.3 cm, respectively). The higher availability of nutrients with higher fertilizer level might have resulted in higher plant height. The results conform to the findings of **Jan and Noor (2007), Kharub and Chander (2008)** and **Jan *et al* (2011).** Unfertilized control resulted in significantly lower plant height than all the other treatments. This might be due to lesser availability of nutrients in the absence of any external input. The results corroborated the findings of **Sushila and Giri (2000) and Shiva kumar and Ahlawat (2008).**The data revealed that the plant height varied with the varieties. The variety LOK-1 attained significantly higher plant height (15.0 cm) than the other varieties at 30 DAS due toits higher initial growth rate. But at 60 and 90 DAS the plant height of LOK-1 was statistically at par with the variety RAJ 3077. DBW 303 showed significantly lower plant height at 30, 60 and 90 DAS than the other varieties but at 120 DAS and at harvest it resulted in significantly higher plant height than RAJ 3077 and LOK-1 (99.3 cm and 107.1 cm, respectively). LOK-1 recorded significantly lower plant height than the other varieties at 120 DAS and at harvest. Though the plant height is the resultant of the interactions between genetic character and environment, the duration of the crop also affects it significantly. The growing duration of variety LOK-1 was significantly shorter and DBW 303 was significantly longer than the other varieties. So at 120 DAS and at harvest DBW 303 resulted in significantly higher plant height than the other varieties. The plant heights of DBW 303, RAJ 3077 and LOK-1 have been reported as 110 cm, 86 cm and 80 cm (Anonymous 2011b) which support the findings.

Dry matter accumulation is the result of total accumulation of photosynthetic formed and total nutrient uptake by the plant up to the stipulated growth period. The dry matter recorded at 30, 60, 90, 120 DAS and at harvest differed significantly with nutrition and variety (Table 2).The dry matter accumulation by the varieties varied with the growing period and growth habit. At 30, 60 and 90 DAS, the dry matter accumulation was significantly higher by the variety LOK-1 (4.3, 17.4 and 60.5 q ha^{-1}, respectively) than the other varieties. It might be due to its fast initial growth. The trend for dry matter accumulation was reverse for DBW 303. It resulted in significantly lower dry matter accumulation (3.0 and 11.8 q ha^{-1} at 30 and60 DAS, respectively) than the other two varieties, but at 90 DAS the dry matter accumulation (46.1 q ha^{-1}) was statistically at par with RAJ 3077. At 120 DAS and at harvest, the dry matter accumulation was significantly higher for DBW 303 because of its more plant height and significantly longer duration of maturity than the other varieties. At 120 DAS, LOK-1 gave significantly higher dry matter accumulation (77.4 q ha^{-1}) than RAJ 3077 (71.9 q ha^{-1}), but at harvest they were statistically at par. Due to significantly shorter duration of

LOK-1 than the other two varieties, it resulted in less increase in dry matter accumulation from 120 DAS to harvest stage as compared to the other varieties.

The tillers m^{-2} is a genetic character of a variety, but it may vary with the influence of growing environment. At 60 DAS, the variety DBW 303 resulted in significantly higher tillers m-2 (545.3) and variety RAJ 3077 produced significantly lower than the other varieties. At 90 and 120 DAS, the variety DBW 303 gave significantly higher tillers m^{-2} (452.2 and 381.6, respectively), whereas RAJ 3077 resulted in lowest tillers m-2 (382.9 and 321.6, respectively) which were statistically at par with the LOK-1 (401.0 and 324.2, respectively).

The highest number of effective tillers m^{-2} (422.4) was recorded with the application of chemical fertilizers (RDF) and it was significantly higher than all the other treatments. This might be due to the proper supply of readily available nutrients in required amount with the chemical fertilizers. Though the results are supported by **Channabasana gowda *et al* (2008)** and **Dhar *et al* (2010)**, these were contradictory to the findings of **Singh *et al* (2008b)** who reported that 15 t fertilizer ha^{-1} was able to produce effective tillers m^{-2} statistically at par with the RDF in a two year study in cropping system mode in arid region of Rajasthan. The fertilizer level supplying nitrogen equivalent to the chemical fertilizers (M3), resulted in significantly lower effective tillers m^{-2} (272.0) than the higher level of fertilizer (311.1), but it was statistically at par with the lower level of fertilizer (249.7). The higher level of fertilizer gave significantly higher effective tillers m^{-2} than the lower fertilizer levels and unfertilized control. The results are supported by the findings of **Jan and Noor (2007).** Unfertilized control gave significantly lower effective tillers m^{-2} thanother treatments. **Nehra *et al* (2001)** and **Shivakumar and Ahlawat (2008)** also reported significant increase in effective tillers m^{-2} with fertilizer than unmanured control.

