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Varietal Response to Organic and Inorganic Fertilizers on Bulb Yield, Storability, and Production Economics of Onion (*Allium cepa* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The field experiment was conducted in the Rabi season of 2021-22 in the research farm of the Regional Research Center, Raiya (Jhajjar) of Maharana Pratap Horticultural University, Karnal, Haryana to examine the impact of organic manures and inorganic fertilizers on the growth, bulb yield and self-life of two indigenous onion varieties was examined. The treatment combinations comprised seven treatments along with one control that was arranged in a randomized block design (factorial) with four replications and two varieties namely Hisar Onion-2 and Hisar Onion-4. The results of the study showed that bulb yield-related parameters such as average fresh weight of bulbs (82.39 g), yield per plot (26.74 kg), and yield per hectare (29.71 t) were recorded maximum in the treatment T6. However, the better storage life of bulbs was estimated in treatment control which was at par with treatment T3 i.e., physiological loss in weight (20.23%), sprouting (3.14%), and rotting (11.43%) were observed minimum after 120 days of storage period. Hisar onion-4 was found superior in all the bulb yield and shelf-life parameters in comparison to Hisar Onion-2. Treatment consisting of 50% recommended dose of NPK + 50% RDN supplied through Vermi-compost recorded maximum net return (Rs.1, 97,942) and benefit-cost ratio (2.25). Therefore, it can be inferred that the combined use of organic manures and inorganic fertilizers contributes to the improved shelf life of onion bulbs and enhances the long-term production potential of the soil.

Keywords: Onion; organic; inorganic; manures; fertilizers; yield and variety.

1. INTRODUCTION

The onion (*Allium cepa* L.) belongs to the Amaryllidaceae family and is one of the most valuable commercial vegetable crops grown in India and around the world. It is a vital component in every household as a spice, vegetable, and salad, and hence fetches a high price in the domestic market. Onions are valued for their flavor and pungency due to the presence of the volatile sulfur compound allyl propyl disulfide. In India, the use of inorganic fertilizers, agrochemicals, and the extension of onion growing into non-traditional regions all contributed to an increase in onion production in the past [1]. India's average onion production per hectare is 16.41 t ha-1, which is significantly less than the global average of 20.61 t ha-1 [2]. Instead of adding more agricultural inputs like inorganic fertilizers, productivity needs to be boosted with the help of the natural resources that are already available [3-6]. This can be done by cultivating improved cultivars and improving nutrient usage efficiency [7,8] because the widespread use of agrochemicals and synthetic fertilizers has led to various undesirable environmental effects. The exclusive and continuous application of inorganic fertilizers led to a decrease in the soil's organic matter content and diminished its micronutrient content. The decline in soil organic matter adversely affected the soil's water-holding capacity, soil structure, and water infiltration and resulting in increased soil compaction. Simultaneously, the depletion of soil micronutrients resulted in deficiencies of these essential elements [9].

According to Doran and Parkin, [10] soil organic matter serves as an indicator of the overall quality of the soil by influencing its biological, physical, and chemical aspects. Additionally, it serves as a reservoir for plant nutrients and serves as a substrate for soil microbes [9]. The addition of organic manure is essential for revitalizing soil health and sustaining prolonged onion production in tropical and subtropical climates. However, while organic manure application alone enhances soil health, there is a decrease in bulb yield in organic farming systems, ranging from 22% to 45% compared to inorganic systems in the early years, according to these authors [11]. Practices for managing nutrients that involve a combination of chemical fertilizers organic manures and bio-fertilizers thus become critical for enhancing bulb output and maintaining the vitality of the soil. The current investigation indicates that the farmers are applying excess chemical fertilizers as per crop requirements. The integrated nutrient management approach also improved both the quality and post-harvest storage life of the onion crop. Considering this, we conducted a field experiment to explore the impact of organic manures and inorganic fertilizers on both bulb yield and the storage life of onions.

