Original Research Article

Performance and Economical cost analysis of different Radish (*Raphanus sativus* L.) varieties under sub tropical conditions of Central India

ABSTRACT

The present study was carried out at Research cum Instructional Farm of College of Horticulture and Research Station, Jagdalpur, Chhattisgarh, during the *Rabi* season of 2021 to investigate the selection of superior radish varieties having high yield potential with better quality root for Bastar plateau. The experiment was laid out in randomized block design (RBD) with fifteen treatments and three replications. The fifteen varieties of radish, used for study as treatments were *viz.* Pusa Chetki, Pusa Mridula, Pusa Shweta, Pusa Gulabi, Pusa Jamuni, Kashi Hans, Kashi Muli 40, Kashi Lohit, Chinese Pink, MRH111, Snow White, Mino Early, Ivory White, R-30 and Palak Patta (check). The growth attributing characters of radish varieties expressed in terms of days to 50 per cent germination and days to harvest were significantly the earliest in Pusa Mridula (6.33 and 47.33 respectively); plant height, fresh weight of roots, dry weight of roots, root yield (kg plot^{-1}) and root yield (t ha^{-1}) were the maximum in Kashi Lohit (37.69 cm, 153.75 g, 26.27 g, 7.69 kg plot^{-1} and 38.44 t ha^{-1}) respectively number of leaves plant^{-1}, East-West spread of the plant, fresh weight of leaf and leaf area index in Pusa Jamuni (13.33, 33.43 cm, 109.59 g and 5.47 respectively); North-South spread of the plant in Ivory White (46.50 cm); fresh and dry weight of plant in Kashi Muli-40 (254.93 g and 30.28 g respectively), dry weight of leaf in Mino Early (11.00 g) While, Pusa Gulabi recorded the maximum leaf yield kg plot^{-1} and leaf yield t ha^{1} (5.48 kg plot^{-1} and 27.40 t ha^{-1} respectively). Among all the treatments significantly higher length of root (31.03 cm), diameter of root (5.65 cm) and root to shoot ratio (2.17) at harvest were observed in variety R-30, Pusa Chetki and Kashi Hans respectively. The results depicted that Kashi Lohit produced significantly the maximum net income, gross income and benefit-cost ratio (Rs 3,84,373.30 ha^{-1} ; Rs 2,87,580.30 ha^{-1} and 2.97 respectively) among the other treatments.

Keywords: Radish, B:C ratio, income, performance

Introduction

Radish (*Raphanus sativus* L.) is derived from the Latin word "*radix*" and is one of the most important root crops of the family Cruciferae, has a chromosome number 2n = 2x = 18 originated from the central and western China and India. India is the second largest producer of horticulture after China. Remarkable progress has been made in area expansion resulting in higher production of radish over the last few decades. During 2019-20 area under vegetables was 10.35 million hectares with a production of 191.76 metric tonnes. In India, radish was grown over an area of 0.212 million hectares in 2019-20 with an annual production of 3.107 metric tonnes (nhb.gov.in). It is mainly grown in West Bengal, Bihar, Uttar Pradesh, Karnataka, Punjab, Maharashtra and Assam. According to the Directorate of Horticulture and Farm Forestry, Chhattisgarh 2020, the area under production of white radish in Chhattisgarh was 0.0134 million ha and 0.244 metric tonnes respectively. However in Bastar commercial cultivation has not been reported yet.

Radish is a root cum leafy vegetable suitable for tropical and temperate climates. The leaves and roots are consumed both as salad and as cooked vegetable (Thamburaj and Singh, 2005). The consumption of fresh vegetables has increased worldwide, not only through population growth, but also due to the greater awareness of the importance of a healthy diet. Consumers are also becoming increasingly demanding, in terms of the quality of the produce, and its year-round availability. The ancient varieties of radish were long and tapering rather than cylindrical, apically bulbous, elliptic or spherical. Various radish varieties having varying length, size, colour, taste, yield potential and quality parameters are available in market (Dongarwar, *et al*. 2017). Demand and supply trend of vegetables is shift from quantity to quality The new trend in vegetable production is not only to obtain higher yields but also to have better quality produce, as producers are getting higher price for quality produce (Tey *et al*. 2009). As the climatic factors favours the cultivation of this crop in Bastar, the growers are searching for the high yielding and varieties having good qualities every year. Farmers buy radish seed according to the information provided by the seed traders. The productivity and quality of these different varieties are not yet tested scientifically. This research focused on the selection of superior radish variety having high yield potential with better quality roots, hence growing radish can be very beneficial for the farmers for earning good returns per unit area in Bastar region of Chhattisgarh.

Material and Methods

(a) Site of Experiment: The present field experiment on radish was conducted during the *Rabi* season of 2021 from last week of October to December at Research cum Instructional Farm

of College of Horticulture and Research Station, Dharampura, Jagdalpur, Bastar, Chhatishgarh 494001.

(b) The experimental materials: The experiment was laid out in randomized block design (RBD) with fifteen treatments and three replications. The fifteen varieties of radish, used for study as treatments were *viz.*$T_{1:}$ Pusa Chetki, T_2: Pusa Mridula, T_3: Pusa Shweta, T_4: Pusa Gulabi, T_5: Pusa Jamuni, T_6: Kashi Hans, T_7: Kashi Muli-40, T_8: Kashi Lohit, T_9: Chinese Pink, T_{10}: MRH111, T_{11}: Snow White, T_{12}: Mino Early, T_{13}: Ivory White, T_{14}: R-30 and T_{15} (check): Palak Patta. Table 1 shows the source of different treatments taken for this study.

Table 1. Treatment details and source

Treatments		Treatments Details	Source
T_1	:	Pusa Chetki	IARI, New Delhi
T_2	:	Pusa Mridula	IARI, New Delhi
T_3	:	Pusa Shweta	IARI, New Delhi
T_4	:	Pusa Gulabi	IARI, New Delhi
T_5	:	Pusa Jamuni	IARI, New Delhi
T_6	:	Kashi Hans	IIVR, Varanasi
T_7	:	Kashi Muli – 40	IIVR, Varanasi
T_8	:	Kashi Lohit	IIVR, Varanasi
T_9	:	Chinese Pink	Agro seeds
T_{10}	:	MRH-111	Dhanya veg seeds
T_{11}	:	Snow White	Advanta golden seeds
T_{12}	:	Mino Early	Sungro seeds
T_{13}	:	Ivory White	Syngenta
T_{14}	:	R-30	Agro seeds
T_{15}	:	Palak Patta (check)	Manyata seeds

(c) Methods of experiment: Soil samples were collected at depth of 0-15 cm and were brought into laboratory, dried in shade at room temperature and processed to pass through 2-mm sieve. The soil of the experimental block was inceptisols. Table 2 indicates the results of soil pH was in slightly acidic in nature, In terms of EC (dSm^{-1}) of soil also showed that EC of soil was within safe limit. Organic carbon (%) the result indicated that the organic carbon content of soil was medium. The Available nitrogen (kg ha^{-1}) was 203.23 kg ha^{-1}, Available phosphorus (kg ha^{-1}) was 10.71 and available potash (kg ha^{-1}) was 139.23. The field was prepared by ploughing and frequent harrowing. FYM was given at the rate of 10 cart load $hectare^{-1}$ before last harrowing and mixed well with soil. Later on sowing was done on 27th of October. The ridges and furrow was opened in a bed size 20 x 10c.m. A spacing of 20 cm was kept between the ridges. The seed was dibbled at 10 cm spacing. Fertilization carried out as per recommendations and all the necessary cultural practices were adopted.