IV Result and Discussion

The perusal of data revealed that ear length was significantly more (9.94 cm) with the recommended dose of chemical fertilizers (RDF) than all the other treatments. The similar results were reported by **Singh *et al* (2007)** who compared the ear length of wheat with 100 kg N ha^{-1}, 150 kg N ha^{-1} through inorganic nutrition, fertilizer (5 tha^{-1}) and unfertilized control. Higher level of fertilizer (M4) gave significantly more ear length (9.46 cm) than the lower level of fertilizer (M2) and unfertilized control, but it was statistically at par with the medium level of fertilizer (M3). Medium level of fertilizer (M3) resulted in the ear length that was statistically at par with the lower level of fertilizer (M2) and unfertilized control. The results corroborated the findings by **Tanveer *et al* (2010)** where fertilizer application gave statistically at par ear length with unfertilized control.

Variety RAJ 3077 gave maximum number of grains ear^{-1} (45.4) which was statistically at par with LOK-1. The variety DBW 303 gave significantly lower number of grains ear^{-1} (31.3) than the other varieties. All the interactions were found to be non-significant.

Variety DBW 303 resulted in significantly higher 1000-grain weight (49.0 g) than the other two varieties. RAJ 3077 gave significantly lower 1000-grain weight (43.4 g) than LOK-1 and DBW 303. The results support the earlier findings in which DBW 303 has been reported as a bold seeded variety (**Anonymous 2011b**).

The increase in grain yield was due to the cumulative effect of subsequent increase in all the yield attributing characters. The recommended chemical fertilizers and increasing fertilizer levels increased the number of effective tillers m^{-2}, ear length and number of grains ear^{-1} (Table 4.3). The higher availability of nitrogen to the plants increased the grain yield significantly. The recommended chemical fertilizers supplied readily available nitrogen to the crops throughout the growing period whereas nutrient release from fertilizer is a slow process. So the availability of nitrogen might be less with the fertilizer application. The fertilizer level supplying nitrogen equivalent to 187.5 kg N ha^{-1} was unable to meet the required amount of 125 kg N ha^{-1} to wheat and resulted in lower grain yields than that with RDF.

The varietal differences in straw yield were mainly due to their genetic characteristics. The straw yield with the variety DBW 303 was significantly higher (65.0 q ha^{-1}) than the other two varieties. The straw yield of the variety LOK-1 was statistically at par with RAJ 3077.

The medium level of fertilizer (M3) gave statistically at par HI (42.6%) with the lower level of fertilizer (42.3%) and unfertilized control (42.6%). Higher level of fertilizer (M4) gave significantly lower (40.3%) HI than all the other treatments. The similar results were reported by **Singh and Kaur (2004)** who reported the significant decrease in HI with 15 t fertilizer ha^{-1} than unmannered control.

The variety DBW 303 gave significantly lower HI (37.3%) than the other varieties due to its higher straw yield. The varieties RAJ 3077 and LOK-1 gave statistically at par HI value (44.8% and 45.2%, respectively).

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Table 1: Periodic plant height and plant population of wheat as affected by nutrition and varieties.

Treatment	Plant height (cm)					Plant Population
	30DAS	60DAS	90DAS	120DAS	Atharvest	15 DAS
Nutrition						
M4	14.8	34.6	65.3	90.2	97.9	161.00
M3	14.3	31.1	61.1	86.6	94.3	163.00
M2	13.3	29.0	60.1	85.7	93.3	166.00
M1	12.8	24.8	54.1	79.2	86.6	159.00
CD(p= 0.05)	**NS**	**3.4**	**3.5**	**3.5**	**3.3**	**NS**
Varieties						
V3	14.3	31.7	63.5	83.0	91.1	167.00
V2	15.0	31.8	62.0	81.1	88.0	160.00
V1	12.1	28.1	59.6	99.3	107.1	158.00
CD(p= 0.05)	**0.7**	**1.6**	**1.6**	**1.7**	**1.8**	**2.31**
Interactions	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Table 2: Periodic dry matter accumulation of wheat as affected by nutrition and varieties.

