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EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON QUALITY OF ONION (*ALLIUM CEPA* L.)

Madanpal Singh[1], Pratap Singh[2] and Joginder Singh[3*]
[1]Department of Horticulture, R.S.M. (PG) College, Dhampur, Bijnor, U.P., India
[2]Department of Agriculture, Monad University, Hapur, U.P., India
[3]Department of Horticulture, J.V. College, Baraut, Baghpat, U.P., India
*Corresponding author email: drjsingh1982@gmail.com

ABSTRACT

The Experimental Farm, Department of Agriculture, School of Sciences and Agriculture, Kasmabad, Monad University, Hapur, Uttar Pradesh, was the site of the current investigation during the *rabi* seasons of 2021–22 and 2022–23. In the current study, a Randomised Block Design (RBD) with three replications and sixteen treatment combinations was utilised for the variable analysis.The details of treatments comprised of T_1 Control (water spray), T_2 (100% RDF [NPK- 120:60:60 kg/ha]), T_3 (75% RDF + 6.0 t/ha FYM), T_4 (75% RDF + 1.0 t/ha PM), T_5 (75% RDF + 2.0 t/ha VC), T_6 (75% RDF + 3.0 t/ha FYM + 0.5 t/ha PM), T_7 (75% RDF + 1.0 t/ha VC + 0.5 t/ha PM), T_8 (75% RDF + 6.0 t/ha FYM + Azotobacter (4 kg/ha)), T_9 (75% RDF + 1.0 t/ha PM + Azotobacter (4 kg/ha)), T_{10} (75% RDF + 2.0 t/ha VC + Azotobacter (4 kg/ha)), T_{11} (50% RDF + 12.0 t/ha FYM), T_{12} (50% RDF + 2.0 t/ha PM), T_{13} (50% RDF + 4.0 t/ha VC), T_{14} (50% RDF + 6.0 t/ha FYM + Azotobacter (4 kg/ha)), T_{15} (50% RDF + 2.0 t/ha PM + Azotobacter (4 kg/ha)) and T_{16} (50% RDF + 2.0 t/ha VC + Azotobacter (4 kg/ha). From the above experimental finding it is concluded that the treatment T_8 (75% RDF + 6.0 t/ha FYM + Azotobacter (4 kg/ha) was found to be best in the terms of quality of Onion evaluated for different doses of organic and inorganic fertilizers integrated together.

***Keywords* :** *Allium cepa*, Farmyard Manure, Vermicompost, Benefit cost ratio

Introduction

Onions are a commercially important bulb crop that are eaten by both vegetarians and non-vegetarians due to their nutritional and flavouring properties. Onions are known for their stimulant, diuretic, expectorant, and antibacterial qualities. Heart disease is prevented by lowering blood cholesterol and lipid levels (Sharangi and Datta, 2005). Botanically known as *Allium cepa* (L.), it is closely related to garlic, scallion, leek, and chives (Anonymous, 2020). It is a member of the Amaryllidaceae family. Some species in this genus that are also called onions and are grown for food are the Japanese bunching onion *Allium fistulosum,* the Canada onion Allium canadense, and the tree onion *Allium × proliferum.* Although many Allium species are called "wild onions," only A. cepa has been studied in cultivation. Its ancestral wild form is unknown, despite the fact that escapes from cultivation have become established in some areas (McNeal *et al.*, 2002). Chromosome number 2n=16 is present in onions (Firbos and Amon, 2014). The history of the ancestors of onion species is not well documented. Since the onion has been used historically in both western and eastern Asia, its geographic origin is unknown. Nonetheless, domestication most likely took place in West or Central Asia, despite being variously credited to Iran, western Pakistan, and Central Asia (Cumo, 2015). The majority of onions are biennial or perennial plants, despite the fact that they are usually grown as annuals and harvested during their first growing season. At a certain day length, the bulb at the base of the onion plant swells. The leaves of the onion plant are hollow and have a bluish-green colour. Compressed and shortened underground stems with a central bud at the tip surrounded by fleshy modified scales, or leaves, make up the bulbs. Onion production in India in 2021–2022 covered 5.36 million hectares, producing 31.28 million tonnes in total, according to data from the Ministry of Agriculture &