2. MATERIALS AND METHODS

The research work was carried out during the Rabi season 2021-22 in the research farm of the Regional Research Center, Raiya (Jhajjar) of Maharana Pratap Horticultural University, Karnal, Haryana. It is situated about 8 km towards South from District Jhajjar on Jhajjar – Kosali road with an elevation of 222 m above the mean sea level. It experiences a typical semi-arid climate characterized by hot and dry summers and extremely cold winters, with an annual rainfall of 456 mm. The experimental site's topography was uniform, the field was leveled flat, and the soil was sandy loam with a medium water retention capacity. Experimental material consists of eight treatments of different nutrient status and two different varieties Hisar Onion-2 and Hisar Onion-4. The experiment was arranged in a factorial randomized block design with four replications including one absolute control and one recommended dose of fertilizers (RDF) (125:50:25 kg NPK/ha). At the time of transplanting, half of the required nitrogen, as well as the entire quantity of the phosphorus and potash were applied as basal dose. The remaining nitrogen dose was administered in two equal split doses, 30 and 45 days after transplanting, while organic manures, including farmyard manure, vermicompost, and poultry manure, were thoroughly mixed in the top 15 cm of soil as per treatment during field preparation. The various treatment combinations along with their symbols are presented in Table 1. Eight-week-old seedlings were dipped into the solution of phosphorous-solubilizing bacteria for 30 minutes as per treatment except for control and then transplanted in flat beds of 3 m x 3 m size at a spacing of 15 cm x 10 cm.

The observations were collected on the bulb yield characteristics for randomly selected five plants per treatment per plot in each replication and the observations recorded for yield parameters were the average weight of fresh bulb (g), number of bulbs per kg, yield per plot (kg), yield per hectare (tonnes). For a collection of data on self- life of onions, three kilograms of onion bulbs from each treatment and replication were stored in ventilated wooden cages at room temperature and observations were recorded at 40, 80, and 120 days after storage for sprouting, rotting, and physiological loss in weight (%). To calculate the cost of bulb cultivation, all operations including nursery and land preparation, soil reclamation, planting materials, intercultural operation, irrigation, plant protection, harvesting, and cost of various manures and fertilizers were taken into consideration. The gross and net incomes were calculated along with the benefit-cost ratio. The data about various parameters were subjected to statistical analysis using the Analysis of Variance (ANOVA) technique as outlined by Panse and Sukhatme [12].

3. RESULTS AND DISCUSSION

The maximum average fresh weight of the bulb (82.39 g) was recorded when the nutrient was applied with 50% RDF through NPK + 50% RDN through VC, which was observed statistically at par with the application of 50% RDF through NPK + 50% RDN through PM (80.38 g) and RDF (79.98 g). Whereas the minimum average fresh weight of the bulb (54.63 g) was reported in the control treatment. Within the onion varieties, Hisar Onion-4 (26.68 t) produced significantly more bulb yield per plot and yield per hectare than Hisar Onion-2 (23.08 kg and 25.46 t. The increase in bulb yield contributing characters as mentioned in Fig. 1. is because organic manures are advantageous to plants because they are a source of many crucial macro and micronutrients. They are rich in organic matter and boost the availability and uptake of nitrogen, phosphorous and potassium, which stimulates photosynthesis and metabolic activities and has a beneficial impact on plant cell division and elongation, which leads to an increase in size and fresh weight of bulb ultimately results in an overall improvement in the yield of onion bulbs. Verma et al. [13] Singh et al. [14] and Dhaker et al. [15] also have similar findings.

Hisar Onion-4 (73.60 g) had produced significantly higher fresh weight of bulb than Hisar Onion-2 (71.78 g). Lesser number of bulbs per kg (12.15) was recorded in treatment T6 (50% RDF through NPK + 50% RDN through VC) followed by treatment having 50% RDF through NPK + 50% RDN through PM (12.46) and RDF (12.52), whereas, the maximum number of bulbs per kg (18.37) was observed in T8 (control). In case of onion varieties the minimum number of bulbs per kg was noted in Hisar Onion-4 (13.82) in comparison to Hisar Onion-2 (14.19). Application of 50% RDF through NPK + 50% RDN through VC produced significantly higher bulb yield per plot (26.74 kg) and yield per hectare (29.71 t), which was observed statistically at par with the application of 50% RDF through NPK + 50% RDN through PM (26.20 kg and 29.11 t) and RDF (25.57 kg and 28.42 t). The control treatment produced the minimum bulb yield per plot and yield per hectare (16.95 kg and 17.23 t). Among the onion varieties, Hisar Onion-4 (24.18 kg and 26.68 t) produced significantly more yield per plot and yield per hectare than Hisar Onion-2 (23.08 kg and 25.46 t).