	Dry matter accumulation (q ha^{-1})				
	30 DAS	60 DAS	90 DAS	120 DAS	At harvest
Nutrition					
M4	4.1	15.7	59.1	95.8	102.8
M3	3.8	14.5	45.0	70.4	81.2
M2	3.4	13.1	42.7	66.5	76.0
M1	2.9	11.5	40.7	53.7	62.3
CD(p= 0.05)	**0.7**	**1.4**	**7.1**	**9.7**	**5.2**
Varieties					
V3	3.4	14.1	49.6	71.9	82.9
V2	4.3	17.4	60.5	77.4	83.8
V1	3.0	11.8	46.1	87.3	98.2
CD(p= 0.05)	**0.4**	**1.1**	**4.6**	**5.1**	**7.2**

Interactions	**NS**	**NS**	**NS**	**NS**	**NS**

Table 3: Yield attributes of wheat as affected by nutrition and varieties.

Treatment	Effective tillers m^{-2}	Ear length (cm)	Number of grains ear^{-1}	1000-grain weight (g)
Nutrition				
M4	311.1	9.46	40.9	46.9
M3	272.0	9.28	40.1	46.4
M2	249.7	9.10	39.9	46.3
M1	204.3	8.95	38.8	45.2
CD(p= 0.05)	**38.5**	**0.35**	**2.0**	**1.5**
Varieties				
V3	273.4	9.60	45.4	43.4
V2	275.3	9.35	44.6	44.8
V1	327.0	9.08	31.3	49.0
CD(p= 0.05)	**23.2**	**0.31**	**2.2**	**1.0**
Interactions	**NS**	**NS**	**NS**	**NS**

Table 4: Effect of nutrition and varieties on grain and straw yield, harvest index and days to maturity of wheat

Treatment	Grain yield qha^{-1})	Straw yield (qha^{-1})	Harvest index (%)	Days to maturity
Nutrition				
M4	43.1	64.7	40.3	139.3
M3	36.8	50.1	42.6	136.3
M2	33.5	46.6	42.3	134.0
M1	27.3	38.1	42.6	132.3
CD(p= 0.05)	**3.1**	**3.8**	**1.7**	**2.9**
Varieties				
V3	39.6	48.2	44.8	136.6
V2	39.9	48.6	45.2	130.6

V1	38.3	65.0	37.3	143.0
CD (p= 0.05)	**NS**	**4.9**	**1.5**	**1.8**
Interactions	**NS**	**NS**	**NS**	**NS**

V Conclusion:

The quantity of fertilizer supplying nitrogen equivalent to the recommended nitrogen to wheat gave significantly lower grain yield (33.5 q ha^{-1}) than that with recommended fertilizers (55.6 q ha^{-1}). Even the quantity of fertilizer supplying nitrogen equivalent to 1.5 times the recommended nitrogen failed to produce the grain yield as that with recommended fertilizers. However, the quantity of fertilizer supplying 187.5 kg N ha^{-1}gave significantly higher grain yield than the lower fertilizer levels supplying 125 and 62.5 kg N ha^{-1}. The performance of varieties (RAJ 3077, LOK-1 and DBW 303) did not differ with the variation in fertilizer levels. Protein and gluten content were significantly lower under all the levels of fertilizer as compared to chemical fertilizers, but grain hardness and sedimentation value under highest level of fertilizer were statistically at par with chemical fertilizers. Mineral content except copper was significantly higher under higher dose of fertilizer than chemical fertilizers. Quality characteristics of all the varieties were in optimum range but variety RAJ 3077 had significantly higher grain protein was significantly higher in DBW 303.

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Effect of Nitrogen Management through Different Sources on Growth and Yield of Organic Wheat (*Triticum aestivum* L.)

