Original Research Article

Performance and Economical cost analysis of different Radish(*Raphanussativus* L.) varieties under sub tropical conditions of central India

ABSTRACT

Start with the aim of the reseach as a statementThis research focused on selection of superior radish varieties having high yield potential with better quality root for Bastar plateau. This research was conducted at the Research cum Instructional Farm of College of Horticulture and Research Station, Jagdalpur, Chhattisgarh, during the *Rabi*season of 2021.The experiment consisted of fifteen treatments of radish which was laid out in randomized block design (RBD) with three replications. The treatments of the present investigation consisted of varieties:PusaChetki, PusaMridula, PusaShweta, PusaGulabi, PusaJamuni, Kashi Hans, KashiMuli 40, KashiLohit, Chinese Pink, MRH111, Snow White, Mino Early, Ivory White, R-30 and (check): PalakPatta.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 inPM (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 KL(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}, E-W spread of the plant, fresh weight of leaf andleaf area index in PJ(13.33, 33.43 cm, 109.59 g and 5.47 respectively); N-S spread of the plant in IW(46.50 cm); fresh and dry weight of plant in KM-40 (254.93 g and 30.28 g respectively), dry weight of leaf inME (11.00 g).While, PGrecorded 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 varietyR-30, PC andKHrespectively.The results depicted that KLproduced 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 (*Raphanussativus*L.) is one of the most important root crops ~~belonging to~~of the family Cruciferaeand ~~having~~ hasa chromosome number 2n = 2x = 18. It ~~is~~ originated in Europe and Asia around which years ~~.Radish is derived from the Latin word "*radix*~~should be the opening sentence". India is the second largest producer of horticulture quote the statistics after China. Remarkable progress has been made in area of expansion resulting in higher production of radish over the last few decades quote figures. Over the last decade, the area under horticulture grew by 2.6 per cent per annum and annual production increased by 4.8 per cent. During 2017-2018 area under vegetables was 10.26 million hectares with a production of 184.40 metric tonnes. In India, radish was grown over an area of 212 million hectares in 2018-19 with an annual production of 3316 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 (2020) the area ~~and~~ under production of white radish in Chhattisgarh was 13,253 ha and 2,38,496 MT respectively. However in Bastar~~its~~ 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). Radish roots vary greatly in size, shape and other external characters as well as for the time upto which they remain edible. Depending upon the cultivar, the length may vary from 25-30 cm. Its shape varies from cylindrical to long tapering and the external colour may be white or different shades of scarlet. Various flesh coloured variety has also been developed. 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. There are several factors like variety, season of planting, nutrition and irrigation which plays a dominant role in yield contribution and quality production.

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Material and Methods

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

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Horticulture and Research Station, Dharampura, Jagdalpur, Bastar (CG) – 494001. The experiment was laid out in a randomized block design (RBD) with three treatments. The treatments include fifteen varieties viz., T_1: PC, T_2: PM, T_3: PS, T_4: PG, T_5: PJ, T_6: KH, T_7: KM-40, T_8: KL, T_9: CP, T_{10}: MRH111, T_{11}: SW, T_{12}: ME, T_{13}: IW, T_{14}: R-30 and T_{15} (check): PP. Soil samples were collected at depth of 0-15 cm and were brought into laboratory, dried in shade at room temperature and processed topass through 2-mm sieve. The soil of the experimental block was medium Brown. Results of pH indicated that soil 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}) was203.23 kg ha^{-1}, Available phosphorus (kg ha^{-1}) was 10.71 and availablepotash (kg ha^{-1}) was 139.23.The field was prepared by ploughing andfrequent harrowing. FYM was given at the rate of 10 cart load $hectare^{-1}$ before last harrowing andmixed well with soil. Later on sowing was doneon 27th of October. The ridges and furrow wasopened in a bed size 20 x 10c.m. A spacing of 20 cm was kept between the ridges. The seedwas dibbled at 10 cm spacing. Fertilizationcarried out as per recommendations and all thenecessary cultural practices were adopted.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- Southspread 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. TheANOVA were carried out as suggested.

Table 1. Physico-chemical properties of soil

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).