As regards the storage studies of 40 days after storage, the rotting percentage was observed least (0.34%) in control (T8), whereas the maximum rotting percentage (0.75%) was observed in treatment consisting of 100% RDF (T1). However, after 80 and 120 days of storage, it was observed minimum (2.45%) and (11.18%) in control (T8) which was statistically at par with treatment T3 – 100% RDN through VC (2.63%) and (11.43%) respectively, whereas maximum rotting percentage at 80 days after storage (3.72%) and 120 days after storage (16.03%) was observed in treatment consisting 100% RDF (T1) as depicted in Table 2. This could be attributed to the elevated nitrogen application levels, which may prompt the plants to produce larger bulbs with soft and succulent tissues. This condition renders them more susceptible to bacterial infections, leading to the development of bulbs with thick necks that hinder proper drying and consequently result in rotting. Diaz-Perez et al. [16] concluded that excessive application of nitrogen fertilizer should be avoided although it minimizes the risk of bolting it tends to elevate bulb decay.

Table 1. Treatments detail various organic and inorganic fertilizers and their combination

Treatment symbols	Treatment details
T1	Recommended dose of fertilizer (125:50:25 kg/ha)
T2	Recommended dose of nitrogen supplied through farmyard manure
T3	Recommended dose of N supplied through vermicompost
T4	Recommended dose of N supplied through poultry manure
T5	50% Recommended dose of NPK + 50% Recommended dose of N supplied through Farm Yard Manure
T6	50% Recommended dose of NPK + 50% Recommended dose of N supplied through vermicompost
T7	50% Recommended dose of NPK + 50% Recommended dose of N supplied through poultry manure
T8	Control (Without any fertilizers)

Table 2. Effect of organic and inorganic fertilizers on rotting losses (%) of different onion varieties during storage

Treatments	Rotting losses (%) at 40 DAS			Rotting losses (%) at 80 DAS			Rotting losses (%) at 120 DAS		
	Varieties			Varieties			Varieties		
	HO-2	HO-4	Mean	HO-2	HO-4	Mean	HO-2	HO-4	Mean
T1	0.79	0.71	0.75	3.89	3.55	3.72	16.42	15.64	16.03
T2	0.62	0.53	0.57	2.97	2.72	2.84	12.61	11.63	12.12
T3	0.53	0.48	0.5	2.69	2.56	2.63	11.58	11.22	11.40
T4	0.59	0.52	0.56	2.81	2.64	2.72	12.24	11.56	11.90
T5	0.63	0.56	0.59	3.15	2.96	3.05	14.24	13.44	13.84
T6	0.64	0.61	0.63	3.26	3.05	3.15	13.67	13.12	13.40
T7	0.66	0.64	0.65	3.33	3.1	3.21	14.14	13.46	13.80
T8	0.3	0.39	0.34	2.51	2.39	2.45	11.27	11.08	11.18
Mean	0.59	0.55		3.08	2.87		13.28	12.64	
Factors	Factor (T)	Factor (V)	Factor (T X V)	Factor (T)	Factor (V)	Factor (T X V)	Factor (T)	Factor (V)	Factor (T X V)
C.D. at 5%	0.06	0.03	NS	0.22	0.11	NS	0.24	0.12	NS

T1: RDF, T2: RDN through FYM, T3: RDN through VC, T4: RDN through PM, T5: 50% RDF through NPK + 50% RDN through FYM, T6: 50% RDF through NPK + 50% RDN through VC, T7: 50% RDF through NPK + 50% RDN through PM, T8: Control

