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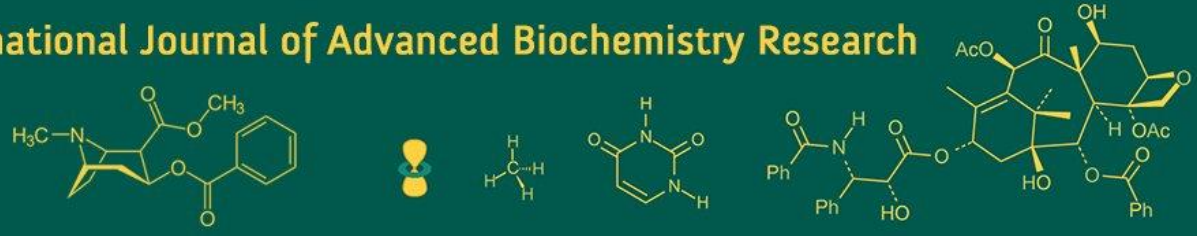

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Integrated nutrient approaches for maximizing growth, yield and quality in onion (*Allium cepa* L.) cv. Bhima Kiran

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Abstract
A field trial was carried out during the rabi crop cycle of 2023 to assess the effect of integrated nutrient management on growth, yield and quality of onion (*Allium cepa* L.) cv. Bhima Kiran at Horticulture Research Farm-1 of the Department of Horticulture, Babasaheb Bhimrao Ambedkar University, Lucknow (U.P.). The experiment was implemented using a randomized block design (RBD) at a spacing of 20 cm × 10 cm with three replications in sandy loam soil with an alkaline pH of 8.5. The evaluation encompassed ten blends of inorganic (N, P and K), organic (FYM) and bio-based fertilizers (phosphorous solubilizing bacteria). From the experiment, it was witnessed that the implementation of 75% RDF + 25% FYM (T_7) yielded significantly loftier growth characteristics like tallness of the plant (cm), leaf count, foliage length (cm) and neck diameter of the plant (mm) as compared to other treatments, while the minimum values were obtained from treatment T_0 (control). The yield attributes like number of bulbs harvested per plot, bulb output per plot (Kg), bulb size (cm), bulb neck thickness (cm), mean bulb weight (g), fresh bulb production (q/ha) and scale count per bulb were at their maximum in treatment T_7 (75% RDF + 255 FYM), while the minimum values were obtained in treatment T_0 (control). Similar trends were followed for quality attributes like T.S.S. (^{0}Brix), ascorbic acid (mg/100g) and pH estimation, respectively.

Keywords: Onion, nutrient management, yield attributes, RDF, FYM and PSB

Introduction
Onion (*Allium cepa* L.), with a chromosome number of 2n = 16, widely recognizes as the "Queen of the Kitchen," is a crucial commercial vegetable and spice crop produced extensively worldwide. It belongs to the family Alliaceae and is utilized in various culinary forms, including as a cooked vegetable, a salad ingredient and in the preparation of sauces, soaps and pickles. Raw onion is known for its medicinal properties, attributed to its phenolic compounds like catechol, which have antifungal properties (Santas *et al*., 2010) [14]. Onion juice serves as an insect repellent and is also used in fabric dyes. The sharp flavor of onion bulbs is attributed to the aromatic compound allyl propyl disulphide ($C_6H_{12}O_2$), an organic molecule rich in sulfur. Onions contain 11 amino acids. In a 100-gram portion of a raw onion bulb, the nutritional composition includes approximately 86.8 grams of water content, 11 grams of saccharides, 1.2 grams of dietary protein, 0.6 grams of fiber, 0.4 grams of minerals, 0.08 milligrams of thiamine, 1 milligram of vitamin C, 180 milligrams of calcium, 50 milligrams of phosphorus and 0.01 milligrams of riboflavin (Boss *et al*., 2003) [3].
India is ranked second in the world for onion cultivation, following China and holds the third position in onion exports, following the Netherlands and China. In India, onions are cultivated over an area of 1,222.0 thousand hectares, achieving an annual yield of 22,819 thousand metric tonnes (Anonymous 2018-19) [1]. Onion bulb formation is primarily regulated by day length, but other factors such as planting schedule, growing temperature, nutrition and irrigation also play significant roles. Onions require ample manure for optimal growth. Numerous fertilizer experiments have shown that to achieve high onion yields, a combination of all three primary nutrients—nitrogen, phosphorus and potassium (NPK)—is essential, alongside secondary elements. The continuous decline in soil health and the existence of nutrient imbalances in onion fields have highlighted soil nutrient management as

a critical aspect of environmentally conscious onion farming. Integrated Nutrient Management (INM) has been recognized as an effective approach (Dimri and Singh, 2005) [5]. There is a growing acceptance of transitioning from exclusively using organic sources to incorporating some inorganic fertilization. This transition underpins the concept of INM, which typically involves the use of both inorganic fertilizers and manures. INM advocates for the careful and balanced use of selected nutrient inputs to ensure access to all important nutrients, thereby supporting sustained crop production.