Table 2. Treatment details and source

Treatments		Treatments Details	Source
T_1	:	PusaChetki (PC)	IARI, New Delhi
T_2	:	PusaMridula (PM)	IARI, New Delhi
T_3	:	PusaShweta (PS)	IARI, New Delhi
T_4	:	PusaGulabi (PG)	IARI, New Delhi
T_5	:	PusaJamuni (PJ)	IARI, New Delhi
T_6	:	Kashi Hans (KH)	IIVR, Varanasi
T_7	:	KashiMuli– 40 (KM-40)	IIVR, Varanasi
T_8	:	KashiLohit (KL)	IIVR, Varanasi
T_9	:	Chinese Pink (CP)	Agro seeds
T_{10}	:	MRH-111	Dhanya veg seeds
T_{11}	:	Snow white (SW)	Advanta golden seeds
T_{12}	:	Mino early (ME)	Sungro seeds
T_{13}	:	Ivory white (IW)	Syngenta
T_{14}	:	R-30	Agro seeds
T_{15}	:	PalakPatta (check) (PP)	Manyata seeds

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). The minimum number of days to 50% germination was observed inPM (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 PJ(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.The results revealed that there was non-significant difference in plant height at 15 DAS. However at 30 DAS, PP recorded significantly the maximum plant height (21.20) which was statistically at par with R-30 (20.07), ME (19.13), KL (18.87), KH(18.27), PC(18.07) and IW(18.04). However, PG(15.13) recorded the minimum plant height among the others.At 45 DAS KLrecorded the maximum plant height (35.27) which was statistically at par with ME(34.45), KH(34.05), KM-40(33.77), CP(30.74) and R-30(28.33) while, the minimum plant height was recorded in PM(22.89). At harvest KLrecorded the maximum plant height (37.69) which was statistically at par with treatmentME(36.41), KM- 40(36.33), KH(36.29), IW(33.73), PP(32.57), CP(32.19),PG(32.16), R-30(31.98) and PS(31.97) while, the minimum plant height was observed in PM(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. The results revealed that there was non-significant difference in number of leaves plant^{-1} at 15 DAS. However at 30DAS, PPrecorded the maximum number of leaves plant^{-1} (8.47) which was statistically at par with KH(8.20), PM(7.93), KL(7.47) and PC(7.15). At 45 DAS, KM–40recorded significantly the maximum number of leaves plant^{-1}(12.60) which was statistically at par with treatmentsPP(12.06), KH(11.87), KL(11.60), PJ(11.13), R-30(11.01), PG(10.93), MRH-111(10.87), PS(10.73), SW(10.67) and PC(10.13). At harvest, PJrecorded the maximum number of leaves plant^{-1} (13.33) which was statistically at par with treatmentPP (12.06), KH(11.87), KL(11.60), PJ(11.13), R-30(11.01), PG(10.93), PS(10.73) and PC(10.13). While, the minimum number of leaves plant^{-1} was observed in PM(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
PC	8.43	6.07	18.07	29.53	30.47	4.42	7.15	10.13	10.53
PM	6.33	6.20	16.90	22.89	23.68	4.53	7.93	9.40	9.80
PS	9.33	5.33	17.91	26.11	31.97	3.87	6.53	10.73	11.13
PG	10.33	5.27	15.13	25.24	32.16	3.80	6.47	10.93	13.06
PJ	10.67	5.13	15.53	24.64	31.47	3.93	6.07	11.13	13.33
KH	7.67	6.25	18.27	34.05	36.29	4.33	8.20	11.87	12.13
KM-40	8.67	5.93	17.87	33.77	36.33	3.80	6.73	12.60	13.01
KL	8.33	6.13	18.87	35.27	37.69	3.87	7.47	11.60	12.05
CP	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
SW	9.10	5.87	15.33	23.46	29.71	3.73	6.80	10.67	11.27
ME	7.53	5.67	19.13	34.45	36.41	4.40	7.13	9.07	10.06
IW	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
PP (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

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 earlyrecorded the maximum spread of the plant (8.53) which was statistically at par with Ivory white(8.13) and PM(8.07). While, the minimum plant spread was observed in PJ(5.73). At 30 DAS, Ivory whiterecorded the maximumE-Wspreadof the plant (23.13) which was statistically at par with KM-40(22.33), PP (22.32),ME(22.27), KH(21.93), PM(21.07), SW(20.87), R-30(20.42) and KL(20.40).At 45DAS, IWrecorded the maximum E-W spread of the plant (29.90) which was statistically at par with ME(28.30), KM- 40(26.71), R-30(26.70), KL(25.70), KH(25.10) and PP (24.83). At harvest, PJrecorded significantly the maximum E-W spread of the plant