Table 2. Physico-chemical properties of experimental plot

S.No.	Characteristic	Value	Range	Source
1.	pH	**6.80**	Slightly acidic	Glass electrode pH meter (Piper, 1967)
2.	EC (dS m^{-1})	**0.10**	Medium	Solubridge conductivity method (Black,1965)
3.	Organic Carbon (%)	**0.58**	Medium	Walkley and Black's rapid titration method (Black, 1965)
4.	Available N (kg ha^{-1})	**203.218**	Low	Alkaline permanganate method (Subbiah and Asija, 1956)
5.	Available P (kg ha^{-1})	**10.71**	Very Low	Olsen's method (Olsen *et al*., 1959**)**
6	Available K (kg ha^{-1})	**139.216**	Medium	Flame photometer method (Muhr *et al.*, 1965).

(d) Data collection: Observation of important aspects such as days to 50% germination, plant height (cm), number of leaves $plant^{-1}$, East-West spread of the plant (cm), North- South spread of the plant (cm), fresh weight of leaves (g), dry weight of leaves(g), fresh weight of roots (g), dry weight of roots (g), diameter of root(cm), length of root (cm), root: shoot ratio, days to harvest, leaf yield (kg $plot^{-1}$), leaf yield (t ha^{-1}), root yield (kg $plot^{-1}$), root yield (t ha^{-1}), gross income, net income and benefit-cost ratio were recorded on five random plants from each replication. The ANOVA were carried out by statistical analysis as per the procedure laid down by Gomez and Gomez (1984). The variance ratio (F-value) was used to test the significance of the treatment effect. Appropriate standard errors and critical difference at 5% probability level was used to test the statistical significance of the results. The following Analysis of variance (ANOVA) table was prepared for each character recorded. The statistical analysis was carried out for each observed character by using MS-Excel and OPSTAT.

Result and Discussion

Days to 50% germination:

Days to 50% germination is determined by seed genetic composition, morphological features and environmental factors. Less number of days to 50% germination is desirable to obtain early maturity of the crop. The values for the character days to 50% germination ranged from 6.33-10.67 (Table 3 and Figure 1). The minimum number of days to 50% germination was observed in Pusa Mridula (6.33) suggesting the superiority of the varieties for the given trait among all the other treatments whereas, the maximum number of days to 50% germination was observed in Pusa Jamuni (10.67). Seed germination is influenced by various environmental factors such as availability of moisture, light, air and optimum temperature. But, the plant genotype also plays a critical role in germination. The characteristics such as seed vigour and dormancy are genetically inherited, which may be the

reason for these variations. Singh (2020) also reported similar findings for days to 50% germination in radish.

Plant height (cm):

The data with respect to plant height was recorded at an interval of 15 days from sowing upto the harvest and is presented in Table 3 and Figure 2. The results revealed that there was non-significant difference in plant height at 15 DAS. However at 30 DAS, Palak Patta recorded significantly the maximum plant height (21.20) which was statistically at par with R-30 (20.07), Mino Early (19.13), Kashi Lohit (18.87), Kashi Hans (18.27), Pusa Chetki (18.07) and Ivory White (18.04). However, Pusa Gulabi (15.13) recorded the minimum plant height among the others. At 45 DAS, Kashi Lohit recorded the maximum plant height (35.27) which was statistically at par with Mino Early (34.45), Kashi Hans (34.05), Kashi Muli- 40 (33.77), Chinese Pink (30.74) and R-30 (28.33) while, the minimum plant height was recorded in Pusa Mridula (22.89). At harvest, Kashi Lohit recorded the maximum plant height (37.69) which was statistically at par with treatment Mino Early (36.41), Kashi Muli-40 (36.33), Kashi Hans (36.29), Ivory White (33.73), Palak Patta (32.57), Chinese Pink (32.19), Pusa Gulabi (32.16), R-30 (31.98) and Pusa Shweta (31.97) while, the minimum plant height was observed in Pusa Mridula (23.68). The non-significant difference in early stages of growth is obvious, as during germination and growth initiation process the varieties might not have expressed their genetic potential. Plant height is an indicator of vegetative growth that differed significantly among all fifteen varieties. The variation in plant height and growth of different radish varieties were also observed by Dahal (2021).

Number of leaves plant^{-1}:

The data with respect to number of leaves plant^{-1} was recorded at an interval of 15 days from sowing upto the harvest is presented in Table 3 and Figure 2. The results revealed that there was non-significant difference in number of leaves plant^{-1} at 15 DAS. However at 30 DAS, Palak Patta recorded the maximum number of leaves plant^{-1} (8.47) which was statistically at par with Kashi Hans (8.20), Pusa Mridula (7.93), Kashi Lohit (7.47) and Pusa Chetki (7.15). At 45 DAS, Kashi Muli–40 recorded significantly the maximum number of leaves plant^{-1} (12.60) which was statistically at par with treatments Palak Patta (12.06), Kashi Hans (11.87), Kashi Lohit (11.60), Pusa Jamuni (11.13), R-30 (11.01), Pusa Gulabi (10.93), MRH-111 (10.87), Pusa Shweta (10.73), Snow White (10.67) and Pusa Chetki (10.13). At harvest, Pusa Jamuni recorded the maximum number of leaves plant^{-1} (13.33) which was statistically at par with treatment Palak Patta (12.06), Kashi Hans (11.87), Kashi Lohit (11.60), Pusa Jamuni (11.13), R-30 (11.01), Pusa Gulabi (10.93), Pusa Shweta (10.73) and

Pusa Chetki (10.13). While, the minimum number of leaves plant^{-1} was observed in Pusa Mridula (9.80).The non-significant difference in early stages of growth is attributed to the growth initiation process of the varieties that might not have expressed their genetic potential at the early stages. The significant differences thereafter could be attributed to the requirement of developing plants for more quantum of carbohydrates, which might have forced the plants of these varieties to produce more number of leaves. The variation in number of leaves among different radish varieties was also reported by Ola *et al.* (2018).