Farmers Welfare, Government of India's Department of Economics and Statistics (DES). In terms of area and onion production in 2021–2022, Maharashtra was the top state, followed by Gujarat, Madhya Pradesh, and Karnataka. The production area of onions in Uttar Pradesh was 0.21 million hectares, yielding 5.08 million tonnes of output in the same year. Onions can be cultivated in tropical, subtropical, and temperate climates despite being a temperate crop. The best outcomes can be obtained in mild weather that stays away from temperature, precipitation, and extremes of heat or cold. Farmyard manure gives plants readily available forms of nitrogen, phosphorus, potassium, and other vital nutrients through biological breakdown. It enhances the organic matter content, microbial activity, aggregation, aeration, water-holding capacity, and available nutrients, among other physical, chemical, and biological aspects of soil. Worm casting, organic materials, and living earthworms are combined to create vermicompost. It is organic manure that releases nutrients gradually and contains the majority of the macro and micronutrients needed by plants (Gebremichael *et al.,* 2017). On average, well-decomposed farmyard manure contains approximately 0.5% Nitrogen (N), 0.2% Phosphate (P_2O_5), and 0.5% Potassium (K_2O). In addition, FYM increases soil phosphorus availability. Moreover, FYM may affect the potential availability and solubility of applied phosphorus when combined with fertiliser phosphorus. It's critical to understand that, in contemporary intensive farming, neither the exclusive application of organic manure nor chemical fertilisers can guarantee sustainable and fruitful yields. Long-term agricultural sustainability frequently requires a balanced strategy that incorporates both chemical and organic inputs (Singh and Singh, 2018). By adding organic matter and encouraging microbial activity, vermicompost enriches the soil rhizosphere and plant system with nutrients (Patidar *et al.,* 2017). The organic matter left over from chickens, mostly consisting of urine and faeces, is referred to as poultry manure. Poultry litter is rich in many plant nutrients, including N, P, and K, and in trace elements like Zn and Cu. Biofertilizers are products that are made from living cells of different microorganisms; they help fix nitrogen in the atmosphere and solubilize phosphorus, which increases crop yield. Through biological processes, they can also transform elements from complex forms into accessible forms (Singh and Singh, 2018). NPK fertilisers are the chemical fertilisers that plants require for rapid growth. Nitrogen accelerates plant growth and is more essential to plants because it is the main component of proteins, enzymes, nucleic acids, and chlorophyll (Yohannes *et al.,* 2013). Phosphorus (P), an essential part of enzymes, nucleic acids, and phospholipids, is needed in the plant system for energy transfer. According to Singh *et al.,* (2019), the phosphorus nutrient promotes early root enlargement. Potassium (K) is necessary for plants to carry out metabolic functions such as photosynthesis, metabolite translocation, enzyme activation, and pest-disease resistance (Singh and Singh 2017). Modern biotechnology known as vermicomposting converts industrial and agricultural waste into useful products. It enhances soil fertility, structure, and vermicompost's richness and ongoing ability to support agricultural vitality when utilised in organic farming (Garg and Gupta, 2009). Biofertilizers are believed to act as growth regulators in addition to biologically fixing nitrogen, which causes a greater response on a range of growth and yield-related characteristics. Onion biofertilizer inoculations lowered the cost of cultivation by increasing yield and reducing the need for fertiliser by 25% (Devi and Ado, 2005). Biofertilizers are substances that contain live cells of various microorganisms that can use biological processes to change nutritionally significant elements into a form that is readily obtainable (Ramakrishnan and Thamizhiniyan 2004). It has been acknowledged that moving developing countries away from traditional commodities and towards market-driven production can hasten economic growth, generate employment, and reduce rural poverty (Fullagar *et al.,* 2006). Because of this change, households can now produce goods that yield higher returns on labour and land. Consequently, compared to cereal crops, the cultivation of vegetables has grown more quickly (Keatinge *et al.,* 2011). Vegetables contribute significantly to higher income levels and better nutritional standards in these countries, both socially and economically. Farmers engaged in vegetable cultivation typically earn substantially higher incomes compared to those focusing on cereals, with reported farm incomes per capita reaching up to five times higher. Additionally, horticultural products provide income-boosting opportunities for small-scale farmers, contributing significantly to increased employment. In modern agriculture, reducing reliance on chemical fertilizers and promoting sustainable production are crucial goals addressed by integrated plant nutrient supply systems (IPNS). Integrated nutrient management is an environmentally friendly approach to managing soil health and achieving sustainable productivity without adversely affecting the soil. Alongside chemical fertilizers, other methods such as biofertilizers and organic manures can provide nutrients to plants. Organic manures are particularly effective in mitigating multiple nutrient deficiencies.

For instance, onion cultivation, being a heavy feeder of mineral elements, requires significant amounts of nitrogen (N), phosphorus (P), and potassium (K). About 120 kg of NO_3^-, 50 kg of P_2O_5, and 160 kg of K_2O are removed per hectare with a crop yield of 35 t/ha. Therefore, integrating organic manures into cultivation practices can help replenish these essential nutrients in the soil and maintain its fertility in a sustainable manner. Therefore, the potential yield increases with the amount of nutrients it can use to produce crops. In order to investigate the various inorganic, organics, and bio-organic treatment combinations, the current experiments were undertaken to find out the effect of inorganic fertilizers and bio-organics on yield of onion and to find out the suitable dose of inorganic fertilizers and sources of organic manures and bio-inoculants.