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Abstract

An experiment was carried out at research farm- career point university, Kota (Rajasthan) during *rabi* 2023-24 to study on Effect of Nitrogen Management through Different Sources in Organic Wheat (*Triticum aestivum* L.). The experiment comprises nine treatments with three replications were laid out in randomized block design. The objective of the experiment was to select appropriate dose and source of nitrogen to crop to achieve higher productivity under vertisols of Rajasthan. The soil of the experimental field was clay loam in texture, medium in available nitrogen and phosphorous, high in available potassium and alkaline in reaction. Growth parameters *viz*., plant height and dry matter production, yield attributes *viz*., number of effective tillers m^{-1} row length, length of ear, grains ear^{-1} and test weight, grain, straw and biological yield, were recorded significantly higher under application of 120 kg N ha^{-1} through vermicompost (T_2) over rest of the treatment which was remained at par with application of 120 kg N ha^{-1} through FYM (T_3) and application of 120 kg N ha^{-1} through castor cake (T_4).

Keywords: Wheat, Vermicompost, Castor cake, FYM

I Introduction

Organic farming is a production system which avoids the use of synthetic fertilizers, pesticides and growth regulators (Reddy *et al.*, 2005). Organic farming systems often include recycled organic manure as fertilizer and bio control measures for plant protection. The global area under organic agriculture is about 74.9 million hectare and world organic market is now 120.6 billion US$ (FiBL and IFOAM 2021). In India, about 4.33 million ha area is under organic cultivation and total production of certified organic products is 3.49 MMT (APEDA, 2021). India is fastly growing base for production and supply of organically produced agricultural products to the world market.

II Literature Review:

Use of organic manures including farmyard manure, vermicompost, goat manure, green manure, cakes and poultry litter might be a substitute of the chemical fertilizers use for crop production (Sarwar *et al.*, 2008). Organic agriculture minimizes environmental pollution and the use of non-conventional natural resources. It conserves soil fertility and soil erosion through implementation of appropriate conservation principles (Trewavas, 2001). Several reasons like limited land holdings, poor economic condition of farmers, rise in input costs *etc* have been attributed for the need of organic farming (Sharma, 2002).

Wheat (*Triticum aestivum* L.) belongs to family “Poaceae” and genus “Triticum”. It is a crop of temperate zone with cool winters and hot summers being very conducive for its growth. Among the food crops, wheat is one of the most abundant sources of energy and protein for the world population and for food security enhancement in production is essential. It is necessary to sustain the wheat crop production for meet the demand of wheat in India as well as world (Sharma *et al.*, 2008). Wheat is generally grown in organic farming systems (Burnett and Rutherglen, 2008). In India, total area under wheat cultivation is 30.55 million ha with 107.18 million tons production and average yield of 35.08 q ha^{-1} in 2019-20. In Rajasthan, area under wheat cultivation is 3.93 million ha with production of 10.92 million tons and average yield is 35.01 q ha^{-1} (FAI, 2019).

The excessive use of fertilizers and pesticides over the last 50 years has helped make good progress earlier, but in recent decades the decline in the growth and stagnation in crop yields, creating big problems and the chain of many problems, has been addressed. A number of deleterious effects on the soil, water and air have been caused by the indiscriminately used fertilizers and pesticides. This has declined soil productivity by deteriorating soil health as regards soil fertility and microbial activity. Despite the numerous benefits of organic farming and organic foods, organic inputs do not produce immediate results, especially in soils with a high C: N ratio. Compost, FYM, vermicompost, crop residues, green manures, green leaf manuring in crop rotation and biofertilizers are used to increase soil organic carbon, provide all essential plant nutrients and improve soil properties. Organic nutrient management plays a key role in protecting soil quality through soil organic matter, beneficial microbes and enzymes. Long-term organic material addition to soil increased organic matter, crop yields and soil biological activity (Collins *et al*., 1992).

III Methodology

Methods and Materials An investigation was carried out at Research Farm- Career Point University, Kota (Rajasthan), which is placed in the South-East part of Rajasthan at an altitude of 579.5 metre above mean sea level and at 24º35 °C N latitude and 73º42 °C E longitude. The experimental site's soil type was clay-loam, and it had a reaction-friendly pH of 7.5 and good drainage capabilities. The soil had low levels of accessible potassium (235 kg/ha) and phosphorus (155 kg/ha) and was found to have low levels of organic carbon (0.29%) and available nitrogen (112 kg/ha). Three replications of the experiment were employed, and the RBD (Randomized Block Design) method was used to build it up. The present experiment consisting of eight treatment combinations was laid out in Randomized Block Design. The experiment was involved nine treatments N equivalent to 120 kg ha^{-1} through FYM, N equivalent to 120 kg ha^{-1} through vermicompost, N equivalent to 120 kg ha^{-1} through castor cake, N equivalent to 90 kg ha^{-1} through FYM + NPK consortium (Seed treatment), N equivalent to 90 kg ha^{-1} through vermicompost + NPK consortium (Seed treatment), N equivalent to 90 kg ha^{-1} through castor cake + NPK consortium (Seed treatment), N equivalent to 90 kg ha^{-1} through FYM + NPK consortium (Soil application), N equivalent to 90 kg ha^{-1} through vermicompost + NPK consortium (Soil application) and N equivalent to 90 kg ha^{-1} through castor cake + NPK consortium (Soil application).