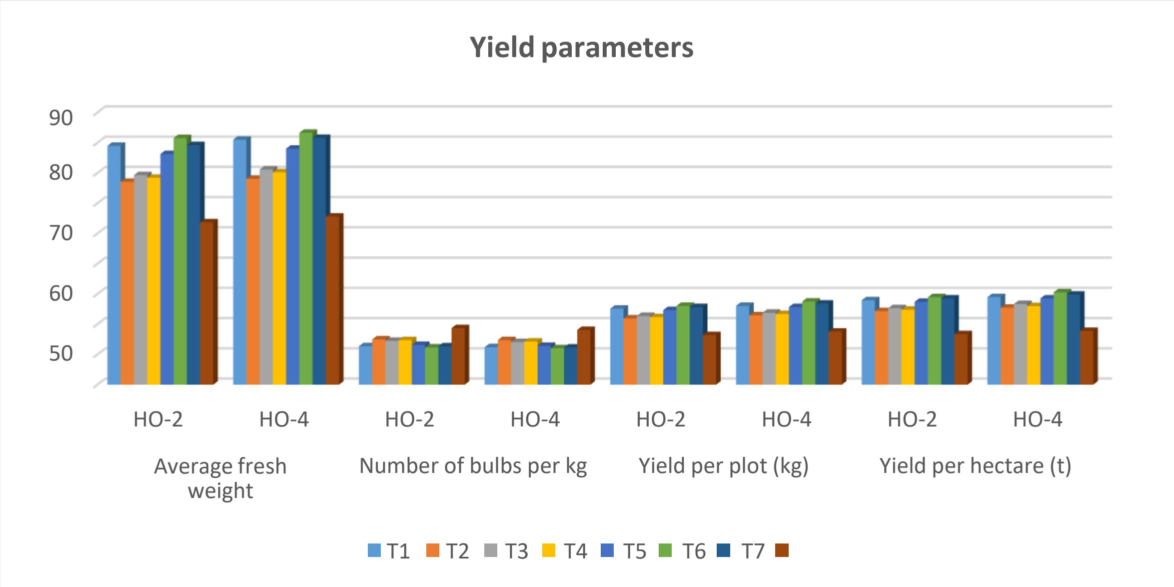

Fig. 1. Effect of organic manures and inorganic fertilizers on bulb yield characteristics of onion

The data is presented in Table. 3 indicates that the sprouting percentage was noted as negligible up to a period of 40 days after storage. After 80 and 120 days of storage, the sprouting percentage varied from 1.10% to 5.06%. Same as rotting (%), significantly, least sprouting was observed in treatment T8 (control) at 80 (1.10%) and 120 (3.08%) days of storage, which was statistically at par with T3 (1.18%) and (3.14%). The maximum sprouting (2.07% & 5.06%) was observed in treatment T1 (100% RDF) after 80 and 120 days of storage. The current study related to the findings of Eze and Orkwor [17] who observed that higher sprouting was exhibited when inorganic fertilizers and organic manure were applied compared to the control.

At 40 days after storage, the minimum physiological loss in weight was found in the treatment control (T8), i.e., (4.89%) which was significantly at par with the application of 100% RDN through VC, i.e., (5.03%), whereas, the

Table 3. Effect of organic and inorganic fertilizers on sprouting losses (%) of different onion varieties during storage

Treatments	Sprouting losses (%) at 40DAS			Sprouting losses (%) at 80DAS			Sprouting losses (%) at 120DAS		
	Varieties			Varieties			Varieties		
	HO-2	HO-4	Mean	HO-2	HO-4	Mean	HO-2	HO-4	Mean
T1	0	0	0	2.19	1.94	2.07	5.12	5.01	5.06
T2	0	0	0	1.46	1.34	1.4	3.54	3.23	3.38
T3	0	0	0	1.21	1.15	1.18	3.11	3.16	3.14
T4	0	0	0	1.29	1.2	1.24	3.33	3.19	3.26
T5	0	0	0	1.64	1.45	1.55	4.23	4.17	4.20
T6	0	0	0	1.74	1.51	1.63	4.16	3.93	4.05
T7	0	0	0	1.72	1.61	1.66	4.04	4.12	4.08
T8	0	0	0	1.13	1.07	1.1	3.09	3.07	3.08
Mean	0	0		1.55	1.41		3.83	3.73	
Factors	Facto r(T)	Facto r(V)	Factor (T X V)	Factor (T)	Factor (V)	Factor (T X V)	Facto r(T)	Factor (V)	Factor (T XV)
C.D. at 5%	0	0	NS	0.12	0.06	NS	0.16	0.08	NS

T1: RDF, T2: RDN through FYM, T3: RDN through VC, T4: RDN through PM, T5: 50% RDF through NPK + 50% RDN through FYM, T6: 50% RDF through NPK + 50% RDN through VC, T7: 50% RDF through NPK + 50% RDN through PM, T8: Control