Materials and Methods

The present investigation was conducted during the *rabi* season of 2021-22 and 2022-23 at the Experimental Farm, Department of Agriculture, School of Sciences and Agriculture, located in Kasmabad, Monad University, Hapur, Uttar Pradesh, India. Geographically, Hapur serves as both a city and the administrative headquarters of the Hapur district in Uttar Pradesh. It is situated approximately 60 kilometres to the east of New Delhi and is an integral part of the Delhi National Capital Region (NCR). Hapur has an average elevation of 213 meters above mean sea level and is positioned between coordinates 77°78" E longitude and 28°72" N latitude. This region falls under Agroclimatic Zone V, known as the Upper Gangetic Plain Region. The experimental site's topography is predominantly flat, and the soil composition is characterized as sandy loam. Soil samples were systematically collected from a depth of 0-30 cm and subjected to comprehensive analysis to assess various parameters. The soil pH was determined to be 7.06 using a digital pH meter, while the organic carbon content was measured to be 0.52% using the wet method as described by Walkely and Black (1965). Understanding the agricultural conditions and directing agricultural practices in the area requires knowledge of the soil characteristics of the experimental site, which is provided by these findings. A statistical analysis of the data was conducted using the Fisher and Yates, 1963 method. INDOSTAT was the analysis software utilised. The Agrifound light red onion variety was utilised. In the study, the percentage of total soluble solids of the fruit was determined with the help of Portable Hand Refractometer. The sample of juice for this purpose was taken from the strained juice. The observed value of T.S.S. was recorded from the scale of the instrument (0-32 range). Nitrogen content was calculated using Micro Kjeldahl's method, Jackson, 1973.

Nitrogen (%)

$$= \frac{(\text{Sample titration} - \text{blank titration}) \text{ X N.of } H2SO4 \text{ X } 14x \text{ X } 100}{\text{sample weight X } 1000}.$$

In the present investigation the design used for analysis of variables were Randomized Block Design (RBD) comprising 3 replications sixteen treatment combinations. The details of treatments comprised of T_1 Control (water spray), T_2 (100% RDF [NPK-120:60:60 kg/ha]), T_3 (75% RDF + 6.0 t/ha FYM), T_4 (75% RDF + 1.0 t/ha PM), T_5 (75% RDF + 2.0 t/ha VC), T_6 (75% RDF + 3.0 t/ha FYM + 0.5 t/ha PM), T_7 (75% RDF + 1.0 t/ha VC + 0.5 t/ha PM), T_8 (75% RDF + 6.0 t/ha FYM + Azotobacter (4 kg/ha)), T_9 (75% RDF + 1.0 t/ha PM + Azotobacter (4 kg/ha)), T_{10} (75% RDF + 2.0 t/ha VC + Azotobacter (4 kg/ha)), T_{11} (50% RDF + 12.0 t/ha FYM), T_{12} (50% RDF + 2.0 t/ha PM), T_{13} (50% RDF + 4.0 t/ha VC), T_{14} (50% RDF + 6.0 t/ha FYM + Azotobacter (4 kg/ha)), T_{15} (50% RDF + 2.0 t/ha PM + Azotobacter (4 kg/ha)) and T_{16} (50% RDF + 2.0 t/ha VC + Azotobacter (4 kg/ha).

Results and Discussion

According to data on TSS in bulb, there were notable variations in treatment combinations for the 2021–2022 *rabi* season. The highest TSS in bulb (19.63 °Brix) was found in T_8 (75% RDF + 6.0 t/ha FYM + Azotobacter (4 kg/ha). At 18.66 °Brix, T_{10} (75% RDF + 2.0 t/ha VC + Azotobacter) was the next in line. With an average TSS in bulb of 10.09 °Brix, T_1 (control) had the lowest yield. The combination of treatments applied during the 2022–2023 *rabi* season resulted in a slight alteration in the data regarding the TSS in bulb of the bulb. Treatment T_8 (75% RDF + 6.0 t/ha FYM + Azotobacter (4 kg/ha) yielded the highest TSS in bulb (20.72 °Brix), on par with treatment T_{10} (75% RDF + 2.0 t/ha VC + Azotobacter (4 kg/ha), which yielded the second highest TSS (19.70 °Brix). In the T_1 (control) treatment, the lowest TSS in bulb was 11.17 °Brix. A comparable pattern was also revealed by pooled mean analysis. The interaction effect can be disregarded because it is not statistically significant and is small in comparison to the average effect. This implies that the treatment regimen should be followed in the same order each year. The bulb data's pooled mean Depending on the mix of treatments applied, there was a noticeable variation in the TSS in bulb. For T_8 (75% RDF + 6.0 t/ha FYM + Azotobacter (4 kg/ha), the maximum TSS in bulb was 20.17 °Brix. With 19.18 °Brix, T_{10} (75% RDF + 2.0 t/ha VC + Azotobacter (4 kg/ha)) took second place. At 10.63