Table 3: Performance of different radish varieties with respect to days to 50% germination, plant height and number of leaves plant^{-1}

Treatments	Days to 50% germination	Plant height (cm)				Number of leaves plant^{-1}			
		15 DAS	30 DAS	45 DAS	At harvest	15 DAS	30 DAS	45 DAS	At harvest
Pusa Chetki	8.43	6.07	18.07	29.53	30.47	4.42	7.15	10.13	10.53
Pusa Mridula	6.33	6.20	16.90	22.89	23.68	4.53	7.93	9.40	9.80
Pusa Shweta	9.33	5.33	17.91	26.11	31.97	3.87	6.53	10.73	11.13
Pusa Gulabi	10.33	5.27	15.13	25.24	32.16	3.80	6.47	10.93	13.06
Pusa Jamuni	10.67	5.13	15.53	24.64	31.47	3.93	6.07	11.13	13.33
Kashi Hans	7.67	6.25	18.27	34.05	36.29	4.33	8.20	11.87	12.13
Kashi Muli – 40	8.67	5.93	17.87	33.77	36.33	3.80	6.73	12.60	13.01
Kashi Lohit	8.33	6.13	18.87	35.27	37.69	3.87	7.47	11.60	12.05
Chinese Pink	7.33	5.40	14.60	30.74	32.19	4.40	7.06	9.60	10.27
MRH-111	8.57	5.94	16.20	24.44	28.98	3.77	6.40	10.87	11.80
Snow White	9.10	5.87	15.33	23.46	29.71	3.73	6.80	10.67	11.27
Mino Early	7.53	5.67	19.13	34.45	36.41	4.40	7.13	9.07	10.06
Ivory White	9.67	5.60	18.04	27.13	33.73	3.73	6.87	9.80	10.40
R-30	8.53	5.80	20.07	28.33	31.98	4.33	7.27	11.01	12.27
Palak Patta (c)	7.07	5.53	21.20	31.73	32.57	4.27	8.47	12.06	13.27
SEm±	0.67	0.35	1.15	2.16	2.46	0.22	0.46	0.70	0.85
CD (P=0.05)	1.94	NS	3.34	6.30	7.17	NS	1.34	2.05	2.48
CV%	13.58	10.70	11.38	13.02	13.18	9.12	11.22	11.30	12.67

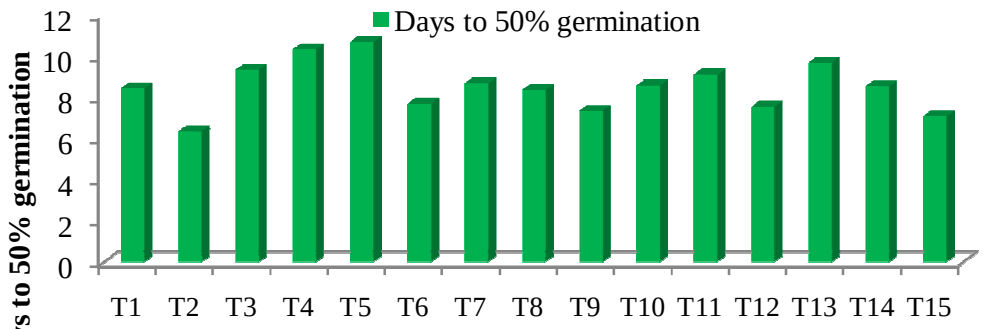

Figure 1: Graphical representation of performance of different radish varieties with respect to days to 50% germination

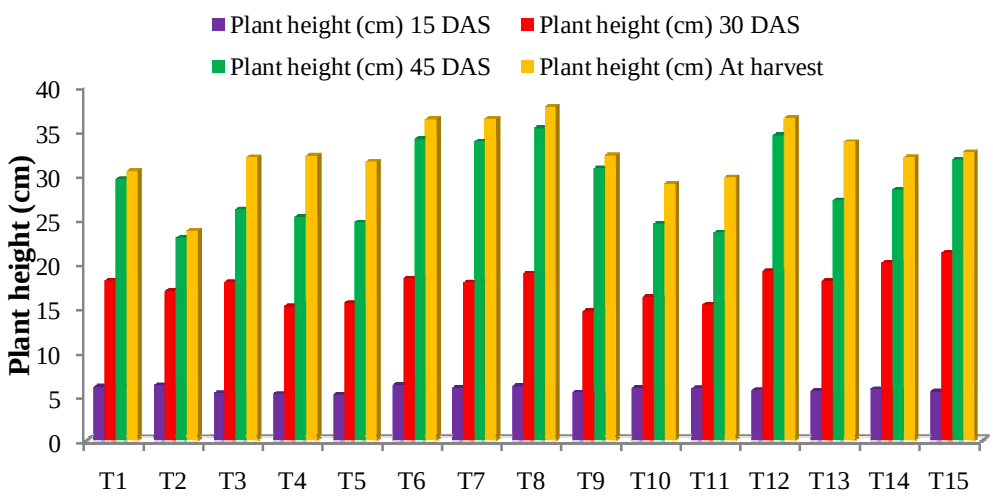

Figure. 2: Graphical representation of performance of different radish varieties with respect to plant height (cm) at different stage.

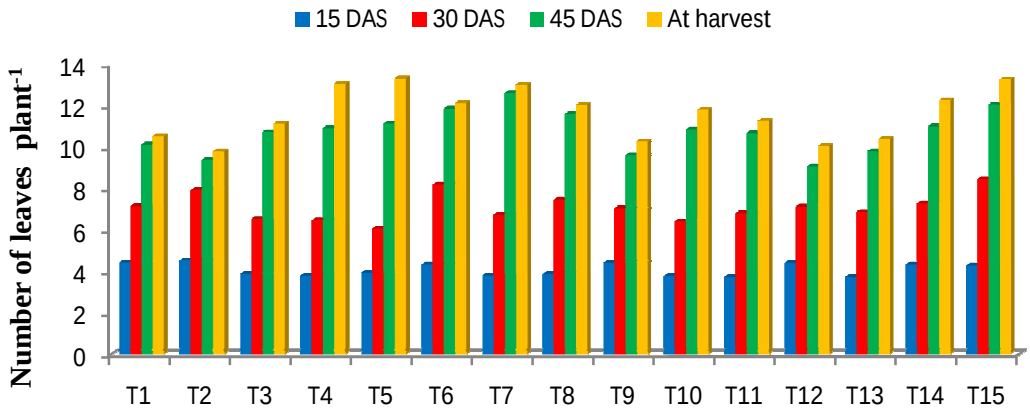

Figure. 3: Graphical representation of performance of different radish varieties with respect to number of leaves plant^{-1}

East – West spread of the plant (cm)

The data with respect to the E-W spread of the plant recorded at an interval of 15 days from sowing upto the harvest is presented in Table 4. The perusal of data revealed that there was significant difference in the E-W spread of the plant at 15 DAS. Mino early recorded the maximum spread of the plant (8.53) which was statistically at par with Ivory white (8.13) and Pusa Mridula (8.07) While, the minimum plant spread was observed in Pusa Jamuni (5.73). At 30 DAS, Ivory white recorded the maximum E-W spread of the plant (23.13) which was statistically at par with Kashi Muli-40 (22.33), Palak Patta (22.32), Mino Early (22.27), Kashi Hans (21.93), Pusa Mridula (21.07), Snow White (20.87), R-30 (20.42) and Kashi Lohit (20.40). At 45 DAS, Ivory White recorded the maximum E-W spread of the plant (29.90) which was statistically at par with Mino Early (28.30), Kashi Muli- 40 (26.71), R-30 (26.70), Kashi Lohit (25.70), Kashi Hans (25.10) and Palak Pattta (24.83). At harvest, Pusa Jamuni recorded significantly the maximum E-W spread of the plant (33.43) which was statistically at par with Ivory White (32.10), R-30 (31.90) and Pusa Gulabi (31.37). However, the minimum E-W spread of the plant was recorded in Pusa Mridula (20.90). Maximum spread of plant might be helpful for more photosynthesis and making food for better yield potential character of plant growth and produce maximum yield. The differences in spread of plant among the varieties might be due to the genetic makeup of the plant and its expression to the growing soil and environmental conditions. The variation in spread growth of different radish varieties was also observed by Yogesh (2020).