Table 4. Effect of organic and inorganic fertilizers on physiological losses of weight (%) of different onion varieties during storage

Treatments	Physiological losses of weight(%) at 40 DAS			Physiological losses of weight(%) at 80 DAS			physiological losses of weight (%)at 120 DAS		
	Varieties			Varieties			Varieties		
	HO-2	HO-4	Mean	HO-2	HO-4	Mean	HO-2	HO-4	Mean
T1	8.32	7.68	8.00	13.12	12.71	12.91	27.13	26.42	26.78
T2	5.37	5.17	5.27	9.65	9.49	9.57	22.34	21.44	21.89
T3	5.12	4.95	5.03	9.44	9.29	9.36	20.73	19.53	20.13
T4	5.18	5.02	5.10	9.55	9.41	9.48	21.56	20.55	21.06
T5	6.53	6.30	6.42	11.23	11.08	11.15	26.24	25.29	25.76
T6	6.68	6.43	6.56	11.37	11.28	11.32	24.68	23.63	24.16
T7	6.73	6.49	6.61	11.45	11.32	11.38	25.28	24.31	24.80
T8	5.03	4.74	4.89	9.07	8.94	9.00	19.98	19.23	19.61
Mean	6.12	5.85		10.61	10.44		23.51	22.55	
Factors	Facto r(T)	Factor (V)	Factor (T X V)	Factor (T)	Factor (V)	Factor (TX V)	Facto r(T)	Factor (V)	Factor (T X V)
C.D. at 5%	0.20	0.10	NS	0.37	0.14	NS	0.53	0.26	NS

T1: RDF, T2: RDN through FYM, T3: RDN through VC, T4: RDN through PM, T5: 50% RDF through NPK + 50% RDN through FYM, T6: 50% RDF through NPK + 50% RDN through VC, T7: 50% RDF through NPK + 50% RDN through PM, T8: Control

Table 5. Effect of organic and inorganic fertilizers on the economics of onion production (Rs/ha)

Treatments	Cost of cultivation	Gross income	Net income	BCR
T1	172655	341040	168385	1.98
T2	170500	298440	127940	1.75
T3	174500	311520	137020	1.79
T4	170500	304320	133820	1.78
T5	156577.5	335280	178702.5	2.14
T6	158577.5	356520	197942.5	2.25
T7	156577.5	349320	192742.5	2.23
T8	134500	206760	72260	1.54

T1: RDF, T2: RDN through FYM, T3: RDN through VC, T4: RDN through PM, T5: 50% RDF through NPK + 50% RDN through FYM, T6: 50% RDF through NPK + 50% RDN through VC, T7: 50% RDF through NPK + 50% RDN through PM, T8: Control

maximum physiological loss in weight (8%) was observed in treatment T1 (100% RDF) as recorded in Table 4. The minimum physiological loss in weight was recorded in the treatment where no nutrient source was applied, i.e., control (9%) which was significantly lesser and at par with the application of 100% RDN through VC, i.e., T3 (9.36%), whereas, the maximum physiological loss in weight (12.91% & 26.78%) was found in the treatment (T1) having 100% RDF application after 80 and 120 days of storage period. The beneficial effect of organic manure in reducing the post-harvest losses of horticultural crops has been reported by Sankar et al. [18] and Ahmad [19].

Table 5. illustrates the economic data associated with various treatments. It is evident from the data obtained that a significant maximum bulb yield of 29.71 t/ha was obtained under the treatment T6 (50% RDF through NPK + 50% RDN through VC) with a maximum net return of Rs.197942.5/ha and benefit-cost ratio of 2.25. However, the minimum bulb yield of 17.23 t/ha, with a minimum net return of Rs.72260/ha and a benefit-cost ratio of 1.54 was noted in treatment T8 (Control).

4. CONCLUSION

Based on the one-year study, it can be concluded that the maximum bulb yield (29.71 t) and cost-benefit ratio (2.25) were observed when the onion varieties were applied with 50% of the recommended dose of NPK + 50% of the recommended dose of nitrogen supplied through vermicompost. The storage life of onion was recorded higher in treatment, whereas 100% of the recommended dose of nitrogen was supplied through vermicompost. The treatment T2, T3 and T4 are the most agroecological treatments that do not depend on external fertilizers and pollute less soil and water.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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