°Brix, the T_1 (control) exhibited the lowest TSS in bulb. The treatment combination of 75% recommended fertilizer dose (RDF), 6.0 t/ha farmyard manure (FYM), and Azotobacter (4 kg/ha) enhances Total Soluble Solids (TSS) quality in onions compared to other treatments, notably the control. This improvement stems from the synergistic action within this combination: the 75% RDF provides essential nutrients crucial for quality TSS development; the 6.0 t/ha FYM enriches the soil with organic matter, improving soil health and nutrient retention, resulting in better TSS accumulation. Azotobacter's role in nitrogen fixation further enhances nutrient uptake, particularly sugars, contributing to higher TSS levels. Collectively, this combination optimizes soil fertility, nutrient uptake, and sugar content, culminating in superior TSS quality in onions compared to alternative methods, notably the control. The results were concluded in studies carried out by Nirala *et al.* (2019), Yadav *et al.* (2020) and Singh *et al.* (2023). According to data on Nitrogen content in bulb, there were notable variations in treatment combinations for the 2021–2022 *rabi* season. The highest Nitrogen content in bulb (3.21 %) was found in T_8 (75% RDF + 6.0 t/ha FYM + Azotobacter (4 kg/ha). At 3.04 %, T_{10} (75% RDF + 2.0 t/ha VC + Azotobacter) was the next in line. With an average Nitrogen content in bulb of 1.42 %, T_1 (control) had the lowest yield. The combination of treatments applied during the 2022–2023 *rabi* season resulted in a slight alteration in the data regarding the Nitrogen content in bulb of the bulb. Treatment T_8 (75% RDF + 6.0 t/ha FYM + Azotobacter (4 kg/ha) yielded the highest Nitrogen content in bulb (3.40 %), on par with treatment T_{10} (75% RDF + 2.0 t/ha VC + Azotobacter (4 kg/ha), which yielded the second-highest N-content (3.23 %). In the T_1 (control) treatment, the lowest Nitrogen content in bulb was 1.58 %. A comparable pattern was also revealed by pooled mean analysis. The interaction effect can be disregarded because it is not statistically significant and is small in comparison to the average effect. This implies that the treatment regimen should be followed in the same order each year. The bulb data's pooled mean Depending on the mix of treatments applied, there was a noticeable variation in the Nitrogen content in bulb. For T_8 (75% RDF + 6.0 t/ha FYM + Azotobacter (4 kg/ha), the maximum Nitrogen content in bulb was 3.31 %. With 3.13 %, T_{10} (75% RDF + 2.0 t/ha VC + Azotobacter (4 kg/ha)) took second place. At 1.50 %, the T_1 (control) exhibited the lowest Nitrogen content in bulb. In comparison to other treatments, particularly the control, the combination of 75% recommended fertiliser dose (RDF), 6.0 t/ha farmyard manure (FYM), and Azotobacter (4 kg/ha) greatly increases the nitrogen content in onion bulbs. The synergy between the two ingredients contributes to this improvement: the 6.0 t/ha FYM enriches the soil with organic matter, increasing nitrogen availability and uptake by onion plants, while the 75% RDF provides vital nitrogenous nutrients that are critical for nitrogen accumulation in bulbs. The nitrogen-fixing capacity of Azotobacter raises the nitrogen levels in the bulbs even more. When these components work together to maximise nitrogen availability, uptake, and assimilation, onion bulbs treated with this combination have a noticeably higher nitrogen content than bulbs treated with other methods, most notably the control. The studies conducted by Priyanshu *et al.* (2020), Yadav *et al.* (2020), and Singh *et al.* (2021) concluded with similar findings.