North - South spread of the plant (cm)

The data with respect to N-S spread of the plant was recorded at an interval of 15 days from sowing upto the harvest and is presented in Table 4. The data revealed that there was significant difference in spread of the plant at 15 DAS. Pusa Mridula recorded maximum spread of the plant (10.07) which was statistically at par with Chinese Pink (9.73) and R-30 (9.05). At 30 DAS, Chinese Pink recorded the maximum spread of the plant (33.06) which was statistically at par with Ivory White (32.73), Mino Early (32.20) and Kashi Muli- 40 (32.13). While, the minimum spread of the plant was observed in Pusa Mridula (24.60).At 45 DAS, Ivory White recorded the maximum spread of the plant (41.13) which was at par with Pusa Shweta (40.53), Mino Early (40.13), Palak Patta (39.67) and R-30 (37.87). However, Pusa Mridula (26.60) recorded the minimum N-S spread of the plant. At harvest, Ivory White recorded the maximum spread of the plant (46.50) which was statistically at par with Pusa Jamuni (46.49), Pusa Shweta (45.57), R-30 (44.83), Palak Patta (44.63) and Mino Early (44.03). While, the minimum spread of the plant was recorded in Pusa Mridula (28.10). Such

variations could be attributed to the genetic background of the varieties, which bears a strong influence on the growth potential of a plant. The variation in spread growth of different radish varieties was also observed by Yogesh (2020).

Table 4: Performance of different radish varieties with respect to East– West spread of the plant (cm) and North - South spread of the plant (cm)

Treatments	East –West spread of the plant (cm)				North - South spread of the plant (cm)			
	15 DAS	30 DAS	45 DAS	At harvest	15 DAS	30 DAS	45 DAS	At harvest
Pusa Chetki	6.33	18.67	23.83	26.10	8.97	26.13	32.67	34.7
Pusa Mridula	8.07	21.07	18.83	20.90	10.07	24.6	26.6	28.1
Pusa Shweta	6.40	19.07	21.70	26.23	8.2	26.33	40.53	45.57
Pusa Gulabi	5.87	18.47	23.30	31.37	8.4	30.17	36.07	44.1
Pusa Jamuni	5.73	16.67	21.43	33.43	8.3	31.73	38.2	46.49
Kashi Hans	7.07	21.93	25.10	28.50	7.87	30.13	37.53	40.43
Kashi Muli – 40	6.67	22.33	26.71	30.17	8.07	32.13	37.87	42.1
Kashi Lohit	7.40	20.40	25.70	29.43	8.97	31.13	38.53	40.97
Chinese Pink	6.87	17.60	24.23	27.50	9.73	33.06	32.67	36.03
MRH-111	6.13	17.47	23.23	26.43	9.07	30.06	35.07	41.23
Snow White	6.20	20.87	24.30	29.10	9.67	31.13	37.87	42.83
Mino Early	8.53	22.27	28.30	30.50	8.99	32.2	40.13	44.03
Ivory White	8.13	23.13	29.90	32.10	8.93	32.73	41.13	46.5
R-30	7.41	20.42	26.70	31.90	9.05	31.8	37.87	44.83
Palak Patta (c)	6.73	22.32	24.83	26.10	8.96	31.6	39.67	44.63
SEm±	0.37	1.32	1.73	2.16	0.43	1.78	2.44	2.94
CD (P=0.05)	1.09	3.84	5.03	6.28	1.26	5.19	7.1	8.56
CV%	9.36	11.31	12.2	13.03	8.42	10.17	11.47	12.27

Fresh weight of leaves (g)

The fresh weight of leaves was recorded at an interval of 15 days from sowing upto the harvest and is presented in Table 5. Significant variations were observed in the fresh weight of leaves in different varieties of radish at different growth periods. Pusa Mridula recorded significantly the maximum fresh weight of leaves (9.47) which was statistically at par with the treatments Pusa Shweta (9.28), Palak Patta (9.24), R-30 (8.31), Pusa Gulabi (8.18), Chinese Pink and Mino Early (8.04). However, the minimum fresh weight of leaves was observed in Kashi Hans (6.01) at 15 DAS. At 30 DAS, Pusa Jamuni recorded significantly the maximum fresh weight of leaves (86.60) followed by Kashi Muli- 40 (70.49) and Pusa Gulabi (62.00). However, it was the minimum in MRH-111 (40.75). At 45 DAS, Mino Early recorded the maximum fresh weight of leaves (102.16) which was statistically at par with Pusa Jamuni (98.52), Kashi Muli- 40 (96.59) and Kashi Lohit (87.99), while, the minimum weight was observed in MRH-111 (51.50). At harvest, Pusa Jamuni recorded the

maximum fresh weight of leaves (109.00) which was statistically at par with Mino Early (106.60), Kashi Muli- 40 (102.42), Kashi Lohit (93.48), Pusa Gulabi (90.70), Pusa Chetki (88.55) and Chinese Pink (85.57). However, the minimum fresh weight of leaves was found in treatment Kashi Hans (71.29). According to Ola *et al.* (2018) the factors influencing the weight of leaves are leaf length and leaf size and sometimes even the nutrient content in the leaves. So the phenotypic and genotypic features of leaf are an important feature in determining the weight of the leaves among different genotypes. The present findings are in conformity with the work of Dongarwar *et al.* (2017).

Fresh weight of roots (g)

The data with respect to fresh weight of roots was recorded at an interval of 15 days from the DAS upto the harvest is presented in Table 5. The perusal of data revealed that there was significant difference in the fresh weight of roots after 15 DAS. Kashi Muli– 40 recorded the maximum fresh weight of roots (3.85) which was statistically at par with MRH-111 (3.65), Kashi Lohit (3.43) and Palak Patta (3.00) however, it was the minimum in Pusa Gulabi (1.02). At 30 DAS, Snow White recorded maximum fresh weight of radish root (89.19) followed by R-30 (73.65) while, the minimum fresh weight of root was observed in Pusa Mridula (31.05). Kashi Lohit recorded the maximum fresh weight of roots (151.15) at 45 DAS, which was statistically at par with Kashi Hans, Kashi Muli- 40, R-30, Mino Early, Palak Patta, Snow White, Pusa Shweta, MRH-111, MRH-111, Ivory White and Chinese Pink (150.02, 147.42, 147.10, 145.82, 141.34, 139.73, 139.67, 137.33, 133.20 and 132.73 respectively). At harvest, Kashi Lohit recorded significantly the maximum fresh weight of roots (153.75) which was statistically at par with the treatments Kashi Hans (153.03), Kashi Muli- 40 (152.51), R-30 (151.32), Pusa Shweta (151.05), Mino Early (148.07), Palak Patta (145.63), Snow White (145.55), MRH-111 (141.13), Ivory White (139.07) and Chinese Pink (136.87) while, the minimum fresh weight of roots was recorded in treatment Pusa Mridula (72.81). The increase in grade wise weight of root might be due to the early root development and growth of plant because of less weed competition which leads to proper aeration in root zone, availability of nutrient, water, space and sunlight which resulted in better growth of photosynthetic organs, translocation of nutrients and photosynthesis to developing plant parts. The variation in the fresh weight of roots might also be due to the genetic variation. The present findings are in conformity with the work of Hosneara *et al.* (2012) and Shrestha *et al.* (2021).

