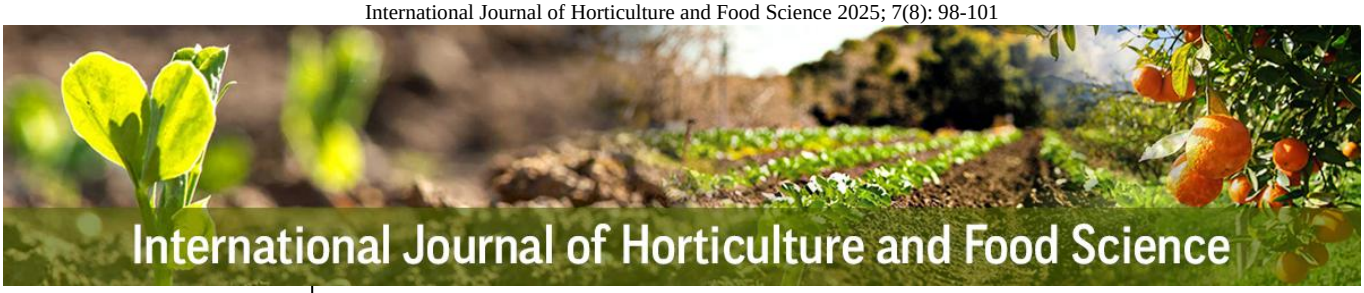

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Comparative evaluation of growth and yield in improved and local Radish varieties in Varanasi region

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Abstract
An investigation was conducted to assess the performance of various radish varieties, focusing on growth, yield, and quality attributes. Statistical analysis of the data revealed significant varietal differences across all parameters. For growth, Kashi Mooli-40 demonstrated the highest leaf count (10.73), while Pusa Desi exhibited the greatest shoot length (6.73 cm). The shoot length was maximum (6.73 cm) in Pusa Desi. The variety Kashi Lohit has recorded maximum (1223.87 cm^2) leaf area. The variety Kashi Hans required minimum (43.33) number of days for the edible size of root. The significant differences in yield parameters were observed. The root weight and shoot weight was maximum in variety Kashi Hans and Pusa Himani had the highest root-to-shoot ratio (4.45). Ultimately, Pusa Reshmi was identified as the superior variety for yield, producing the maximum root yield of 33.23 kg per plot.

Keywords: *Raphanus sativus*, radish, varietal evaluation, yield, quality, Varanasi

Introduction
Radish (*Raphanus sativus L.*) is a globally cultivated root vegetable with a history of human consumption dating back to at least 400 BC. It was recorded for human consumption dates back to approximately 400 BC, indicating that it is an ancient domesticated species native to both the Eastern Mediterranean and Eastern Asia (Becker 1962; George and Evans 1981; Kaneks and Matsuzawa 1993) [3, 10, 11]. The Middle East and Eastern Asia are considered its centers of origin. Radish is a diploid, cross-pollinated brassicaceous crop with 2n=18 chromosomes. Varieties can be annual or biennial and are grown for their swollen tap roots, which can be globular, tapering, or cylindrical. It is a diploid organism possessing two sets of eighteen chromosomes (2n=18), (Richharia 1937) [18]. The ideal temperature for achieving optimal size, texture, and enhanced flavor ranges from 15 °C to 18 °C (Angell and Hillyer, 1962). Radish seeds exhibit superior germination at a temperature of 5 °C, with an optimal threshold of 15 °C to attain the highest germination percentage in radish (Abdel *et al*., 2016) [1].

It is predominantly a cool-season crop (optimum temperature: 15-18 °C), Asiatic varieties are known to tolerate higher temperatures. In India, it is sown from September to January in the northern plains, but can be grown year-round in the milder climate of peninsular India. Radish is a valuable source of vitamin C, minerals, and fiber. The USDA Nutrient Database (2007) notes that 100 g of edible radish contains 94.4 g moisture, 66kJ of energy, and 3.4g carbohydrates. In India, radish cultivation covered 0.212 million hectares in 2019-2020, with an annual production of 3.107 metric tons. This contributes to the national vegetable production, which stood at 191.76 million metric tons from an area of 10.35 million hectares during the same period. The seeds are also a source of fatty oil used for various purposes, including soap making. It is a vital part of agriculture, with India producing 3.107 metric tons of the crop from 0.212 million hectares in 2019-2020.

The crop is a good source of vitamins, minerals, and fiber. Despite its importance and the availability of numerous varieties (such as Pusa Desi, Pusa Chetki, and Kashi Hans), the performance of these cultivars including their growth, yield, and quality varies significantly by location. The increasing demand for salad vegetables highlights the need for varieties that are not only high-yielding but also possess superior quality.