According to data on Phosphorus content in bulb, there were notable variations in treatment combinations for the 2021–2022 *rabi* season. The highest Phosphorus content in bulb (0.94 %) was found in T_8 (75% RDF + 6.0 t/ha FYM + Azotobacter (4 kg/ha) at par with 0.89 %, T_{10} (75% RDF + 2.0 t/ha VC + Azotobacter) was the next in line. With an average Phosphorus content in bulb of 0.22 %, T_1 (control) had the lowest yield. The combination of treatments applied during the 2022–2023 *rabi* season resulted in a slight alteration in the data regarding the Phosphorus content in bulb of the bulb. Treatment T_8 (75% RDF + 6.0 t/ha FYM + Azotobacter (4 kg/ha) yielded the highest Phosphorus content in bulb (1.01 %), on par with treatment T_{10} (75% RDF + 2.0 t/ha VC + Azotobacter (4 kg/ha), which yielded the second-highest P-content (0.96 %). In the T_1 (control) treatment, the lowest Phosphorus content in bulb was 0.29 %. A comparable pattern was also revealed by pooled mean analysis. The interaction effect can be disregarded because it is not statistically significant and is small in comparison to the average effect. This implies that the treatment regimen should be followed in the same order each year. The bulb data's pooled mean Depending on the mix of treatments applied, there was a noticeable variation in the Phosphorus content in bulb. For T_8 (75% RDF + 6.0 t/ha FYM + Azotobacter (4 kg/ha), the maximum Phosphorus content in bulb was 0.98 %. With 0.93 %, T_{10} (75% RDF + 2.0 t/ha VC + Azotobacter (4 kg/ha)) took second place. At 0.26 %, the T_1 (control) exhibited the lowest Phosphorus content in bulb. In comparison to other treatments, particularly the control, the combination of 75% recommended fertiliser dose (RDF), 6.0 t/ha farmyard manure (FYM), and Azotobacter (4 kg/ha) greatly increases the Phosphorus content in onion bulbs. The synergy between the two ingredients contributes to this improvement: the 6.0

t/ha FYM enriches the soil with organic matter, increasing Phosphorus availability and uptake by onion plants, while the 75% RDF provides vital Phosphorus nutrients that are critical for Phosphorus accumulation in bulbs. The Phosphorus-fixing capacity of Azotobacter raises the Phosphorus levels in the bulbs even more. When these components work together to maximise Phosphorus availability, uptake, and assimilation, onion bulbs treated with this combination have a noticeably higher Phosphorus content than bulbs treated with other methods, most notably the control. The studies conducted by Priyanshu *et al.* (2020), Yadav *et al.* (2020), and Singh *et al.* (2021) concluded with similar findings.