Table 5: Performance of different radish varieties with respect to Fresh weight of leaves (g) and Fresh weight of roots (g)

Treatments	Fresh weight of leaves (g)				Fresh weight of roots (g)			
	15 DAS	30 DAS	45 DAS	At harvest	15 DAS	30 DAS	45 DAS	At harvest
Pusa Chetki	6.52	60.75	83.77	88.55	2.91	34.97	116.13	120.53
Pusa Mridula	9.47	44.80	75.79	77.10	2.02	31.05	70.00	72.81
Pusa Shweta	9.28	48.21	67.12	75.18	1.97	40.95	139.67	151.05
Pusa Gulabi	8.18	62.00	82.64	90.70	1.02	50.69	77.56	84.51
Pusa Jamuni	7.13	86.60	98.52	109.59	1.53	50.99	74.47	80.62
Kashi Hans	6.01	50.26	68.67	71.29	2.14	44.94	150.02	153.03
Kashi Muli – 40	7.71	70.49	96.59	102.42	3.85	53.86	147.42	152.51
Kashi Lohit	7.57	59.83	87.99	93.48	3.43	66.69	151.15	153.75
Chinese Pink	8.04	55.53	81.55	85.57	2.63	52.97	132.73	136.87
MRH-111	7.44	40.75	51.50	77.13	3.65	73.41	137.33	141.13
Snow White	6.53	57.13	81.37	87.23	2.73	89.19	139.73	145.55
Mino Early	8.04	56.33	102.16	106.60	2.85	66.31	145.82	148.07
Ivory White	7.57	53.49	76.26	80.60	3.15	72.11	133.2	139.07
R-30	8.31	45.22	69.45	76.87	2.22	73.65	147.1	151.32
Palak Patta (c)	9.24	54.41	75.92	81.65	3.00	58.34	141.34	145.63
SEm±	0.49	4.01	6.02	7.29	0.14	3.76	8.87	10.18
CD (P=0.05)	1.43	11.68	17.52	21.24	0.42	10.94	25.84	29.65
CV%	10.88	12.32	13.03	14.53	9.60	11.34	12.11	13.38

Dry weight of leaves (g)

The data on dry weight of leaves was recorded at an interval of 15 DAS upto the harvest and is depicted in Table 6. The data revealed significant differences in dry weight of leaves in radish at 15 DAS, Palak Patta recorded significantly maximum dry weight of leaves (1.01) which was statistically at par with Pusa Mridula (1.00), Pusa Shweta (0.99) and R-30 (0.91). However, it was the minimum in Kashi Hans (0.66). At 30 DAS, Pusa Jamuni recorded the maximum dry weight of leaves (8.16) which was statistically at par with Pusa Gulabi and Pusa Chetki (8.11 and 6.14 respectively) Whereas, MRH-111 (4.93) recorded the minimum dry weight of leaves among the other varieties. At 45 DAS, Mino Early recorded the maximum dry weight of leaves (10.15) which was statistically at par with the treatments Kashi Muli- 40 (9.22), Pusa Jamuni (9.08), Pusa Gulabi (8.88) and Kashi Lohit (8.77). However, the minimum dry weight of leaves was found in MRH-111 (5.80). At harvest, Mino early recorded the maximum dry weight of leaves (11.00) which was statistically at par with Pusa Jamuni, Kashi Muli– 40, Pusa Gulabi and Pusa Chetki (10.72, 10.22, 9.95 and 9.11 respectively). However, the minimum dry weight of leaves was recorded in Pusa Shweta

(8.00). According to Semba *et al.* (2019) solar radiation and temperature might have accelerated growth process and accumulated more dry matter plant^{-1} over the varieties. The present findings are in conformity with the work of Gyewali *et al*. (2020).

Dry weight of roots (g)

The data with regard to the dry weight of roots was recorded at an interval of 15 DAS upto the harvest and is presented in Table 6. The data as shown in Table 6 revealed that there was significant difference in dry weight of roots at 15 days interval. Kashi Muli– 40 recorded significantly maximum dry weight of roots (0.41) which was statistically at par with treatment MRH-111 (0.39) and Kashi Lohit (0.36) while, the minimum in Pusa Gulabi (0.11) at 15 DAS. At 30 DAS, Snow white recorded significantly the maximum dry weight of roots (10.54) while, the minimum dry weight of roots was found in Pusa Mridula (3.67). At 45 DAS, Kashi Lohit recorded the maximum dry weight of roots (19.05) which was statistically at par with treatments Kashi Hans (18.86), R-30 (18.49), Mino Early (18.33), Kashi Muli - 40 (18.10), Palak Patta (17.77), Snow White (17.56), Pusa Shweta (17.40), MRH-111 (17.26), Ivory White (16.74) and Chinese Pink (16.60). However, it was the minimum in Pusa Mridula (8.80). At harvest, Kashi Lohit recorded the maximum dry weight of roots (26.27) which was statistically at par with treatments Kashi Hans (19.59), Kashi Muli- 40 (19.52), Pusa Shweta (19.33), R-30 (19.23), Mino Early (18.95), Palak Patta (18.64), Snow White (18.59), MRH-111 (18.07), Ivory White (17.80) and Chinese Pink (17.52). While, the minimum dry weight of roots was observed in Pusa Mridula (9.32). Better heritability quality from the parents influences the root weight. The present findings are in conformity with the work of Sivathanu *et al*. (2014) and Singh *et al.* (2019).