Materials and Methods

The research was conducted at the Horticulture Research Farm 1 within the Department of Horticulture, Babasaheb Bhimrao Ambedkar University, Lucknow (U.P.) during the Rabi season of 2023-24. The experimental plot's soil was texturally classified as sandy loam and exhibited a slightly alkaline pH of 8.5, E.C. 0.24 dSm^{-1} and E.S.P. 13.50. The seeds were sown in a 15-cm-high, 3 meters long and 1-meter-wide nursery bed on October 19, 2023. The seedlings were replanted at a distance of 20 cm × 10 cm, with spacing between and within rows. The experiment consisted of 10 treatments [T_0 (control), T_1 (100% RDF), T_2 (100% FYM), T_3 (100% PSB), T_4 (50% RDF + 50% FYM), T_5 (50% RDF + 50% PSB), T_6 (50% FYM + 50% PSB), T_7 (75% RDF + 25% FYM), T_8 (75% RDF + 25% PSB) and T_9 (75% FYM + 25% PSB)], which were laid out in a randomized block design with three replications. The treatments featured ten distinct combinations of inorganic (N, P and K), organic (FYM), and biofertilizers (phosphorous solubilizing bacteria).

Influence of organic manures, i.e., FYM, manufactured fertilizers containing N, P and K combined with PSB, on the growth, yield and quality of onion (Cultivar Bhima Kiran). The soil within the research plot consisted of available N_2 (115.50 kg/ha), P_2O_5 (45 kg/ha) and accessible K_2O (193.40 kg/ha). The recommended dose for the crop onion is 100 kg of nitrogen, 50 kg of phosphorus, and 80 kg of potash per hectare. At the moment of transplanting, fifty percentage of the nitrogen dose, the whole phosphorous dose, and the complete potash dose were applied as recommended. The rest of the nitrogen dose was administered in two portions, i.e., the first 30 DAT and the second 45 DAT. Growth benchmarks like plant height (cm), leaf length (cm), number of leaves per plant and neck thickness of the plant (mm) were measured at 30, 60 and 90 DAT. The neck thickness was measured using a Vernier caliper. Yield parameters like bulb size in cm (polar diameter and equatorial diameter), neck thickness of bulb (cm), average weight of bulb (g), bulb yield (kg/plot) and bulb yield (q/ha) were recorded at the time of harvest of the onion crop. Quality parameters like total soluble solids (°B) were calibrated using a hand refractometer, ascorbic acid (Vitamin-C) was assessed using 2,6-dichlorophenol indophenol d ye and pH was monitored employing a digital pH meter. The bulbs were harvested at maturity, when the neck fell 50-70%.

Results and Discussion

Growth parameter

Plant height is a crucial morphological trait influencing crop yield. It has a direct relationship with biomass production and photosynthetic activity, resulting in higher yields and productivity (table 1). Measurements of plant height were taken at 30, 60 and 90 days post- transplant. Notable variations were observed across different treatments at these time intervals. Maximum plant height (34.78 cm, 63.38 cm, 65.50 cm) at 30^{th}, 60^{th} and 90^{th} DAT was recorded with treatment T_7 (75% NPK + 25% FYM), while minimum plant height (21.22 cm, 32.92 cm, 37.90 cm) was observed in combination T_0 (control). The highest plant height was observed with treatment T_7 at different growth stages; this could be the result of integrated utilization of natural fertilizer (FYM) and synthetic fertilizers (Urea, DAP and MOP). The same results were also found by Kumar (2021) [8]. Organic manures provide a variety of essential macro- and micronutrients to plants, which are crucial for their proper growth and development. Their slow decomposition gradually releases these nutrients, promoting plant growth. Additionally, sufficient nitrogen application positively impacts plant height. These findings are in conformity with Nandal and Bedi (2010) [11] and Khandelwal (2010) [7].