(33.43) which was statistically at par with IW(32.10), R-30(31.90) and PG(31.37). However, the minimum E-W spread of the plant was recorded in PM(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. PM recorded maximum spread of the plant (10.07) which was statistically at par with CP(9.73) and R-30(9.05).At 30DAS, CPrecordedthe maximum spread of the plant (33.06) which was statistically at par with IW(32.73), ME(32.20) and KM- 40(32.13). While, the minimum spread of the plant was observed in PM(24.60).At 45 DAS, IWrecorded the maximum spread of the plant (41.13) which was at par with PS(40.53), ME(40.13), PP (39.67) and R-30(37.87). However, PM(26.60) recorded the minimum N-S spread of the plant.At harvest, IWrecorded the maximum spread of the plant (46.50) which was statistically at par with PJ(46.49), PS(45.57), R-30(44.83), PP(44.63) and ME(44.03). While, the minimum spread of the plant was recorded in PM(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
PC	6.33	18.67	23.83	26.10	8.97	26.13	32.67	34.7
PM	8.07	21.07	18.83	20.90	10.07	24.6	26.6	28.1
PS	6.40	19.07	21.70	26.23	8.2	26.33	40.53	45.57
PG	5.87	18.47	23.30	31.37	8.4	30.17	36.07	44.1
PJ	5.73	16.67	21.43	33.43	8.3	31.73	38.2	46.49
KH	7.07	21.93	25.10	28.50	7.87	30.13	37.53	40.43
KM-40	6.67	22.33	26.71	30.17	8.07	32.13	37.87	42.1
KL	7.40	20.40	25.70	29.43	8.97	31.13	38.53	40.97
CP	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

SW	6.20	20.87	24.30	29.10	9.67	31.13	37.87	42.83
ME	8.53	22.27	28.30	30.50	8.99	32.2	40.13	44.03
IW	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
PP (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. PM recorded significantly the maximum fresh weight of leaves (9.47) which was statistically at par with the treatmentsPS(9.28), PP(9.24), R-30(8.31), PG(8.18), CPandME(8.04). However, the minimum fresh weight of leaves was observed in KH(6.01) at 15 DAS.At 30 DAS, PJrecorded significantly the maximum fresh weight of leaves (86.60) followed byKM-40(70.49) and PG(62.00). However, it was the minimum inMRH-111 (40.75).At 45 DAS, MErecorded the maximum fresh weight of leaves(102.16) which was statistically at par withPJ(98.52), KM- 40(96.59) and KL(87.99), while, the minimum weight was observed in MRH-111(51.50). At harvest, PJrecorded the maximum fresh weight of leaves(109.00) which was statistically at par withME(106.60), KM- 40(102.42), KL(93.48), PG(90.70), PC(88.55) and CP(85.57). However, the minimum fresh weight of leaves was found in treatmentKashi 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 ofDongarwar*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 DASupto the harvest ispresented in Table 5. The perusal of data revealed that there was significant difference in the fresh weight of roots after 15 DAS. KM– 40recorded the maximum fresh weight of roots (3.85) which was statistically at par withMRH-111(3.65), KL(3.43) and PP (3.00) however, it was the minimum in PG(1.02). At 30DAS, SWrecorded maximum fresh weight of radish root (89.19) followed by R-30(73.65) while, the minimum