Table 6: Performance of different radish varieties with respect to dry weight of leaves (g) and dry weight of roots (g)

Treatments	Dry weight of leaves (g)				Dry weight of roots (g)			
	15 DAS	30 DAS	45 DAS	At harvest	15 DAS	30 DAS	45 DAS	At harvest
Pusa Chetki	0.78	6.14	8.09	9.11	0.31	4.13	14.6	15.43
Pusa Mridula	1.00	5.03	7.34	8.21	0.21	3.67	8.80	9.32
Pusa Shweta	0.99	5.37	6.58	8.00	0.21	4.84	17.4	19.33
Pusa Gulabi	0.79	8.11	8.88	9.95	0.11	5.99	9.75	10.82
Pusa Jamuni	0.74	8.16	9.08	10.72	0.16	6.02	9.36	10.32
Kashi Hans	0.66	5.94	7.35	8.37	0.23	5.31	18.86	19.59
Kashi Muli – 40	0.83	7.52	9.22	10.22	0.41	6.36	18.10	19.52
Kashi Lohit	0.80	6.57	8.77	9.73	0.36	7.88	19.05	19.68
Chinese Pink	0.84	5.64	7.38	8.86	0.28	5.42	16.60	17.52
MRH-111	0.79	4.93	5.80	8.23	0.39	8.67	17.26	18.07
Snow White	0.71	6.18	7.69	9.01	0.29	10.54	17.56	18.59
Mino Early	0.84	6.19	10.15	11.00	0.30	7.83	18.33	18.95
Ivory White	0.81	5.75	7.45	8.52	0.34	8.51	16.74	17.80
R-30	0.91	5.09	7.03	8.12	0.24	8.70	18.49	19.23
Palak Patta (c)	1.01	6.00	7.58	8.73	0.32	6.89	17.77	18.64
SEm±	0.05	0.51	0.63	0.66	0.02	0.52	1.17	1.37
CD (P=0.05)	0.15	1.47	1.84	1.91	0.05	1.52	3.41	3.99
CV%	10.96	14.20	13.90	12.49	10.65	13.48	12.74	14.07

Fresh weight of plant (g)

The data regarding to the fresh weight of the plant is presented in Table 7. The results revealed that there were significant differences in the fresh weight of plant at 15 days interval. Palak Patta recorded the maximum dry weight of roots (12.233), which was statistically at par with Kashi Muli - 40 (11.56), Pusa Mridula (11.49), Pusa Shweta (11.25), Kashi Lohit (11.1), Mino Early (10.89), Ivory White (10.75), Chinese Pink (10.67) and R-30 (10.55). At 30 DAS, Snow white recorded the maximum fresh weight of plant (146.317) which was statistically at par with Pusa Jamuni (137.60), Kashi Lohit (126.52), Ivory White (125.60), Kashi Muli- 40 (124.35) and Mino Early (122.64) while, it was the minimum in Pusa Mridula (75.85). At 45 DAS, Mino Early recorded the maximum fresh weight of plant (247.97) which was statistically at par with Kashi Muli-40 (245.22), Kashi Lohit (238.95), Snow White (221.10), Kashi Hans (218.69), Palak Patta (217.26), R-30 (216.54), Chinese Pink (213.62). Ivory White (209.46) and Pusa Shweta (206.78). While, the minimum fresh weight of plant was observed in Pusa Mridula (145.79). At harvest, Kashi Muli– 40 recorded the maximum fresh weight of plant (254.93) which was statistically at par with Mino Early (252.81), Kashi Lohit (247.23), Snow White (232.86), Palak Patta (228.80), R-30 (227.57),

Kashi Hans (224.32), Chinese Pink (222.44), Pusa Shweta (226.24) and Ivory White (220.23), while, the minimum fresh weight of plant was observed in Pusa Mridula (149.91). The difference in plant weight does not only depend on heritability quality but also depends on the environmental factors. These differences in fresh weight could be attributed to overall growth in vegetative structure of difference varieties which is influenced by genetic makeup in the varieties and also depends on their environmental conditions. The present findings are in conformity with the work of Sharma *et al*. (2016) and Semba *et al*. (2019).

Dry weight of plant (g)

The data regarding the dry weight of plant (g) is presented in Table 7. Significant differences were observed in the dry weight of plant at each 15 days interval. Palak Patta recorded the maximum dry weight of plant (1.30) which was statistically at par with treatment Kashi Muli- 40 (1.23), Pusa Mridula (1.22), Pusa Shweta (1.19), MRH-111 (1.18), Kashi Lohit (1.17), Mino Early (1.15), Ivory White (1.14), Chinese Pink (1.13) and R-30 (1.12) while, the minimum dry weight of plant was recorded in Kashi Hans (0.86) at 15 DAS. Snow White recorded the maximum dry weight of plant (16.81) at 30 DAS which was statistically at par with treatment Pusa Jamuni (15.53), Kashi Lohit (14.44) and Ivory White (14.39) while, the minimum dry weight of plant was observed in Pusa Mridula (8.58). At 45 DAS, Mino Early recorded significantly the maximum dry weight of plant (28.44) which was statistically at par with Kashi Lohit (27.69), Kashi Muli- 40 (27.51), Kashi Hans (25.65), Snow White (25.62), R-30 (25.37), Palak Patta (25.28), Chinese Pink (24.67), Ivory White (24.29), and Pusa Shweta (24.20) While, it was the minimum in Pusa Mridula (16.30). At harvest the dry weight of plant (30.28) was the maximum in Kashi Muli– 40 which was statistically at par with Mino Early (29.95), Kashi Lohit (29.49), Snow White (27.80), R-30 (27.49), Palak Patta (27.37), Pusa Shweta (27.23), Kashi Hans (27.07), Chinese Pink (26.50), Ivory White (26.32) and MRH-111 (26.16). While, it was the minimum in Pusa Mridula (17.42). According to Semba *et al*. (2019) the differences in the dry weight of the leaves may be due to the dissimilarities in phenotypic and genotypic differences among the varieties like leaf length, nutrient content etc. The effect of environmental factor among the varieties might also have played a role.

Table 7: Performance of different radish varieties with respect to fresh weight of plant (g) and dry weight of plant (g)

Treatments	Fresh weight of plant (g)				Dry weight of plant (g)			
	15 DAS	30 DAS	45 DAS	At harvest	15 DAS	30 DAS	45 DAS	At harvest
Pusa Chetki	9.44	95.72	199.9	209.08	1.00	10.8	22.89	24.72
Pusa Mridula	11.49	75.85	145.79	149.91	1.22	8.58	16.30	17.42
Pusa Shweta	11.25	89.15	206.78	226.24	1.19	10.13	24.20	27.23
Pusa Gulabi	9.2	112.68	160.19	175.21	0.97	12.8	17.93	20.34
Pusa Jamuni	8.67	137.6	172.98	190.21	0.92	15.53	19.11	21.83
Kashi Hans	8.14	95.2	218.69	224.32	0.86	10.83	25.65	27.07
Kashi Muli –40	11.56	124.35	245.22	254.93	1.23	14.10	27.51	30.28
Kashi Lohit	11.01	126.52	238.95	247.23	1.17	14.44	27.69	29.49
Chinese Pink	10.67	101.39	213.62	222.44	1.13	11.51	24.67	26.50
MRH-111	11.09	114.16	188.83	218.26	1.18	13.14	22.36	26.16
Snow White	9.26	146.32	221.1	232.86	0.98	16.81	25.62	27.80
Mino Early	10.89	122.64	247.97	252.81	1.15	14.02	28.44	29.95
Ivory White	10.75	125.6	209.46	220.23	1.14	14.39	24.29	26.32
R-30	10.55	118.87	216.54	227.57	1.12	13.66	25.37	27.49
Palak Patta (c)	12.23	112.76	217.26	228.8	1.30	12.87	25.28	27.37
SEm±	0.72	8.6	17.2	18.26	0.07	0.91	1.92	2.15
CD (P=0.05)	2.1	25.04	50.07	53.16	0.19	2.65	5.59	6.26
CV%	12.01	13.15	14.42	14.46	10.42	12.23	13.95	14.32

Diameter of root (cm)

The diameter of root was recorded at harvest and is presented in Table 8.The results revealed that Pusa Chetki recorded the maximum diameter of root (5.65) which was statistically at par with Pusa Mridula (4.94) while, the minimum diameter of root was recorded in treatment Ivory White (3.14). Similar findings were reported by Dongarwal *et al.* (2017).