This investigation, therefore, seeks to fill this knowledge gap by assessing the performance of various improved and local radish cultivars specifically in the Varanasi region. Beyond its agricultural significance, radish is also a nutrient-dense food, providing important vitamins, minerals, and fiber. The growing trend of urbanization and changing food habits has led to a sharp increase in the demand for quality salad vegetables. Growers and consumers alike are seeking varieties that not only offer higher yields but also better quality. The new trend in vegetable production is not only to obtain higher yields but also to have better quality produce. Among these factors variety is a predominant. Several varieties of radish are available in the market having varying length, size, colour, taste yield potential and quality parameters.

As radishes constitute a vital component of salads, they remain in high demand throughout the year in metropolitan areas. The growth, yield, and quality of various radish cultivars exhibit considerable variation across different locales and regions. Additionally, certain indigenous varieties have been cultivated for an extended period. Radishes serve as effective companion plants for numerous other crops, likely due to their pungent aroma, which deters a range of insects and pests, including aphids, cucumber beetles, tomato hornworms, squash bugs, and ants. Furthermore, they can act as a trap crop, enticing insect pests away from the primary crops. The performance of a given radish variety is highly dependent on its specific growing environment. Therefore, a localized study is essential to identify the most suitable improved and local cultivars. This investigation was initiated to evaluate and compare the growth, yield, and quality characteristics of different radish varieties under the specific conditions of the Varanasi region. In light of these considerations, the present study is entitled "Comparative Evaluation of Growth and Yield in Improved and Local Radish Varieties in Varanasi region.

Methods and Materials

The experiments were designed using a Randomized Block Design, encompassing three replications and ten treatments, each featuring a single variety. The treatments within each replication were assigned randomly, specifically: T_1 Pusa Desi, T_2 Pusa Chetki, T_3 Pusa Himani, T_4 Pusa Reshmi, T_5 Japanese White, T_6 Kashi Mooli 40, T_7 Kashi Lohit, T_8 Kashi Sweta, T9 Kashi Hans, and T_{10} Kashi Andhra. Seeds from five enhanced radish varieties namely Pusa Deshi, Pusa Chetaki, Pusa Reshami, and Japanese White Radish were procured from diverse sources. Additionally, seeds of five local cultivars, including Kashi Mooli 40, Kashi Lohit, Kashi Sweta, Kashi Hans, and Kashi Aardra, were gathered from farmers within their respective localities as well as from the authantic source in Varanasi.

The land was brought to a fine tilth by ploughing, clod crushing, and two cross harrowing. An area was marked in 30 plots having 2.00×1.75 m2sizes. The distances of 0.5 m was kept between two plots & 1.0 between two replications. Since as per ideal data the requirement of Nitrogen (N), Phosphorus (P) and Potassium (K) per hectare land for radish cultivation is 50 kg, 100 kg and 50 kg respectively. The observations were recorded on the different growth and yield parameter such as Growth (no. of leaves, shoot length, leaf area day required to be edible size), yield (root weight, shoot weight, root shoot ratio, root yield per plot). Test of significance for correlation coefficients at phenotypic level the estimated values were compared with the table value (statistical table by Fisher and Yates, 1963) at (n-1) degree of freedom at 5% level of significance, respectively.

Results and Discussion

Growth performance of different radish varieties

The results of the current investigations revealed that no significant differences were observed regarding the number of leaves, shoot length, leaf area, and the duration required to reach edible size among the various cultivars at distinct growth stages. The apex of leaf count (10.73) was recorded in the Kashi Mooli-40 variety, whereas the nadir (7.20) was noted in the Japanese White cultivar. Maximum shoot length was produced by Pusa Desi (6.73cm). Leaf area per plant was maximum in variety Kashi Lohit (1223.87cm2) and minimum in variety Kashi Aardra (610.24 cm2). The duration required to achieve an edible size ranged from 43.33 to 60.33 days. The minimum duration observed (43.33 days) was recorded for the variety Kashi Hans, whereas the maximum (60.33 days) was necessitated by the variety Pusa Himani. This might be due to the genetic makeup of the plant and its expression to the growing soil and environmental conditions. Similar result were found by Ponnuswami *et al.* (1980) [14], Rabbani *et al.* (1998) [16] and Pujari *et al*. (1977) [15] in radish.