The experimental field was prepared by ploughing with tractor drawn disc plough followed by cross harrowing and planking to get well-pulverized soil tilth. In the experiment, wheat crop was sown on 20th November, 2023. A uniform seed rate of 100 kg ha^{-1} was used at inter row spacing of 22.5 cm. In order to obtain uniform plant stand, seeds were weighed for each plot separately. Sowing was done manually in furrows followed by irrigation. In wheat, six irrigations were applied in both the years at critical growth stages, *i.e*., at crown root initiation, tillering, late jointing, flowering, milking and dough stages of wheat.

Number of plants 0.5 m^{-1} row length was recorded from five randomly selected places for wheat crop in each experimental unit at 20 DAS and at harvest. These were averaged and number of plants 0.5 m^{-1} row length was worked out for wheat crop. Height of these five plants was measured at 30, 60, 90 DAS and at harvest from the base of the plant to the top of the main shoot by metre scale and their mean was expressed as cm. Dry matter accumulation (g plant^{-1}) was recorded at 30, 60, 90 DAS and at harvest and plants were uprooted randomly from sample rows of each plot. After removal of the root portion, the samples were first air-dried for some days and finally dried in an electric oven at 70^{0}C till a constant weight was achieved. The weight was recorded and expressed as g plant^{-1}. The number of effective tillers (m^{-1} row length) of five plants randomly selected from each plot was counted at harvest and average number of effective tillers m^{-1} row length was worked out. Number of grains ear^{-1} was counted from the five selected (tagged) plant's spike and their mean was taken. The length of ear of each plant was measured from the five selected (tagged) plants and their mean was taken and expressed in cm. Samples were drawn randomly from produce of each plot and one thousand seeds were counted from each sample and weighed to record test weight. After threshing and winnowing of the seeds from each net plot were weighed in kg plot^{-1} and converted in kg ha^{-1} for grain yield. Straw yield was obtained by subtracting the grain yield (kg ha^{-1}) from biological yield (kg ha^{-1}). At maturity completely, dried biomass *i.e.* grain and straw from each net plot harvested were weighed and computed for biological yield as kg ha^{-1}. The harvest index was calculated by using following formula and expressed as percentage (Singh and Stoskoff, 1971).

$$\text{HI (\%)} = \frac{\text{Economic yield (kg ha}^{-1}\text{)}}{\text{Biological yield (kg ha}^{-1}\text{)}} \times 100$$

Data from an experiment performed in RBD were evaluated using a standard procedure recommended by Panse and Sukhatme (1985). The 'F' (variance) test and calculating C. D. at a 5% level of significance were used to determine whether there was a significant difference between the treatments.

IV Results and Discussion

Growth parameters The pant height and dry matter accumulation were the growth metrics of wheat that were impacted by the various nutrient management practices (Table 1-4). Our observations of plant height included measurements of dry matter accumulation periodical intervals of at 30, 60, 90 DAS as well as at harvest. At 20 DAS, there were no discernible variations caused by intercrops in terms of plant height. Results presented in Table 4.1 to 4.3 revealed that application of N equivalent to 120 kg ha^{-1} through vermicompost (T_2) recorded tallest plant at 60, 90 DAS and harvest and highest dry matter accumulation at 60, 90 DAS and harvest of wheat which was significantly higher over rest of the treatments but remained

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at par with application of N equivalent to 120 kg ha^{-1} through FYM (T_1) and N equivalent to 120 kg ha^{-1} through caster cake (T_3).

Increase in plant height in treatment T_2 (N equivalent to 120 kg ha^{-1} through vermicompost) might be due to basal application of vermicompost supply macro as well as micro nutrients through organic source, which improve soil physical and biological properties and increase the availability of nutrients and solubilizing them. Thus, favourable influence of nutrients to produce larger cells with thinner cell walls and its contribution in cell division and cell elongation which improved vegetative growth and ultimately increased the plant height of soybean. These are in conformity with the results of Dekhane *et al*. (2017), Jain *et al*. (2021) and Chauhan *et al*. (2022).

