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COMPARATIVE PERFORMANCE OF IMPROVED ONION VARIETIES FOR GROWTH, YIELD AND QUALITY UNDER ORGANIC AND INORGANIC CONDITIONS

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ABSTRACT

This study comparatively assessed the performance of onion varieties under organic and conventional cultivation systems during *Rabi* season of 2023-24 and 2024-25. Thirteen onion varieties comprising NHRDF Red, NHRDF Red-2, NHRDF Red-3, NHRDF Red-4, NHRDF Fursungi, NHO-920, ALR, HO-4, RO-1, Pusa Riddhi, Pusa Sona, Pusa Shobha and Bhima Raj were assessed for growth, yield, quality and economic parameters. The experiment was laid out in a randomized block design with four replications under both nutrient management systems. Pooled data analysis revealed significant variation among varieties for plant height, number of leaves, neck thickness, bulb size, bulb weight, yield and quality attributes. Inorganic production system recorded higher early vegetative growth however organic management resulted in comparable or superior bulb size, TSS and economic returns for certain varieties. Among the tested varieties, HO-4, Pusa Sona, RO-1, Pusa Shobha and NHRDF Red-2 exhibited superior bulb yield and profitability. The highest bulb yield under inorganic system was recorded with RO-1 (325 q ha^{-1}) whereas, Pusa Riddhi (321 q ha^{-1}) and Pusa Shobha (313 q ha^{-1}) performed better under organic cultivation. Economic analysis indicated the maximum benefit-cost ratio with HO-4 (5.13) under inorganic and RO-1 (5.05) under organic system. The study concludes that specific varieties respond differently to nutrient management systems and selection of suitable varieties is crucial for enhancing productivity and profitability in organic onion cultivation.

***Key words*:** Onion, organic farming, inorganic farming, varieties, yield and economics

Introduction

Onion (*Allium cepa* L.) is one of the most important commercial vegetable crops grown extensively throughout the country. It is a bulbous biennial herb and occupies a prominent place among vegetable, condiment and spice crops due to its wide demand worldwide. India is the second largest producer of onion in the world after China. About 70 per cent of the total onion production in India comes from the winter (*Rabi*) season while the remaining 30 per cent is contributed by the kharif season as an off-season crop (Dhaker *et al*., 2017). India accounts for about 11.40 per cent of the global onion area, 10.40 per cent of total world production, and 16 per cent of global productivity. In the country, onion is cultivated over an area of 1774 thousand hectares with a production of 28877 thousand tonnes, registering an average productivity of 18.82 tonnes per hectare. Maharashtra is the leading onion-growing state in India (Anonymous, 2024).

The productivity of onion is influenced by several factors such as genotypes, climate, soil type, nutrient management and cultural practices. Among all of these, varietal selection and nutrient management play a vital role in determining quality and yield of produce. With increasing concerns about soil health, environmental sustainability and consumer preference for residue-free produce, organic farming has gained considerable attention. However, the performance of many high yielding onion varieties under organic production systems is not well documented (Lee *et al*., 2014). Organic nutrient management primarily relies on organic manures such as farmyard manure, compost, vermicompost, green manures and biofertilizers that release nutrients slowely. This slow and steady nutrient release improves soil structure, water holding capacity, microbial activity and overall soil health. While, conventional inorganic systems supply readily available nutrients through chemical fertilizers resulting in rapid vegetative growth, early establishment and often higher initial yields (Liopa-Tsakalidi and Giannopoulou, 2025). However, continuous and imbalanced use of chemical fertilizers may lead to nutrient imbalances, soil acidification and reduced soil biological activity over time (Lori *et al*., 2017).

The response of onion varieties to these contrasting nutrient management systems varies widely due to genetic differences in nutrient uptake efficiency, root architecture, growth dynamics and stress tolerance mechanisms (Kaswan *et al*., 2017). Varieties bred for high input systems may not perform optimally under organic conditions where nutrient availability is slower and more dependent on microbial activity. While, certain varieties may exhibit better adaptation to organic systems due to efficient nutrient utilization and resilience under low input conditions. Hence, systematic evaluation of varieties under both organic and conventional systems is essential to generate reliable recommendations for farmers (Ponti *et al*., 2012). For organic agriculture to expand as a sustainable component of the food system, cultivars must be specifically evaluated and selected for adaptation to the soils, nutrient sources, pest pressures and management practices characteristic of organic farming systems (Avdikos *et al*., 2021). Modern plant breeding programmes have predominantly focused on developing cultivars suited to high input agriculture involving synthetic fertilizers, assured irrigation and chemical plant protection measures. Although such cultivars are often high yielding and their dependence on external inputs may compromise long term sustainability and ecological balance (Przystalski *et al*., 2008).