Length of root (cm)

The length of root was recorded at harvest and is depicted in Table 8. There was significant difference among the varieties for length of roots at harvest. R-30 recorded the maximum length of root (31.03) which was statistically at par with Mino Early (30.74), Ivory White (29.41), Kashi Muli-40 (28.84), MRH-111 (28.25), Snow White (27.97), Chinese Pink (27.49), Kashi Lohit (27.10), Kashi Hans (27.05), Palak Patta (26.55), Pusa Gulabi (26.43) and Pusa Chetki (25.89). In radish, root is the principal storage organ and its development involves complex interactions between environmental, genetic and physiological factors. The present findings are in corroboration with the results of Shrestha *et al.* (2021).

Root: Shoot Ratio

The data in respect of root: shoot ratio was recorded at harvest and is presented in Table 8. Kashi Hans recorded the maximum root: shoot ratio (2.17) which was statistically at par with Pusa Shweta (2.01) and Palak Patta (1.94) however, the minimum ratio was observed in treatment Pusa Jamuni (0.74). The present findings are in conformity with the results of Dahal *et al.* (2021).

Days taken to harvesting

Days taken to harvesting is an essential character that plays a very important role in identifying the early varieties. The varieties were classified as Early (<30 days), Mid (30-50 days) and Late (>50 days). Pusa Mridula (47.33 days) was the earliest variety in terms of marketable maturity (Table 8) as it took the minimum number to harvest. However, on the other hand the maximum days to marketable maturity was observed in Pusa Jamuni (62.33 days). The early variety, if shows high heritability can be used for developing future early varieties. These results were in accordance to those obtained by Singh (2020) and Shrestha *et al.* (2021).

Table 8: Performance of different radish varieties with respect to length of root (cm), diameter of root (cm), root: shoot ratio, days to harvesting and maturity periods

Treatments	Length of root (cm)	Diameter of root (cm)	Root : Shoot ratio	Days to harvesting	Maturity periods
Pusa Chetki	25.89	5.65	1.37	48.08	Mid
Pusa Mridula	16.28	4.94	0.95	47.33	Mid
Pusa Shweta	24.29	4.21	2.01	53.31	Late
Pusa Gulabi	26.43	4.70	0.93	57.03	Late
Pusa Jamuni	24.45	4.33	0.74	60.33	Late
Kashi Hans	27.05	3.75	2.17	49.33	Mid
Kashi Muli –40	28.84	3.91	1.49	50.67	Late
Kashi Lohit	27.10	3.99	1.65	49.10	Mid
Chinese Pink	27.49	4.48	1.61	48.33	Mid
MRH-111	28.25	4.17	1.83	50.67	Late
Snow White	27.97	4.34	1.67	51.68	Late
Mino Early	30.74	4.07	1.41	48.67	Mid
Ivory White	29.41	3.14	1.72	52.33	Late
R-30	31.03	4.08	1.94	51.07	Late
Palak Patta (c)	26.55	3.86	1.75	51.06	Late
SEm±	1.89	0.28	0.11	2.13	
CD (P=0.05)	5.50	0.82	0.32	6.20	
CV%	12.22	11.54	12.44	7.20	

Leaf yield (kg plot^{-1})

The data regarding the leaf yield (kg plot^{-1}) was recorded at harvest and presented in Table 9. Pusa Jamuni recorded the maximum leaves yield kg plot^{-1} (5.48) which was statistically at par with treatments Mino Early, Kashi Muli-40, Kashi Lohit and Pusa Gulabi (5.33, 5.12, 4.67 and 4.54 respectively). The present findings are in confirmation with the findings of Ola *et al.* (2018).

Leaf yield (t ha^{-1})

The leaf yield (t ha^{-1}) recorded at harvest is presented in Table 9. Pusa Jamuni recorded the maximum root yield (27.40 t ha^{-1}) which was statistically at par with Mino Early, Kashi Muli-40, Kashi Lohit and Pusa Gulabi (26.65, 25.60, 23.37 and 22.68 respectively). However, Kashi Hans (17.82t ha^{-1}) recorded the minimum leaf yield among the other treatments.Quite similar results were obtained by Sinchana (2021).

Root yield (kg plot^{-1})

The data with respect to root yield (kg plot^{-1}) was recorded at harvest and is presented in Table 9. Kashi Lohit recorded the maximum root yield (7.69) which was statistically at par with treatments Kashi Hans (7.65), Kashi Muli-40 (7.63), R-30 (7.51), Mino Early (7.41), Palak Patta (7.28), Snow White (7.27), Pusa Shweta (7.55), MRH-111 (7.06), Ivory White (6.95) and Chinese Pink (6.84). According to Yogesh (2020) the widely spaced plants produced longer roots than the closely spaced plants. This might be due to reduced competition for essential soil nutrients and sunlight which probably promoted the accumulation of photosynthesis in the roots. The present findings are in corroboration with the results of Dahal *et al*. (2021).

Root yield (t ha^{-1})

The root yield (t ha^{-1}) of radish is presented in Table 9. Kashi Lohit recorded the maximum root yield kg plot^{-1} (38.44) which was statistically at par with treatments Kashi Hans (38.26), Kashi Muli-40 (38.13), R-30 (37.55), Mino Early (37.02), Palak Patta (36.41), Snow White (36.35), Pusa Shweta (37.76), MRH-111 (35.28), Ivory White (34.77) and Chinese Pink (34.22).. According to Singh *et al*. (2019) yield increase in radish is mainly due to higher root weight and increase in length and diameter of the roots. Quite similar results have been deduced by Shrestha *et al.* (2021).

Table 9: Performance of different radish varieties with respect to leaf yield (kg plot^{-1}), leaf yield (t ha^{-1}), root yield (kg plot^{-1}) and root yield (t ha^{-1})

Treatments	Leaf yield (kg plot^{-1})	Leaf yield (t ha^{-1})	Root yield (kg plot^{-1})	Root yield (t ha^{-1})
Pusa Chetki	4.43	22.14	5.81	29.03
Pusa Mridula	3.85	19.27	3.64	18.2
Pusa Shweta	3.76	18.8	7.55	37.76
Pusa Gulabi	4.54	22.68	4.23	21.13
Pusa Jamuni	5.48	27.4	4.03	20.16
Kashi Hans	3.56	17.82	7.65	38.26
Kashi Muli -40	5.12	25.6	7.63	38.13
Kashi Lohit	4.67	23.37	7.69	38.44
Chinese Pink	4.28	21.39	6.84	34.22
MRH-111	3.86	19.28	7.06	35.28
Snow White	4.36	21.81	7.27	36.35
Mino Early	5.33	26.65	7.41	37.02
Ivory White	4.03	20.15	6.95	34.77
R-30	3.84	19.22	7.51	37.55
Palak Patta (c)	4.08	20.41	7.28	36.41
SEm±	0.33	1.65	0.48	2.38
CD (P=0.05)	0.96	4.77	1.38	6.94
CV%	13.16	13.12	12.51	12.56

Economics

Economics is the major criteria to finalize the best treatments, which are economically profitable and that can be accepted by the community of farmers. The performance of different radish treatments based on economics is presented in Table 10 with Figure 4 and 5. Kashi Lohit recorded the maximum gross income, net income and benefit cost ratio (Rs 3,84,373.30 ha^{-1} ; Rs 2,87,580.30 ha^{-1} and 2.97 respectively)among all the other treatments While, Pusa Mridula recorded the minimum gross income, net income and benefit cost ratio (Rs 1,82,033.30ha^{-1}; Rs 85,240.34ha^{-1} and 0.88 respectively). The present findings are in corroboration with the results of Sharma (2020) and Sinchana (2021).