The higher root length might be due to significant increase in organic matter content in the soil with the application of organic manure which improved the favourable effect on modifying the soil environment physically and hold more water and nutrients, better aeration and enhanced microbial activities, resulting ultimately into higher root length.

Secondly, it might be due to that increase in the root length with application of vermicompost which had accelerated various metabolic processes and resulted in increasing root growth. This clearly indicated that addition of organic manures to the soil increased the availability of nutrients considerably resulting in a positive effect on growth parameters viz. root length.

Increase in dry matter accumulation in treatment T_2 (N equivalent to 120 kg ha^{-1} through vermicompost) might be due to application of vermicompost supplied all essential nutrients, growth hormones and enzymes to plant, which favours rapid cell division and elongation and ultimately results into more development of plant and higher dry matter accumulation. These results are in concurrence with the findings of Dekhane *et al*. (2017), Jain *et al*. (2021), Chauhan *et al*. (2022) and Chaudhary *et al*. (2023).

Yield attributes

Data presented in Table 4 indicate that yield attributes *viz*., number of effective tillers m^{-1} row length at harvest, number of grains ear^{-1}, length of ear and test weight of wheat significantly increased due to application of nitrogen through organic sources during experimentation. Application of N equivalent to 120 kg ha^{-1} through vermicompost (T_2) recorded maximum yield attributes *viz*., number of effective tillers m^{-1} row length, number of grains ear^{-1}, length of ear and test weight of wheat which was significantly higher over rest of the treatments but remained at par with application of N equivalent to 120 kg ha^{-1} through

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FYM (T_1) and N equivalent to 120 kg ha^{-1} through caster cake (T_3). Increase in yield attributes *viz*., number of effective tillers m^{-1} row length at harvest, number of grains ear^{-1}, length of ear and test weight in application of N equivalent to 120 kg ha^{-1} through vermicompost (T_2) might be due to application of vermicompost delayed leaf senescence and this might be the reason for increased seed weight.

Secondly, better growth and development of crop plants due to nitrogen supply might have increased the supply of assimilates to seed, which ultimately gained more weight. This was perhaps due to a continuous supply of nitrogen to the crop at all stages of crop growth, as slow release nutrients might have increase grain weight (Chaudhary, 2016).

As vermicompost supplies essential plant nutrients, vitamins, growth hormones and enzymes, this leads to more production of spikelets ear^{-1} in wheat. Vermicompost also improves soil physical condition, which further improved the absorption of nutrients which results into tissue differentiation from somatic to reproductive meristematic activity and increase in development of floral primordial, resulting in higher number of spikelets ear^{-1}. These results are in conformity to those reported by Jat *et al*. (2018), Kumar *et al*. (2020a) and Game *et al*. (2022), Chauhan *et al*. (2022).

Yield

The grain, straw and biological yield was significantly influenced by the organic manure application (Table 5). Maximum grain, straw and biological yield (4255, 5140 and 9395 kg ha^{-1}, respectively) produced with the application of N equivalent to 120 kg ha^{-1} through vermicompost (T_2) which was significantly higher grain, straw and biological yield over rest of the treatments except application of N equivalent to 120 kg ha^{-1} through FYM (T_1) and N equivalent to 120 kg ha^{-1} through caster cake (T_3). Vermicompost application might have increased activities of N fixing bacteria and increased rate of humification. Humic acid in vermicompost might have enhanced the availability of both added and native nutrients in soil and as a result improved growth, yield attributes and yield of the crop significantly.

Secondly, vermicompost also supply phosphorus which increased availability of phosphorus in soil, which is a major structural element of cell and helped in cell elongation, higher availability of photosynthesis, metabolites and nutrients to develop reproductive structures which promote to increased growth parameters and lead to higher yield attributes and yields of linseed crop. These results are in close accordance with those reported by Dekhane *et al*. (2017), Jat *et al*. (2018), Kumar *et al*. (2020a), Game *et al*. (2022), Chauhan *et al*. (2022) and Chaudhary *et al*. (2023a). However, data clearly showed that different organic

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sources of nitrogen remained akin to harvest index (Table 4.4) and they had no any significant influence on harvest index. It may be due to balance distribution of assimilates to both sink and vegetative growth which ultimately similar harvest index.