Leaves are directly associated with the synthesis of food reserves and chlorophyll content. Increased leaf density per plant leads to increased food reserves and, consequently, a higher bulb yield. The leaf count per plant was noted at 30, 60 and 90 DAT. At 30^{th}, 60^{th} and 90^{th} DAT, the maximum number of leaves per plant (3.86, 11.86 and 13.21) were recorded with treatment T_7 (75% NPK + 25% FYM), while the least number of leaves (3.41, 6.98 and 9.12) were recorded with treatment T_0 (control). The same results also found by Kumar (2021) [8].

Leaf length regulates the photosynthesis activity, which directly affects the bulb, yield and quality of the onion. The length of the leaves was recorded at 30, 60 and 90 DAT. Notable variations were observed for different treatments. The maximum length of leaves (28.16 cm, 46.72 cm and 63.66 cm) was observed in treatment T_7 (75% RDF + 25% FYM), while the minimum value (10.58 cm, 20.60 cm and 30.60 cm) was seen in treatment T_0 (control). Similar results were notified by Brinjh *et al.* (2014) [4], Rabari *et al.* (2014) [13] and Mohanty *et al.* (2015) [10].

Neck thickness is an essential qualitative trait that indicates plant vigor and influences the shelf life of onion bulbs. Bulbs with thinner necks can be stored for longer periods and maintain better quality. Maximum neck thickness (6.22 mm, 8.10 mm and 11.08 mm) was observed at 30, 60 and 90 DAT in treatment T_7 (75% NPK + 25% FYM), while the lowest neck thickness (1.72 mm, 2.34 mm and 4.18 mm) was observed in T_0 (control). Comparable results were revealed by Sedera *et al.* (2012) [15] and Mandal *et al.* (2013) [9].

Yield Parameters

The yield parameters of onions are crucial for optimizing production and ensuring a high-quality, marketable crop. Yield parameters provide valuable insights into various aspects of onion cultivation, from growth characteristics to post-harvest qualities. Key yield parameters of onions include the quantity of bulbs per plot after harvest, bulb harvest per plot (Kg), bulb size (cm), neck thickness of the bulb, average weight of the bulb (g), fresh bulb yield (q/ha), and number of scales per bulb, as detailed in Table 2.

Among these parameters, the utmost number of bulbs per plot was found (44.33) in treatment T_7 (75% NPK + 25% FYM), while the lowest number of bulbs per plot (34.63) was noticed in treatment T_0 (control), which may be due to a deficit of nutrition. The topmost bulb yield per plot was

recorded at 5.34 kg in T_7 (75% NPK + 25% FYM), while the minimal bulb yield per plot (3.32 kg) was recorded in T_0 (control). Similar studies were filed by Yohannes *et al.* (2013) [18] and Prabhakar *et al.* (2017) [1].