In this context, comparative evaluation of improved onion varieties under both organic and conventional cultivation systems becomes highly relevant. Such studies not only help identify suitable cultivars capable of delivering stable yield and superior quality but also provide insights into economic stability and resource use efficiency under different production systems. Keeping this in view, the present investigation was undertaken to study the growth, yield, quality and economics of different onion varieties under organic and conventional cultivation systems.

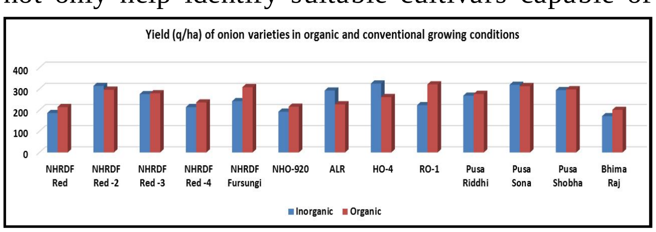

Fig. 1: Effect of organic and conventional growing conditions on yield of onion varieties.

Materials and methods

Experimental Site and Climate

The field experiment was conducted during the *Rabi* seasons of 2023-24 and 2024-25 at the Vegetable Research Farm, BRC ARS, Agriculture University, Jodhpur. The experimental site falls under an arid climatic region characterized by cool winters which is favorable for *Rabi* onion cultivation. The soil of the experimental field was sandy loam in texture with a pH ranging from 7.5 to 8.5 exhibiting good drainage and moderate fertility status.

Experimental Design and Cultivation Practices

The experiment was laid out in a Randomized Block Design (RBD) with four replications under both organic and conventional production systems. Thirteen onion varieties were evaluated *viz*: V_1-NHRDF Red, V_2-NHRDF Red-2, V_3- NHRDF Red-3, V_4- NHRDF Red-4, V_5- NHRDF Fursungi, V_6- NHO-920, V_7- ALR, V_8-HO-4, V_9- RO-1, V_{10}- Pusa Riddhi, V_{11}- Pusa Sona, V_{12}- Pusa Shobha and V_{13}- Bhima Raj.

Each experimental plot measured (2.5×3 m) and seedlings were transplanted at a spacing of 15 × 10 cm. Uniform and healthy seedlings of 45 days were used for transplanting. Recommended cultural practices for Rabi onion cultivation were followed uniformly in both production systems throughout the crop growth period. In the conventional system, fertilizers and plant protection measures were applied as per the recommended package of practices, whereas in the organic system nutrient and pest management were carried out using approved organic inputs only. Intercultural operations such as irrigation, weeding and plant protection were carried out as and when required to ensure optimum crop growth.

Observations Recorded

Growth parameters such as plant height, number of leaves per plant and neck thickness were recorded at 60 and 90 days after transplanting (DAT). Yield attributes included polar diameter, equatorial diameter of bulbs, fresh bulb weight and days to maturity. The polar and equatorial diameters of bulbs were measured using a vernier caliper. Quality parameter, total soluble solids (TSS), was determined using a hand refractometer. Bulb yield was

Table 1: Effect of organic and conventional growing conditions and varieties on growth attributes of onion varieties (Pooled data of 2023-24 and 2024-25).