Table 1 Effect of nitrogen management through various sources on plant population of wheat.

Treatments	**Plant population (0.5 m^{-1} row length)**	
	20 DAS	**Harvest**
N equivalent to 120 kg ha^{-1} through FYM (T_1)	11.12	9.71
N equivalent to 120 kg ha^{-1} through vermicompost (T_2)	11.48	9.89
N equivalent to 120 kg ha^{-1} through castor cake (T_3)	11.51	10.02
N equivalent to 90 kg ha^{-1} through FYM + NPK consortium (Seed treatment) (T_4)	11.64	10.30
N equivalent to 90 kg ha^{-1} through vermicompost + NPK consortium (Seed treatment) (T_5)	11.45	9.88
N equivalent to 90 kg ha^{-1} through castor cake + NPK consortium (Seed treatment) (T_6)	11.57	9.95
N equivalent to 90 kg ha^{-1} through FYM + NPK consortium (Soil application) (T_7)	11.50	9.96
N equivalent to 90 kg ha^{-1} through vermicompost + NPK consortium (Soil application) (T_8)	11.48	9.89
N equivalent to 90 kg ha^{-1} through castor cake + NPK consortium (Soil application) (T_9)	12.24	10.75
SEm ±	**0.54**	**0.56**
CD (5%)	**NS**	**NS**
CV	**8.10**	**9.60**

Table 2 Effect of nitrogen management through various sources on plant height of wheat

Treatments	**Plant height (cm)**			
	30 DAS	**60 DAS**	**90 DAS**	**Harvest**
N equivalent to 120 kg ha^{-1} through FYM (T_1)	28.77	62.13	77.84	87.10
N equivalent to 120 kg ha^{-1} through vermicompost (T_2)	29.35	63.29	79.24	88.59
N equivalent to 120 kg ha^{-1} through castor cake (T_3)	28.31	61.83	77.64	87.11
N equivalent to 90 kg ha^{-1} through FYM + NPK consortium (Seed treatment) (T_4)	28.40	51.50	65.32	74.65
N equivalent to 90 kg ha^{-1} through vermicompost + NPK consortium (Seed treatment) (T_5)	28.00	50.69	64.36	73.94

N equivalent to 90 kg ha^{-1} through castor cake + NPK consortium (Seed treatment) (T_6)	28.26	51.22	64.81	74.07
N equivalent to 90 kg ha^{-1} through FYM + NPK consortium (Soil application) (T_7)	28.11	53.92	68.03	77.56
N equivalent to 90 kg ha^{-1} through vermicompost + NPK consortium (Soil application) (T_8)	28.05	54.60	68.86	78.28
N equivalent to 90 kg ha^{-1} through castor cake + NPK consortium (Soil application) (T_9)	27.92	53.24	67.45	76.72
SEm ±	**1.19**	**2.38**	**2.82**	**3.44**
CD (5%)	**NS**	**7.13**	**8.45**	**10.31**
CV	**7.26**	**7.37**	**6.94**	**7.47**

Table 3 Effect of nitrogen management through various sources on dry matter accumulation of wheat

Treatments	**Dry matter accumulation (g plant^{-1})**			
	30 DAS	**60 DAS**	**90 DAS**	**Harvest**
N equivalent to 120 kg ha^{-1} through FYM (T_1)	4.36	10.88	73.74	78.34
N equivalent to 120 kg ha^{-1} through vermicompost (T_2)	4.45	11.07	75.00	79.60
N equivalent to 120 kg ha^{-1} through castor cake (T_3)	4.29	10.83	73.40	78.00
N equivalent to 90 kg ha^{-1} through FYM + NPK consortium (Seed treatment) (T_4)	4.30	9.15	60.97	65.57
N equivalent to 90 kg ha^{-1} through vermicompost + NPK consortium (Seed treatment) (T_5)	4.24	9.02	60.10	64.70
N equivalent to 90 kg ha^{-1} through castor cake + NPK consortium (Seed treatment) (T_6)	4.28	9.10	60.67	65.27
N equivalent to 90 kg ha^{-1} through FYM + NPK consortium (Soil application) (T_7)	4.26	9.54	63.60	68.20
N equivalent to 90 kg ha^{-1} through vermicompost + NPK consortium (Soil application) (T_8)	4.25	9.65	64.35	68.95
N equivalent to 90 kg ha^{-1} through castor cake + NPK consortium (Soil application) (T_9)	4.23	9.43	62.87	67.47
SEm ±	**0.18**	**0.39**	**2.71**	**2.75**
CD (5%)	**NS**	**1.16**	**8.12**	**8.25**
CV	**7.26**	**6.81**	**7.10**	**6.75**