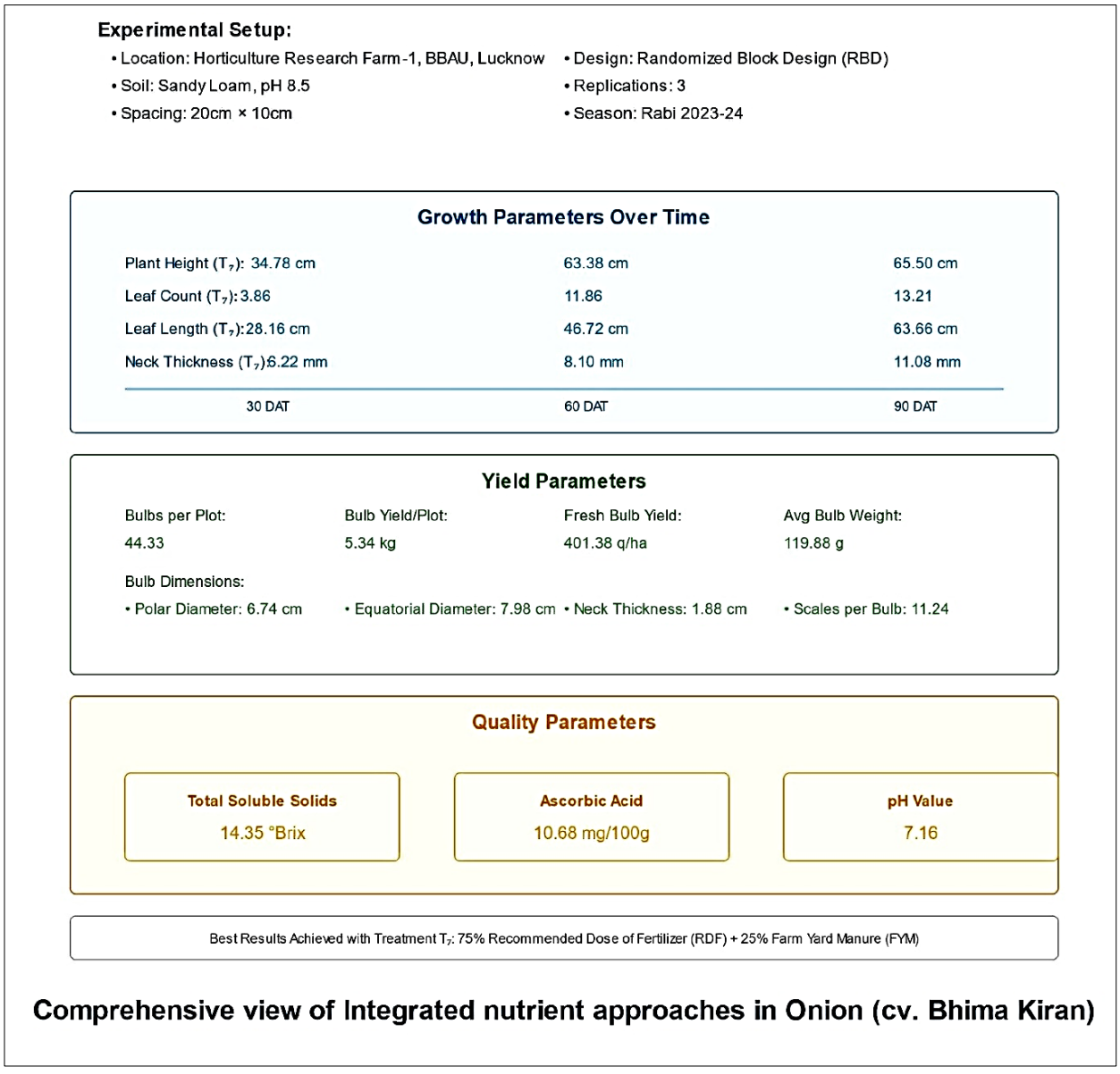
Similarly, INM had a considerable effect on bulb size, i.e., polar and equatorial diameters. The maximum bulb width (6.74 cm and 7.98 cm) was recorded in treatment T_7 (75% NPK + 25% FYM), while the minimum bulb diameter (3.81 cm and 4.58 cm) was spotted in treatment T_0 (control). In the case of neck thickness, the maximum mean value (1.88 cm) was recorded in treatment T_7 (75% NPK + 25% FYM), and its minimum mean value (1.23 cm) was recorded in treatment T_0 (control). Also, the maximum mean value of average bulb weight (119.88 g) was recorded in T_7 (75% NPK + 25% FYM), and the minimum value (90.65 g) was obtained in treatment T_0 (control). Such types of studies were reported by Shedeed *et al.* (2014) [16].

The average maximum average value of fresh bulb yields (401.38 q/ha) was recorded in treatment T_7 (75% NPK + 25% FYM), while the minimum value (226.67 q/ha) was found in T_0 (control). Likewise, INM had a notable effect on the number of scales per bulb. The maximum mean value (11.24) was registered in treatment T_7 (75% NPK + 25% FYM), while the minimum value was found in T_0 (control). These outcomes correspond with Verma *et al.* (2014) [17] and Banjare *et al.* (2015) [2].

Quality parameters

An adequate, proper and equitable access to nutrition during the entire growth stage to harvesting is a key condition for the caliber of bulb products (Jamir *et al.*, 2013) [6]. Bulb quality also depends on environmental conditions, field preparation, cultural practices, diseases and pest management, appropriate time harvesting of crops, and post-harvest management practices.

Total soluble solids, ascorbic acid content and pH value are major quality parameters in the current study (table 3). The maximum total soluble solids (T.S.S.) were seen (14.35 °B) in treatment T_7 (75% NPK + 25% FYM), while the minimum T.S.S. (10.56 °B) was found in T_0 (control). The maximum ascorbic acid content (10.68 mg/100 g) was observed in treatment T_7 (75% NPK + 25% FYM) and the minimum value of ascorbic acid (8.00 mg/100 g) was witnessed in treatment T_0 (control). The maximum mean pH value (7.16) was observed in treatment T_7 (75% NPK + 25% FYM), while the minimum pH value was found in T_0 (control), i.e., 6.30. These insights are in compliance with Brinjh *et al.* (2014) [4] and Mandal *et al.* (2013) [9].