Varieties	Plant height				Number of leaves/plants				Neck thickness (mm)			
	60 DAT		90 DAT		60 DAT		90 DAT		60 DAT		90 DAT	
	IG	OG	IG	OG	IG	OG	IG	OG	IG	OG	IG	OG
NHRDF Red	41.08	38.20	42.38	43.85	5.77	5.48	6.47	7.50	7.41	9.06	9.41	10.38
NHRDF Red -2	48.67	42.77	49.40	47.20	7.18	6.68	9.37	8.48	9.98	10.52	12.89	11.59
NHRDF Red -3	44.63	40.93	47.57	46.87	6.53	6.63	8.02	8.15	9.02	10.38	12.03	11.53
NHRDF Red -4	42.18	39.22	45.05	45.22	6.41	6.45	7.47	7.73	8.21	9.99	11.57	11.28
NHRDF Fursungi	42.65	44.28	46.45	49.42	6.48	7.35	7.68	9.00	8.40	10.86	11.81	11.99
NHO-920	42.22	39.07	43.90	43.73	5.90	5.53	6.87	7.53	8.01	9.27	10.55	11.00
ALR	46.72	39.15	48.32	44.76	6.58	5.60	8.50	7.65	9.36	9.98	12.37	11.07
HO-4	50.10	39.78	56.43	45.68	7.48	6.53	10.18	7.90	11.43	10.01	13.12	11.29
RO-1	42.48	46.98	45.88	52.47	6.47	7.48	7.57	9.43	8.36	11.10	11.72	12.63
Pusa Riddhi	43.88	40.60	46.68	45.98	6.52	6.58	7.82	8.03	8.67	10.20	11.91	11.42
Pusa Sona	49.78	44.68	54.25	50.98	7.23	7.43	9.50	9.07	10.36	10.94	12.94	12.43
Pusa Shobha	47.60	43.85	49.12	48.47	5.62	6.83	8.73	8.75	9.84	10.72	12.52	11.81
Bhima Raj	40.28	36.02	40.32	37.35	5.72	5.35	6.02	5.92	7.00	8.22	8.13	9.36
SEm±	1.40	1.13	1.43	1.47	0.24	0.17	0.27	0.20	0.30	0.35	0.52	0.41
CD at 5%	4.09	3.30	4.16	4.29	0.69	0.50	0.78	0.57	0.87	1.02	1.51	1.18
CV (%)	5.41	4.76	5.21	5.50	6.32	4.56	5.81	4.20	5.78	5.99	7.70	6.18

IG: Inorganic; OG: Organic

expressed in quintals per hectare. Economic analysis was carried out by calculating gross return, net return, and benefit–cost (B:C) ratio.

Statistical Analysis

Pooled data of two years were subjected to analysis of variance (ANOVA). Treatment means were compared at 5% level of significance using critical difference (CD).

Results and Discussion

Growth Attributes

Significant variation in growth parameters was observed among onion varieties under both conventional and organic production systems at all stages of crop growth. Under inorganic conditions, HO-4 (V_8) consistently recorded the highest plant height measuring 50.10 cm and 56.43 cm at 60 and 90 DAT, indicating its superior vegetative vigour and better response to readily available nutrients. Under organic management, RO-1 (V_9) (52.47 cm) and Pusa Sona (V_{11}) (50.98 cm) attained comparatively higher plant height at later growth stages suggesting better adaptation to gradual nutrient release from organic sources (Murphy *et al.*, 2007). Similar findings for plant height in organic and conventional systems were observed by Przystalski *et al.*, 2008 in cereals and Liopa-Tsakalidi and Giannopoulou, 2025 in tomato. The number of leaves per plant increased progressively with crop age in all varieties. At 90 DAT under inorganic conditions HO-4 produced the maximum number of leaves (10.18 leaves plant^{-1}) followed by Pusa Sona (9.50 leaves plant^{-1}) and NHRDF Red-2 (V_2) (9.37 leaves plant^{-1}). Under organic conditions, RO-1 and NHRDF Fursungi recorded higher leaf numbers (9.43 and 9.00 leaves plant^{-1}, respectively) reflecting favourable vegetative growth under organic management.

Neck thickness varied significantly among varieties. Under inorganic conditions, HO-4 recorded the maximum neck thickness at 90 DAT (13.12 mm) closely followed by Pusa Sona (12.94 mm). Under organic conditions, RO-1 exhibited the highest neck thickness (12.63 mm) while Bhima Raj (V_{13}) recorded the minimum (9.36 mm). Moderate neck thickness observed in superior varieties is desirable for better bulb development and storage.

Onion plant growth was significantly higher under the conventional system than under organic management. However, varieties such as RO-1, Pusa Sona and NHRDF Fursungi performed better under organic conditions. Improved growth under organic inputs may be attributed to enhanced availability of N, P, K and micronutrients through mineralization and microbial mediated conversion of nutrients into plant available forms (Prabhakar *et al.*, 2017).