According to data on Potassium content in bulb, there were notable variations in treatment combinations for the 2021–2022 *rabi* season. The highest Potassium content in bulb (4.17 %) was found in T_8 (75% RDF + 6.0 t/ha FYM + Azotobacter (4 kg/ha) at par with 4.09 %, T_{10} (75% RDF + 2.0 t/ha VC + Azotobacter) was the next in line. With an average Potassium content in bulb of 1.44 %, T_1 (control) had the lowest yield. The combination of treatments applied during the 2022–2023 *rabi* season resulted in a slight alteration in the data regarding the Potassium content in bulb of the bulb. Treatment T_8 (75% RDF + 6.0 t/ha FYM + Azotobacter (4 kg/ha) yielded the highest Potassium content in bulb (4.56 %), on par with treatment T_{10} (75% RDF + 2.0 t/ha VC + Azotobacter (4 kg/ha), which yielded the second-highest K-content (4.48 %). In the T_1 (control) treatment, the lowest Potassium content in bulb was 1.76 %. A comparable pattern was also revealed by pooled mean analysis. The interaction effect can be disregarded because it is not statistically significant and is small in comparison to the average effect. This implies that the treatment regimen should be followed in the same order each year. The bulb data's pooled mean Depending on the mix of treatments applied, there was a noticeable variation in the Potassium content in bulb. For T_8 (75% RDF + 6.0 t/ha FYM + Azotobacter (4 kg/ha), the maximum Potassium content in bulb was 4.37 %. T_{10} (75% RDF + 2.0 t/ha VC + Azotobacter (4 kg/ha)) took second place with 4.29 %. At 1.60 %, the T_1 (control) exhibited the lowest Potassium content in bulb. In comparison to other treatments, particularly the control, the combination of 75% recommended fertiliser dose (RDF), 6.0 t/ha farmyard manure (FYM), and Azotobacter (4 kg/ha) greatly increases the Potassium content in onion bulbs. The synergy between the two ingredients contributes to this improvement: the 6.0 t/ha FYM enriches the soil with organic matter, increasing Potassium availability and uptake by onion plants, while the 75% RDF provides vital Potassium nutrients that are critical for Potassium accumulation in bulbs. The Potassium-fixing capacity of Azotobacter raises the Potassium levels in the bulbs even more. When these components work together to maximise Potassium availability, uptake, and assimilation, onion bulbs treated with this combination have a noticeably higher Potassium content than bulbs treated with other methods, most notably the control. The studies conducted by Priyanshu *et al.* (2020), Yadav *et al.* (2020), and Singh *et al.* (2021) concluded with similar findings. According to data on Sulphur content in bulb, there were notable variations in treatment combinations for the 2021–2022 *rabi* season. The highest Sulphur content in bulb (2.58 %) was found in T_8 (75% RDF + 6.0 t/ha FYM + Azotobacter (4 kg/ha) at par with 2.45 %, T_{10} (75% RDF + 2.0 t/ha VC + Azotobacter) was the next in line. With an average Sulphur content in bulb of 1.21 %, T_1 (control) had the lowest yield. The combination of treatments applied during the 2022–2023 *rabi* season resulted in a slight alteration in the data regarding the Sulphur content in bulb of the bulb. Treatment T_8 (75% RDF + 6.0 t/ha FYM + Azotobacter (4 kg/ha) yielded the highest Sulphur content in bulb (2.95 %), on par with treatment T_{10} (75% RDF + 2.0 t/ha VC + Azotobacter (4 kg/ha), which yielded the second-highest S-content (2.85 %). In the T_1 (control) treatment, the lowest Sulphur content in bulb was 1.56 %. A comparable pattern was also revealed by pooled mean analysis. The interaction effect can be disregarded because it is not statistically significant and is small in comparison to the average effect. This implies that the treatment regimen should be followed in the same order each year. The bulb data's pooled mean Depending on the mix of treatments applied, there was a noticeable variation in the Sulphur content in bulb. For T_8 (75% RDF + 6.0 t/ha FYM + Azotobacter (4 kg/ha), the maximum Sulphur content in bulb was 2.76 %. T_{10} (75% RDF + 2.0 t/ha VC + Azotobacter (4 kg/ha)) took second place with 2.65 %. At 1.39 %, the T_1 (control) exhibited the lowest Sulphur content in bulb. The combination of 75% recommended fertiliser dose (RDF), 6.0 t/ha farmyard manure (FYM), and Azotobacter (4 kg/ha) significantly raises the sulphur content of onion bulbs when compared to other treatments, especially the control. This improvement results from the synergy between the two ingredients: the 75% RDF supplies essential sulphur nutrients that are essential for sulphur accumulation in bulbs, while the 6.0 t/ha FYM enriches the soil with organic matter, increasing sulphur availability and uptake by onion plants. The ability of Azotobacter to fix sulphur increases the amount of sulphur in the bulbs. Onion bulbs treated with this combination have a notably higher sulphur content than bulbs treated with other methods, most notably the control, because these components work together to maximise sulphur availability, uptake, and assimilation. The studies conducted by Priyanshu *et al.* (2020), Yadav *et al.* (2020), and Singh *et al.* (2021) concluded with similar findings.

Based on the Allyl propyl disulphide data in onion bulbs, significant variations were observed among treatment combinations during the 2021–2022 *rabi* season. The highest content (4.45 mg/100 g) was recorded in T_8 (75% RDF + 6.0 t/ha FYM + Azotobacter), closely followed by T_{10} (75% RDF + 2.0 t/ha VC + Azotobacter) with 4.39 mg/100 g. Conversely, T_1 (control) exhibited the lowest Allyl propyl disulphide content in bulbs at 3.17 mg/100 g on average. During the 2022–2023 rabi season, alterations in treatment combinations impacted the Allyl propyl disulphide content in onion bulbs. Treatment T_8 (75% RDF + 6.0 t/ha FYM + Azotobacter at 4 kg/ha) exhibited the highest content at 5.02 mg/100 g, while T_{10} (75% RDF + 2.0 t/ha VC + Azotobacter at 4 kg/ha) followed closely at 4.95 mg/100 g. Conversely, the control treatment (T_1) yielded the lowest Allyl propyl disulphide content in bulbs, measuring 3.70 mg/100 g. The pooled mean analysis echoed a similar trend, discounting the statistically insignificant interaction effect. This suggests maintaining a consistent treatment sequence yearly. Across treatment blends, notable variations in Allyl propyl disulphide content in bulbs were evident. T_8 (75% RDF + 6.0 t/ha FYM + Azotobacter at 4 kg/ha) recorded the highest content at 4.74 mg/100 g, followed by T_{10} (75% RDF + 2.0 t/ha VC + Azotobacter at 4 kg/ha) at 4.67 mg/100 g. Conversely, the control (T_1) had the lowest content at 3.44 mg/100 g. The combination of 75% recommended fertiliser dose (RDF), 6.0 t/ha farmyard manure (FYM), and Azotobacter (4 kg/ha) significantly raises the Allyl propyl disulphide content of onion bulbs when compared to other treatments, especially the control. This improvement results from the synergy between the two ingredients: the 75% RDF supplies essential Allyl propyl disulphide nutrients that are essential for Allyl propyl disulphide accumulation in bulbs, while the 6.0 t/ha FYM enriches the soil with organic matter, increasing Allyl propyl disulphide availability and uptake by onion plants. The ability of Azotobacter to fix Allyl propyl disulphide increases the amount of Allyl propyl disulphide in the bulbs. Onion bulbs treated with this combination have a notably higher Allyl propyl disulphide content than bulbs treated with other methods, most notably the control, because these components work together to maximise Allyl propyl disulphide availability, uptake, and assimilation. The studies conducted by Dhakad *et al.* (2019), Prusty *et al.* (2019), Priyanshu *et al.* (2020) and Singh *et al.* (2023) concluded with similar findings.