Comprehensive view of Integrated nutrient approaches in Onion (cv. Bhima Kiran)

Table 1: Effect of integrated nutrient management on growth parameters of onion

Treatments Details	Plant height (cm)			Number of leaves			Length of leaves (cm)			Neck thickness (mm)		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
T_0	21.22	32.92	37.90	3.41	6.98	9.12	10.58	20.60	30.60	1.72	2.34	4.18
T_1	29.72	59.24	64.00	3.80	7.17	9.16	22.24	34.90	46.72	3.24	4.70	6.10
T_2	27.40	58.76	61.30	3.24	7.92	9.96	22.96	35.66	52.94	4.28	5.42	7.96
T_3	27.68	56.58	60.08	3.60	7.38	9.78	26.18	39.60	55.10	4.68	5.98	8.08
T_4	30.36	56.94	61.56	3.60	7.42	10.36	22.48	34.16	54.56	4.46	6.06	7.32
T_5	31.20	57.88	63.28	3.72	8.56	11.38	22.32	35.26	49.34	4.36	6.24	9.00
T_6	30.42	57.72	60.66	3.24	9.32	10.62	21.30	37.84	50.96	4.26	6.00	8.68
T_7	34.78	63.38	65.50	3.86	11.86	13.21	28.16	46.72	63.66	6.22	8.10	11.08
T_8	32.92	62.50	63.84	3.83	9.26	12.26	27.20	45.96	60.38	6.10	7.90	10.70
T_9	31.44	59.70	60.60	3.32	8.58	11.19	26.50	41.12	59.84	6.06	7.86	11.06
SE(m)±	0.299	0.578	0.839	0.050	0.105	0.118	0.256	0.434	0.772	0.047	0.066	0.134
$CD_{5\%}$	0.896	1.732	2.513	0.150	0.315	0.353	0.766	1.300	2.312	0.141	0.197	0.400

Table 2: Effect of integrated nutrient management on yield parameters of onion

Treatments	No. of bulbs per plot	Bulb yield per plot (Kg)	Bulb size (cm)		Neck thickness of bulb	Average weight of bulb (g)	Fresh bulb yield (q/ha)	No. of scales/bulb
			Polar diameter	Equatorial diameter				
T_0	34.63	3.32	3.81	4.58	1.23	90.65	226.67	6.34
T_1	40.33	4.36	6.31	7.35	1.58	116.76	330.53	9.43
T_2	39.45	4.67	4.57	6.23	1.52	110.25	314.16	8.40
T_3	37.00	3.86	4.52	5.90	1.40	100.16	293.04	7.92
T_4	38.86	4.66	5.28	7.26	1.65	112.65	325.11	8.56
T_5	39.44	4.31	5.86	7.32	1.66	111.36	320.36	8.36
T_6	38.68	4.21	5.34	7.10	1.44	110.20	318.76	8.32
T_7	44.33	5.34	6.74	7.98	1.88	119.88	401.38	11.24
T_8	43.21	5.30	6.31	7.44	1.68	117.56	400.42	11.00
T_9	42.56	4.92	5.90	7.00	1.62	116.25	399.76	10.92
SE(m)±	0.448	0.049	0.086	0.094	0.015	1.217	3.613	0.109
$CD_{5\%}$	1.343	0.147	0.258	0.283	0.046	3.643	10.819	0.325

Table 3: Effect of integrated nutrient management on quality parameters of onion

Treatments	T.S.S. (^{0}B)	Ascorbic acid (mg/100g)	pH
T_0	10.56	8.00	6.30
T_1	13.64	10.36	6.74
T_2	13.32	8.68	6.88
T_3	11.38	8.72	6.81
T_4	13.54	9.56	6.54
T_5	11.67	8.62	6.72
T_6	12.00	8.14	6.65
T_7	14.35	10.68	7.16
T_8	13.85	10.46	6.90
T_9	13.10	10.22	6.42
SE(m)±	0.139	0.097	0.073
$CD_{5\%}$	0.415	0.290	0.219

Conclusion

Drawing from the results of this study, it can be concluded that the combined application of organic and inorganic fertilizers, especially 75% RDF and 25% FYM, resulted in the maximum non-reproductive growth and bulb weight of onions grown under Lucknow conditions.

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