Table 4 Effect of nitrogen management through various sources on yield attributes of wheat

Treatments	**Yield attributes**

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	Effective tillers (m^{-1} row length)	**Number of grains ear^{-1}**	**Length of ear**	**Test weight (g)**
N equivalent to 120 kg ha^{-1} through FYM (T_1)	69.74	38.74	10.36	50.72
N equivalent to 120 kg ha^{-1} through vermicompost (T_2)	71.00	39.44	10.54	51.56
N equivalent to 120 kg ha^{-1} through castor cake (T_3)	69.40	38.56	9.81	50.50
N equivalent to 90 kg ha^{-1} through FYM + NPK consortium (Seed treatment) (T_4)	56.97	31.65	8.04	42.22
N equivalent to 90 kg ha^{-1} through vermicompost + NPK consortium (Seed treatment) (T_5)	56.10	31.17	7.91	41.63
N equivalent to 90 kg ha^{-1} through castor cake + NPK consortium (Seed treatment) (T_6)	56.67	31.48	8.00	42.02
N equivalent to 90 kg ha^{-1} through FYM + NPK consortium (Soil application) (T_7)	59.60	33.11	8.41	43.97
N equivalent to 90 kg ha^{-1} through vermicompost + NPK consortium (Soil application) (T_8)	60.35	33.53	8.52	44.47
N equivalent to 90 kg ha^{-1} through castor cake + NPK consortium (Soil application) (T_9)	58.87	32.71	8.31	43.48
SEm ±	2.71	1.58	0.37	1.84
CD (5%)	8.12	4.74	1.11	5.50
CV	7.56	7.93	7.25	6.97

Table 5 Effect of nitrogen management through various sources on yield of wheat.

Treatments	**Yield**			**Harvest index (%)**
	Grain	**Straw**	**Biological**	
N equivalent to 120 kg ha^{-1} through FYM (T_1)	4173	5039	9211	45.30
N equivalent to 120 kg ha^{-1} through vermicompost (T_2)	4255	5140	9395	45.29
N equivalent to 120 kg ha^{-1} through castor cake (T_3)	4150	4980	9130	45.45
N equivalent to 90 kg ha^{-1} through FYM + NPK consortium (Seed treatment) (T_4)	3321	3986	7307	45.45
N equivalent to 90 kg ha^{-1} through vermicompost + NPK consortium (Seed treatment) (T_5)	3263	3916	7179	45.46
N equivalent to 90 kg ha^{-1} through castor cake	3302	3962	7264	45.46

+ NPK consortium (Seed treatment) (T_6)				
N equivalent to 90 kg ha^{-1} through FYM + NPK consortium (Soil application) (T_7)	3498	4196	7694	45.46
N equivalent to 90 kg ha^{-1} through vermicompost + NPK consortium (Soil application) (T_8)	3548	4255	7804	45.47
N equivalent to 90 kg ha^{-1} through castor cake + NPK consortium (Soil application) (T_9)	3448	4138	7586	45.46
SEm ±	**183**	**219**	**399**	**0.36**
CD (5%)	**550**	**658**	**1197**	**NS**
CV	**8.68**	**8.63**	**8.58**	**1.39**

V Conclusion

organic farming presents a sustainable approach to agriculture that emphasizes the avoidance of synthetic fertilizers, pesticides, and growth regulators. With a global area of approximately 74.9 million hectares dedicated to organic agriculture and a market value of $120.6 billion USD, the significance of organic farming is increasingly recognized worldwide. In India, where 4.33 million hectares are under organic cultivation, there is a growing base for the production and supply of organically produced agricultural products to the global market.

Organic farming relies on the use of organic manures such as farmyard manure, vermicompost, and green manure, which serve as substitutes for chemical fertilizers. By minimizing environmental pollution and conserving soil fertility and erosion, organic agriculture contributes to the sustainable management of natural resources.

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