Bulb Characters

The data presented in Table 2 revealed significant variation among onion varieties with respect to yield attributes and quality parameters under both inorganic and organic conditions. Among the varieties, HO-4 recorded the maximum polar diameter (61.89 mm) and

Table 2: Effect of organic and conventional growing conditions on bulb characteristics and quality of onion varieties (Pooled data of 2023-24 and 2024-25).

Varieties	PD		ED		FW		DTM		TS	
	Inorganic	Organic	Inorganic	Organic	Inorganic	Organic	Inorganic	Organic	Inorganic	Organic
NHRDF Red	45.06	45.26	49.20	53.79	70.15	75.50	118	117	12.97	13.17
NHRDF Red -2	58.45	50.91	61.56	57.99	115.30	91.10	117	116	12.73	12.95
NHRDF Red -3	53.68	50.16	58.17	57.25	105.25	90.82	131	130	13.08	13.23
NHRDF Red -4	49.07	49.15	54.43	55.78	95.70	80.98	116	116	13.02	13.80
NHRDF Fursungi	51.33	51.59	56.74	58.86	98.55	93.43	121	119	13.80	12.48
NHO-920	46.20	45.92	53.63	54.61	79.90	77.22	104	104	12.75	14.77
ALR	54.86	48.32	60.05	55.10	109.55	79.82	121	120	15.12	12.25
HO-4	61.89	49.52	64.96	56.38	124.60	82.28	128	126	10.73	9.28
RO-1	50.87	53.11	55.56	59.83	97.18	100.0	130	129	9.48	9.72
Pusa Riddhi	52.88	49.88	56.85	56.48	101.63	89.33	132	130	9.60	9.57
Pusa Sona	59.18	52.21	63.29	59.59	121.00	95.73	126	124	9.57	15.63
Pusa Shobha	55.72	51.71	60.21	58.12	109.88	91.23	119	118	15.82	9.83
Bhima Raj	42.82	42.72	45.93	48.00	63.50	59.15	123	122	9.88	10.37
SEm±	2.15	2.12	2.11	2.19	4.17	3.19	2.53	2.16	0.25	0.17
CD at 5%	6.29	6.18	6.17	6.38	12.17	9.31	7.40	6.30	0.73	0.48
CV (%)	7.11	7.44	6.43	6.73	7.27	6.49	3.60	3.10	3.55	2.38

PD: Polar diameter of bulb (mm); ED: Equatorial diameter of bulb (mm); FW: Fresh weight of bulb (g); DTM: Days taken for Maturity; TS: TSS (°Brix)

equatorial diameter (64.96 mm) under inorganic conditions, which were significantly superior to most other varieties. However, under organic conditions, RO-1recorded superior bulb dimensions (53.11 mm polar and 59.83 mm equatorial diameter).

Fresh bulb weight varied significantly among varieties. The highest fresh weight was recorded in HO-4 (124.60 g) under inorganic conditions, followed by Pusa Sona (121.00 g) and NHRDF Red-2 (115.30 g). Under organic conditions, RO-1 (100.00 g), Pusa Sona (95.73g) and NHRDF Fursungi (93.43 g) performed better compared to other varieties. Higher bulb weight under inorganic system may be attributed to enhanced nutrient availability during critical bulb enlargement stages (Thangasamy *et al.*, 2018). However, organic management resulted in comparable bulb weight in certain varieties indicating their suitability for organic cultivation. These findings are close conformity with the findings of Raslan *et al.*, 2015 in garlic and Ncayiyana *et al.*, 2017 in onion.

Days to maturity ranged from 104 to 132 days under inorganic conditions and 104 to 130 days under organic conditions. NHO-920 (V_6) was the earliest maturing variety (104 days), whereas Pusa Riddhi (V_{10}) (132 days) and RO-1 (V_9) (130 days) were late maturing. Early maturity under inorganic system may be due to faster vegetative growth and earlier bulb initiation (Lee *et al.*, 2014). The standard error of mean (SEm±), critical difference (CD at 5%) and coefficient of variation (CV%) indicated that the differences among treatments were statistically significant for most parameters.

Quality Parameters

Total soluble solids (TSS) content differed significantly among varieties and production systems. Under inorganic conditions, Pusa Shobha (15.82) and ALR (15.12) recorded higher TSS values while under organic management Pusa Sona (15.63) and NHO-920 (14.77) exhibited superior TSS content. Higher TSS under inorganic cultivation may be due to balanced nutrient uptake and enhanced accumulation of carbohydrates resulting in improved bulb quality.