Yield and quality characters of different radish varieties

The results indicated that the root weight, shoot weight, root-to-shoot ratio, and root yield were significantly influenced across the various cultivars. Data pertaining to root weight revealed that the maximum was observed in the Kashi Hans variety (160.46 g). However, the minimum root weight (132.53 g) was recorded in variety Pusa Reshmi. The maximum shoot weight (64.85 g) was observed in variety Kashi Hans and the minimum (29.98g) in Pusa Himani. The maximum root: shoot ratio was obtained (4.45) in Pusa Himani and minimum (2.34) in Kashi Lohit. The maximum root yield, recorded at an impressive 33.23 kg per plot, was achieved by the variety Pusa Reshmi, whereas the minimum yield of 24.16 kg per plot was observed in the variety Kashi Aardra. The disparities in maturity periods can be ascribed to the inherent genetic differences among the cultivars, along with the ecological and climatic conditions influencing their growth. The variation in the root weight, shoot weight, root: shoot ratio and root yield might be due to genetic variation changes in climatic conditions and Management factors. Similar trend of result was also observed by Rajagopal *et al.* (1979) [17], Dixit *et al.* (1980) [9], Deotale *et al.* (1994) [7].

Table 1: Varietal performance in the growth stages of radish (*Raphanus sativus* L.)

Treatment	No of leaf /plant			Shoot length (cm)			Leaf area/ plant (cm2)			Day require to be edible size
	15 DAT	30 DAT	45 DAT	15 DAT	30 DAT	45 DAT	15 DAT	30 DAT	45 DAT	
T_1 Pusa Desi	3.15	6.26	8.23	2.76	4.91	6.73	35.22	424.43	937.75	55.00
T_2 Pusa Chetaki	3.32	7.37	9.68	2.12	3.78	5.50	27.00	452.20	733.43	45.67
T_3 Pusa Himani	2.80	5.00	9.22	2.30	4.20	6.46	28.27	525.22	1113.04	60.33
T_4 Pusa Pusa Reshmi	3.30	6.87	8.90	2.87	4.32	6.48	22.40	510.20	1010.31	60.33
T_5 Japanese White	4.21	5.32	7.20	2.63	4.90	6.23	30.24	412.21	932.28	45.00
T_6 Kashi Mooli-40	3.72	6.52	10.73	2.83	3.95	5.72	24.52	352.21	915.51	51.00
T_7 Kashi Lohit	2.92	5.47	9.40	2.42	4.30	6.32	31.17	623.48	1223.87	47.67
T_8 Kashi Sweta	3.46	7.25	10.00	2.67	4.37	6.20	25.03	342.52	670.15	48.33
T9 Kashi Hans	4.33	8/21	10.39	2.42	3.70	5.93	30.48	357.44	660.22	43.33
T_{10} Kashi Aardra	3.40	6.84	9.24	2.50	2.77	6.12	26.32	180.33	610.24	46.00
SEDm	0.182	0.302	0.840	0.183	0.278	0.314	0.452	2.374	8.729	2.183
CD at 5%	0.383	0.635	1.764	0.384	0.584	0.660	0.951	4.988	18.339	4.587

Table 2: Varietal performance in relation to yield parameters in the radish (*Raphanus sativus* L.) crop

Treatment	Root weight (g)	Shoot weight (g)	Root Shoot ratio	Root yield (kg/plot)
T_1 Pusa Desi	132.82	46.97	2.83	26.30
T_2 Pusa Chetki	137.86	52.16	2.64	30.42
T_3 Pusa Himani	133.29	29.98	4.45	28.68
T_4 Pusa Reshmi	132.53	39.45	3.36	33.23
T_5 Japanese white	150.41	59.81	2.52	26.80
T_6 Kashi Mooli-40	147.62	60.75	2.43	31.65
T_7 Kashi Lohit	141.15	60.32	2.34	28.47
T_8 Kashi Sweta	155.45	58.02	2.68	24.30
T_9 Kashi Hans	160.46	64.85	2.47	29.89
T_{10} Kashi Aardra	140.81	49.86	2.82	24.16
SEDm	2.109	0.473	0.080	0.331
CD at 5%	1.922	0.944	0.167	0.696

Conclusion

The critical evaluation of the outcomes of the present investigation revealed that significant variations were observed in the growth and yield of the various radish cultivars examined. A positive correlation was identified between root yield and several growth and root characteristics, including shoot length, leaf area, edible size, and root girth. In summary, the radish varieties Pusa Desi, Kashi Hans, Pusa Reshmi, Pusa Himani, Japanese White, Kashi Mooli-40, and Kashi Sweta demonstrated markedly superior performance concerning most growth, yield, and quality parameters. Consequently, these varieties are well-suited to the agro-climatic conditions of Varanasi. Among the local cultivars, the variety Kashi Mooli-40 yielded the most favorable results.

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