Table 10: Performance of different radish varieties with respect to gross income, net income and benefit cost ratio

Treatments	Gross Income (Rs./ ha)	Net Income (Rs./ ha)	B : C
Pusa Chetki	2,90,333.30	2,13,373.70	2.21
Pusa Mridula	1,82,033.30	85,240.34	0.88
Pusa Shweta	3,77,626.70	2,80,833.70	2.90
Pusa Gulabi	2,11,273.70	1,14,480.70	1.18
Pusa Jamuni	2,01,552.70	1,04,759.70	1.08
Kashi Hans	3,82,571.70	2,85,778.70	2.95
Kashi Muli – 40	3,81,278.30	2,84,485.30	2.94
Kashi Lohit	3,84,373.30	2,87,580.30	2.97
Chinese Pink	3,42,166.70	2,45,373.70	2.54
MRH-111	3,52,833.30	2,56,040.30	2.65
Snow White	3,64,065.00	2,67,272.00	2.76
Mino Early	3,70,176.70	2,73,383.70	2.82
Ivory White	3,47,666.70	2,50,873.70	2.59
R-30	3,75,533.30	2,81,500.30	2.91
Palak Patta (c)	3,64,065.00	2,67,272.00	2.76
SEm±	23,699.07	16,234.52	0.17
CD (P=0.05)	69,007.73	47,272.23	0.51
CV%	12.50	12.06	12.51

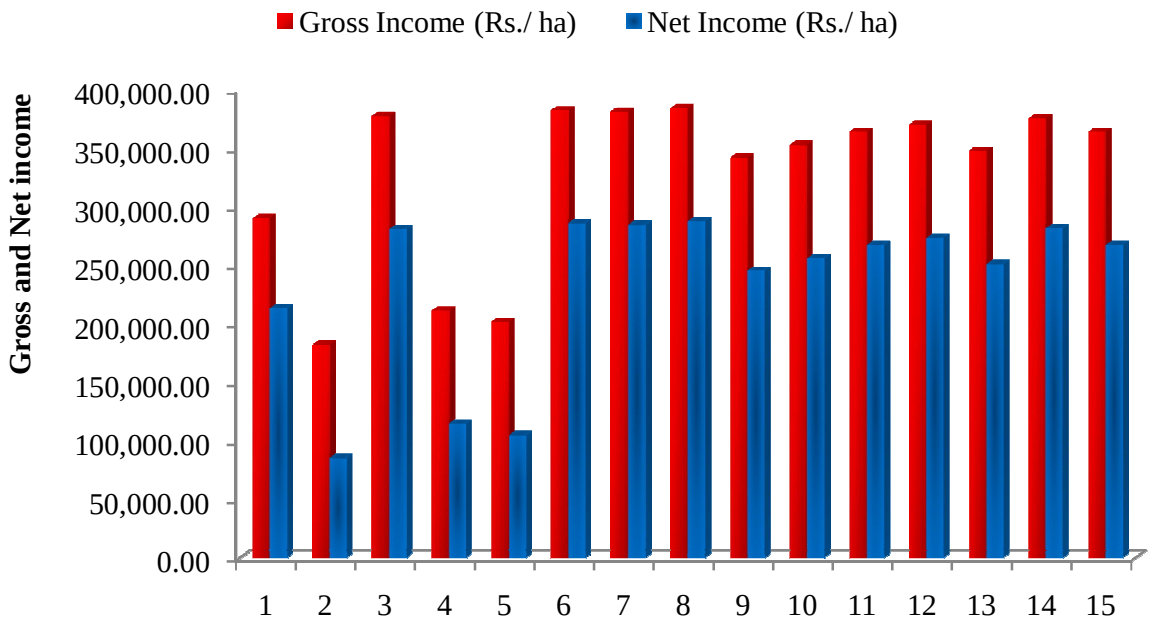

Figure 4: Graphical representation of Gross and Net income of radish varieties

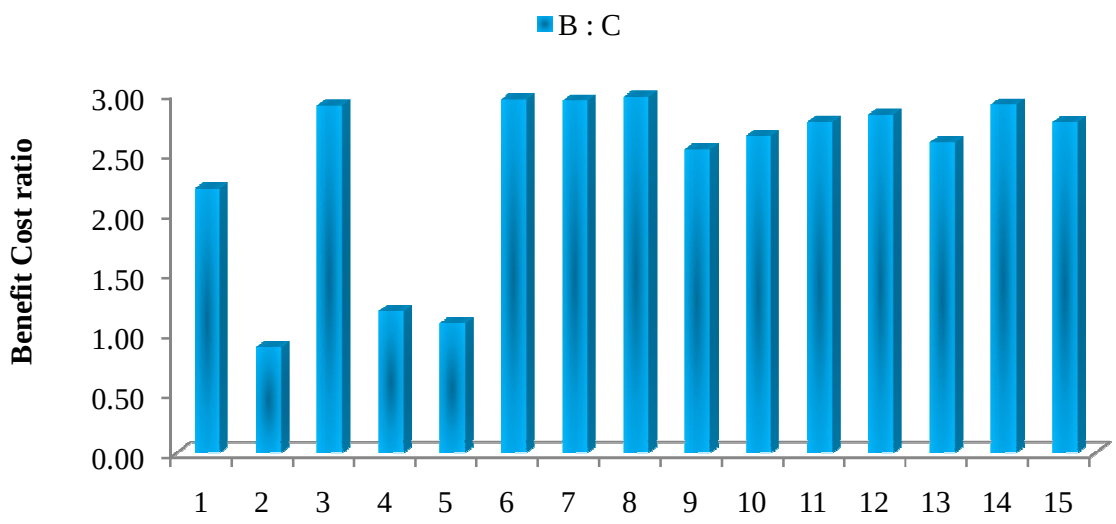

Figure 5: Graphical representation of benefit cost ratio of radish varieties

Conclusion

The variety showing greater yield potential with desirable qualities may be tested under different agro-climatic conditions and those found superior. The present investigation found that Kashi Lohit was observed to be the highest yielding variety which was at par with Kashi Hans, Kashi Muli-40, R-30 and Mino Early. The morphological studies also revealed high variations in these varieties suggesting that the selection of these varieties could be beneficial for commercial cultivations in Bastar as well as northern region of Chhattisgarh.

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