fresh weight of root was observed in PM(31.05). KLrecorded the maximum fresh weight of roots (151.15) at 45 DAS,which was statistically at par withKH,KM- 40, R-30, ME, PP, SW, PS,MRH-111,SW, MRH-111,IWand CP(150.02, 147.42, 147.10, 145.82, 141.34, 139.73, 139.67, 137.33, 133.20 and 132.73 respectively). At harvest, KLrecorded significantly the maximum fresh weight of roots (153.75) which was statistically at par with the treatmentsKH(153.03), KM- 40(152.51), R-30(151.32),PS(151.05), ME(148.07), PP (145.63), SW(145.55), MRH-111(141.13),IW(139.07) and CP(136.87) while, the minimum fresh weight of roots was recorded in treatmentPM(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
PC	6.52	60.75	83.77	88.55	2.91	34.97	116.13	120.53
PM	9.47	44.80	75.79	77.10	2.02	31.05	70.00	72.81
PS	9.28	48.21	67.12	75.18	1.97	40.95	139.67	151.05
PG	8.18	62.00	82.64	90.70	1.02	50.69	77.56	84.51
PJ	7.13	86.60	98.52	109.59	1.53	50.99	74.47	80.62
KH	6.01	50.26	68.67	71.29	2.14	44.94	150.02	153.03
KM-40	7.71	70.49	96.59	102.42	3.85	53.86	147.42	152.51
KL	7.57	59.83	87.99	93.48	3.43	66.69	151.15	153.75
CP	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
SW	6.53	57.13	81.37	87.23	2.73	89.19	139.73	145.55
ME	8.04	56.33	102.16	106.60	2.85	66.31	145.82	148.07
IW	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
PP (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 DASupto the harvest and is depicted in Table 6. The data revealed significant differences in dry weight of leaves in radish at 15 DAS, PP recorded significantly maximum dry weight of leaves (1.01) which was statistically at par with PM(1.00), PS(0.99) and R-30(0.91). However, it was the minimum in KH(0.66).At 30 DAS, PJrecorded the maximum dry weight of leaves (8.16) which was statistically at par withPGand PC(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, MErecorded the maximum dry weight of leaves (10.15) which was statistically at par with the treatmentsKM- 40(9.22), PJ(9.08), PG(8.88) and KL(8.77). However, the minimum dry weight of leaves was found in MRH-111(5.80).At harvest, Mino earlyrecorded the maximum dry weight of leaves (11.00) which was statistically at par with PJ, KM– 40, PGand PC(10.72, 10.22, 9.95 and 9.11 respectively). However, the minimum dry weight of leaves was recorded in PS(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 DASupto the harvest and is presented in Table 6. The data as shown in Table 4 revealed that there was significant difference in dry weight of roots at 15 days interval.KM– 40recorded significantly maximum dry weight of roots (0.41) which was statistically at par with treatmentMRH-111(0.39) and KL(0.36) while, the minimum in PG(0.11) at 15 DAS. At 30 DAS, Snow whiterecorded significantly the maximum dry weight of roots (10.54) while, the minimum dry weight of roots was found inPM (3.67).At 45 DAS, KLrecorded the maximum dry weight of roots (19.05) which was statistically at par with treatmentsKH(18.86), R-30(18.49), ME(18.33), KM - 40(18.10), PP (17.77), SW(17.56), PS(17.40),MRH-111(17.26),IW(16.74)and CP(16.60). However, it was the minimum in PM(8.80).At harvest, KLrecorded the maximum dry weight of roots (26.27) which was statistically at par with treatmentsKH(19.59), KM- 40(19.52), PS(19.33), R-30(19.23),ME(18.95), PP (18.64), SW(18.59), MRH-111(18.07),IW(17.80) and CP(17.52). While, the minimum dry weight of roots was observed in PM(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
PC	0.78	6.14	8.09	9.11	0.31	4.13	14.6	15.43
PM	1.00	5.03	7.34	8.21	0.21	3.67	8.80	9.32
PS	0.99	5.37	6.58	8.00	0.21	4.84	17.4	19.33
PG	0.79	8.11	8.88	9.95	0.11	5.99	9.75	10.82
PJ	0.74	8.16	9.08	10.72	0.16	6.02	9.36	10.32
KH	0.66	5.94	7.35	8.37	0.23	5.31	18.86	19.59
KM-40	0.83	7.52	9.22	10.22	0.41	6.36	18.10	19.52
KL	0.80	6.57	8.77	9.73	0.36	7.88	19.05	19.68
CP	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
SW	0.71	6.18	7.69	9.01	0.29	10.54	17.56	18.59
ME	0.84	6.19	10.15	11.00	0.30	7.83	18.33	18.95
IW	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
PP (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. PP recorded the maximum dry weight of roots (12.233), which was statistically at par with KM - 40(11.56), PM(11.49), PS(11.25), KL(11.1), ME(10.89), IW(10.75), CP(10.67) and R-30(10.55). At 30 DAS, Snow whiterecorded the maximum fresh weight of plant (146.317) which was statistically at par with PJ(137.60), KL(126.52), IW(125.60), KM-40(124.35) and ME(122.64) while, it was the minimum in PM(75.85).At 45DAS, ME recorded the maximum fresh weight of plant (247.97)which was statistically at par with KM-40 (245.22), KL(238.95), SW (221.10),KH(218.69), PP(217.26),R-30(216.54), CP(213.62), IW(209.46)and PS(206.78).While, the minimum fresh weight of plant was observed in PM(145.79).At harvest, KM– 40recorded the maximum fresh weight of plant (254.93) which