Table 1 : Effect of integrated nutrient management on number of scales per bulb and equatorial diameter of bulb of Onion.

		TSS (°Brix)			**Nitrogen content in bulb (%)**		
Treatment Notation	**Treatment Details**	**2021**	**2022**	**Pooled Mean**	**2021**	**2022**	**Pooled Mean**
T_1	Control	10.09	11.17	10.63	1.42	1.58	1.50
T_2	100% RDF [NPK- 120:60:60 kg/ha]	12.96	14.04	13.50	1.62	1.78	1.70
T_3	75% RDF + 6.0 t/ha FYM	14.32	15.39	14.86	1.69	1.85	1.77
T_4	75% RDF + 1.0 t/ha PM	13.54	14.61	14.07	1.77	1.92	1.85
T_5	75% RDF + 2.0 t/ha VC	14.29	15.37	14.83	1.56	1.71	1.64
T_6	75% RDF + 3.0 t/ha FYM + 0.5 t/ha PM	15.11	16.21	15.66	1.65	1.81	1.73
T_7	75% RDF + 1.0 t/ha VC + 0.5 t/ha PM	14.38	15.47	14.92	2.03	2.20	2.12
T_8	75% RDF + 6.0 t/ha FYM + Azotobacter (4 kg/ha)	19.63	20.72	20.17	3.21	3.40	3.31
T_9	75% RDF + 1.0 t/ha PM + Azotobacter (4 kg/ha)	17.76	18.80	18.28	2.28	2.50	2.39
T_{10}	75% RDF + 2.0 t/ha VC + Azotobacter (4 kg/ha)	18.66	19.70	19.18	3.04	3.23	3.13
T_{11}	50% RDF + 12.0 t/ha FYM	15.68	16.70	16.19	2.18	2.46	2.32
T_{12}	50% RDF + 2.0 t/ha PM	15.87	16.90	16.39	2.46	2.66	2.56
T_{13}	50% RDF + 4.0 t/ha VC	15.76	16.78	16.27	2.55	2.73	2.64
T_{14}	50% RDF + 6.0 t/ha FYM + Azotobacter (4 kg/ha)	16.59	17.61	17.10	2.56	2.74	2.65
T_{15}	50% RDF + 2.0 t/ha PM + Azotobacter (4 kg/ha)	16.05	17.08	16.57	2.49	2.71	2.60
T_{16}	50% RDF + 2.0 t/ha VC + Azotobacter (4 kg/ha)	16.47	17.49	16.98	2.49	2.67	2.58
F' Test		**S**	**S**	**S**	**S**	**S**	**S**
$CD_{0.05}$		**0.59**	**0.68**	**0.81**	**0.75**	**1.31**	**0.14**
SE. m (±)		**0.19**	**0.22**	**0.27**	**0.24**	**0.42**	**0.05**
CV. (%)		**2.40**	**2.29**	**2.34**	**2.86**	**2.69**	**2.53**

Table 2 : Effect of integrated nutrient management on polar diameter of bulb and individual bulb weight of Onion.