Bulb Yield

Bulb yield varied significantly among the onion varieties under both production systems. Under conventional conditions, HO-1 (325 q ha^{-1}) recorded the highest bulb yield followed by Pusa Sona (319 q ha^{-1}) and NHRDF Red-2 (314 q ha^{-1}). Under organic conditions, RO-1 produced the maximum bulb yield (321 q ha^{-1}) closely followed by Pusa Sona (313 q ha^{-1}) and NHRDF Fursungi (308 q ha^{-1}). The comparable performance of several varieties under organic cultivation indicates their suitability for low input and organic farming systems. The differences observed in plant growth and yield between conventional and organic agricultural practices originated at the initial vegetative growth stage. The greater availability of soil nutrients particularly higher NO_3-N concentration in conventionally managed soils likely contributed to the enhanced growth rate and bulb

Table 3: Effect of organic and conventional growing conditions on yield and economics of onion varieties (Pooled data of 2023-24 and 2024-25).

Varieties	Bulb yield (q/ha.)		Gross Return(Rs/ha)		Net Return/ha (Rs)		B : C ratio	
	Inorganic	Organic	Inorganic	Organic	Inorganic	Organic	Inorganic	Organic
NHRDF Red	186	214	223752	256393	146712	179353	2.94	3.36
NHRDF Red -2	314	296	376535	355021	299495	277981	4.94	4.66
NHRDF Red -3	275	279	329890	334218	252850	257178	4.32	4.38
NHRDF Red -4	214	236	256893	283579	179853	206539	3.37	3.71
NHRDF Fursungi	242	308	289823	369214	212783	292174	3.80	4.84
NHO-920	192	216	230814	259767	153774	182727	3.03	3.40
ALR	292	227	350036	271885	272996	194845	4.59	3.56
HO-4	325	261	390410	313615	313370	236575	5.13	4.11
RO-1	223	321	267385	385009	190345	307969	3.51	5.05
Pusa Riddhi	268	276	321100	330855	244060	253815	4.21	4.34
Pusa Sona	319	313	382730	375175	305690	298135	5.02	4.92
Pusa Shobha	294	298	352654	357278	275614	280238	4.62	4.69
Bhima Raj	171	201	205201	240647	128161	163607	2.69	3.16
SEm±	9.26	10.33	-	-	-	-	0.15	0.16
CD at 5%	27.02	30.16	-	-	-	-	0.44	0.47
CV (%)	6.29	6.76	-	-	-	-	6.49	6.65

yield (Lee *et al.*, 2014). The similar effects of organic and conventional cultivation systems on yield gap were also reported by Ponti *et al.*, 2012 in various crops Lee *et al.*, 2014 and Rempelos *et al.*, 2023 in onion.

Economics

Significant variation in bulb yield and economic returns was observed among onion varieties under inorganic and organic conditions (Table 3). Under inorganic conditions, HO-4 recorded the highest bulb yield (325 q/ha) followed by Pusa Sona (319 q/ha) and NHRDF Red-2 (314 q/ha). In contrast, under organic conditions, RO-1 produced the maximum yield (321 q/ha), followed by Pusa Sona (313 q/ha) and NHRDF Fursungi (308 q/ha).

Economic analysis revealed that HO-4 gave the highest gross (Rs. 390,410/ha) and net returns (Rs. 313,370/ha) under inorganic conditions whereas RO-1 recorded the maximum gross (Rs. 385,009/ha) and net returns (Rs.307,969/ha) under organic conditions. The benefit–cost ratio was also highest in HO-4 (5.13) under inorganic conditions and RO-1 (5.05) under organic conditions. Overall, HO-4 and RO-1 were the most productive and economically viable varieties under inorganic and organic systems, respectively.

Conclusion

The present study clearly demonstrated that onion varieties respond differently to organic and inorganic production systems. Inorganic cultivation promoted rapid vegetative growth and higher bulb weight while organic management improved bulb quality, TSS and economic returns for selected varieties. Among the evaluated varieties HO-4, RO-1, Pusa Sona, Pusa Shobha and Pusa Riddhi proved superior in terms of yield and profitability. For organic farming, RO-1, Pusa Sona and NHRDF Fursungi are highly recommended. whereas HO-4 and Pusa Sona are suitable for inorganic production. The study highlights the importance of variety specific recommendations for sustainable onion production under organic farming systems.

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