		Phosphorus content in bulb (%)			Potassium content in bulb (%)		
Treatment Notation	**Treatment Details**	**2021**	**2022**	**Pooled Mean**	**2021**	**2022**	**Pooled Mean**
T_1	Control	0.22	0.29	0.26	1.44	1.76	1.60
T_2	100% RDF [NPK- 120:60:60 kg/ha]	0.44	0.51	0.47	1.95	2.27	2.11
T_3	75% RDF + 6.0 t/ha FYM	0.47	0.54	0.50	2.43	2.74	2.59
T_4	75% RDF + 1.0 t/ha PM	0.59	0.66	0.63	2.15	2.46	2.31
T_5	75% RDF + 2.0 t/ha VC	0.61	0.68	0.65	2.42	2.74	2.58
T_6	75% RDF + 3.0 t/ha FYM + 0.5 t/ha PM	0.48	0.55	0.52	2.55	2.89	2.72
T_7	75% RDF + 1.0 t/ha VC + 0.5 t/ha PM	0.69	0.76	0.72	2.74	3.12	2.93
T_8	75% RDF + 6.0 t/ha FYM + Azotobacter (4 kg/ha)	0.94	1.01	0.98	4.17	4.56	4.37
T_9	75% RDF + 1.0 t/ha PM + Azotobacter (4 kg/ha)	0.90	0.98	0.94	3.93	4.32	4.13
T_{10}	75% RDF + 2.0 t/ha VC + Azotobacter (4 kg/ha)	0.89	0.96	0.93	4.09	4.48	4.29
T_{11}	50% RDF + 12.0 t/ha FYM	0.60	0.67	0.64	2.99	3.38	3.19
T_{12}	50% RDF + 2.0 t/ha PM	0.66	0.73	0.69	3.23	3.58	3.41
T_{13}	50% RDF + 4.0 t/ha VC	0.63	0.70	0.67	3.42	3.75	3.58
T_{14}	50% RDF + 6.0 t/ha FYM + Azotobacter (4 kg/ha)	0.71	0.79	0.75	3.58	3.91	3.75
T_{15}	50% RDF + 2.0 t/ha PM + Azotobacter (4 kg/ha)	0.67	0.75	0.71	3.63	3.96	3.80
T_{16}	50% RDF + 2.0 t/ha VC + Azotobacter (4 kg/ha)	0.67	0.74	0.70	3.59	3.91	3.75
F' Test		**S**	**S**	**S**	**S**	**S**	**S**
$CD_{0.05}$		**4.23**	**3.05**	**0.12**	**0.23**	**0.56**	**0.28**
SE. m (±)		**1.36**	**0.98**	**0.04**	**0.08**	**0.18**	**0.09**
CV. (%)		**8.37**	**7.49**	**7.91**	**4.32**	**3.89**	**4.04**

Table 3 : Effect of integrated nutrient management on bulb yield per hectare of Onion.

		Sulphur content in bulb (%)			Allyl propyl disulphide content in bulb (mg/100 g)		
Treatment Notation	**Treatment Details**	**2021**	**2022**	**Pooled Mean**	**2021**	**2022**	**Pooled Mean**
T_1	Control	1.21	1.56	1.39	3.17	3.70	3.44
T_2	100% RDF [NPK- 120:60:60 kg/ha]	1.39	1.75	1.57	3.44	3.97	3.71
T_3	75% RDF + 6.0 t/ha FYM	1.56	1.91	1.74	3.55	4.07	3.81
T_4	75% RDF + 1.0 t/ha PM	1.44	1.79	1.61	3.51	4.03	3.77
T_5	75% RDF + 2.0 t/ha VC	1.57	1.92	1.74	3.19	3.72	3.46
T_6	75% RDF + 3.0 t/ha FYM + 0.5 t/ha PM	1.48	1.83	1.65	3.76	4.28	4.02
T_7	75% RDF + 1.0 t/ha VC + 0.5 t/ha PM	2.11	2.46	2.28	4.04	4.56	4.30
T_8	75% RDF + 6.0 t/ha FYM + Azotobacter (4 kg/ha)	2.58	2.95	2.76	4.45	5.02	4.74
T_9	75% RDF + 1.0 t/ha PM + Azotobacter (4 kg/ha)	2.31	2.69	2.50	4.23	4.82	4.53
T_{10}	75% RDF + 2.0 t/ha VC + Azotobacter (4 kg/ha)	2.45	2.85	2.65	4.39	4.95	4.67
T_{11}	50% RDF + 12.0 t/ha FYM	1.89	2.30	2.10	3.82	4.40	4.11
T_{12}	50% RDF + 2.0 t/ha PM	2.24	2.64	2.44	4.23	4.81	4.52
T_{13}	50% RDF + 4.0 t/ha VC	2.21	2.61	2.41	4.34	4.92	4.63
T_{14}	50% RDF + 6.0 t/ha FYM + Azotobacter (4 kg/ha)	2.41	2.82	2.62	4.20	4.78	4.49
T_{15}	50% RDF + 2.0 t/ha PM + Azotobacter (4 kg/ha)	2.30	2.70	2.50	3.91	4.49	4.20
T_{16}	50% RDF + 2.0 t/ha VC + Azotobacter (4 kg/ha)	2.32	2.72	2.52	3.87	4.45	4.16
F' Test		**S**	**S**	**S**	**S**	**S**	**S**
$CD_{0.05}$		**3.17**	**1.00**	**0.14**	**0.11**	**1.74**	**0.13**
SE. m (±)		**1.02**	**0.32**	**0.05**	**0.04**	**0.56**	**0.04**
CV. (%)		**3.43**	**2.71**	**2.98**	**1.59**	**1.37**	**1.43**

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