was statistically at par withME(252.81), KL(247.23), SW(232.86),PP (228.80), R-30(227.57), KH(224.32), CP(222.44), PS(226.24)andIW(220.23), while, the minimum fresh weight of plant was observed in PM(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. PP recorded the maximum dry weight of plant (1.30) which was statistically at par with treatmentKM-40(1.23), PM(1.22), PS(1.19), MRH-111(1.18), KL(1.17), ME(1.15), IW(1.14), CP(1.13) and R-30(1.12) while, the minimum dry weight of plant was recorded in KH(0.86) at 15 DAS.SWrecorded the maximum dry weight of plant (16.81) at 30 DAS which was statistically at par with treatmentPJ(15.53), KL(14.44) and IW(14.39) while, the minimum dry weight of plant was observed in PM(8.58).At 45 DAS, MErecorded significantly the maximum dry weight of plant (28.44) which was statistically at par with KL(27.69), KM-40(27.51), KH(25.65),SW(25.62),R-30(25.37), PP(25.28),CP(24.67),IW(24.29), and PS(24.20). While, it was the minimum in PM(16.30).At harvest the dry weight of plant (30.28) was the maximum in KM– 40which was statistically at par withME(29.95), KL(29.49), SW(27.80),R-30(27.49),PP (27.37),PS(27.23),KH(27.07), CP(26.50), IW(26.32)andMRH-111(26.16). While, it was the minimum in PM(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
PC	9.44	95.72	199.9	209.08	1.00	10.8	22.89	24.72
PM	11.49	75.85	145.79	149.91	1.22	8.58	16.30	17.42
PS	11.25	89.15	206.78	226.24	1.19	10.13	24.20	27.23
PG	9.2	112.68	160.19	175.21	0.97	12.8	17.93	20.34
PJ	8.67	137.6	172.98	190.21	0.92	15.53	19.11	21.83
KH	8.14	95.2	218.69	224.32	0.86	10.83	25.65	27.07
KM-40	11.56	124.35	245.22	254.93	1.23	14.10	27.51	30.28

KL	11.01	126.52	238.95	247.23	1.17	14.44	27.69	29.49
CP	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
SW	9.26	146.32	221.1	232.86	0.98	16.81	25.62	27.80
ME	10.89	122.64	247.97	252.81	1.15	14.02	28.44	29.95
IW	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
PP (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 PC recorded the maximum diameter of root (5.65) which was statistically at par with PM (4.94) while, the minimum diameter of root was recorded in treatment IW (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-30recorded the maximum length of root (31.03) which was statistically at par with ME(30.74), IW(29.41), KM-40(28.84), MRH-111(28.25), SW(27.97), CP(27.49), KL(27.10), KH(27.05), PP (26.55), PG(26.43) and PC(25.89). In radish, root is the principal storage organ and its developmentinvolves 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. KHrecorded the maximum root: shoot ratio (2.17) which was statistically at par with PS(2.01) and PP (1.94) however, the minimum ratio was observed in treatment PJ(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). PM(47.33 days) was the earliest variety in terms of marketable maturity (Table8) as it took the minimum number to harvest. However, on the other hand the maximum days to marketable maturity was observed in PJ(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
PC	25.89	5.65	1.37	48.08	Mid
PM	16.28	4.94	0.95	47.33	Mid
PS	24.29	4.21	2.01	53.31	Late
PG	26.43	4.70	0.93	57.03	Late
PJ	24.45	4.33	0.74	60.33	Late
KH	27.05	3.75	2.17	49.33	Mid
KM-40	28.84	3.91	1.49	50.67	Late
KL	27.10	3.99	1.65	49.10	Mid
CP	27.49	4.48	1.61	48.33	Mid
MRH-111	28.25	4.17	1.83	50.67	Late
SW	27.97	4.34	1.67	51.68	Late
ME	30.74	4.07	1.41	48.67	Mid
IW	29.41	3.14	1.72	52.33	Late
R-30	31.03	4.08	1.94	51.07	Late
PP (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. PJrecorded the maximum leaves yield kg plot^{-1} (5.48) which was statistically at par with treatmentsME, KM-40, KLand PG(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. PJrecorded the maximum root yield (27.40t ha^{-1}) which was statistically at par withME,KM-40, KLand PG(26.65, 25.60, 23.37 and 22.68respectively). However, KH(17.82t ha^{-1}) recorded the minimum leaf yield among the other treatments.Quite similar results were obtained bySinchana (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. KLrecorded the maximum root yield (7.69) which was statistically at par with treatmentsKH(7.65), KM-40(7.63), R-30(7.51), ME(7.41), PP (7.28), SW(7.27), PS(7.55),MRH-111(7.06),IW(6.95)and CP(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 resultsofDahal*et al.* (2021).

Root yield (t ha^{-1})

The root yield (t ha^{-1}) of radish is presented in Table 9. KLrecorded the maximumroot yield kg plot^{-1} (38.44) which was statistically at par withtreatmentsKH(38.26), KM-40(38.13), R-30(37.55), ME(37.02), PP (36.41), SW(36.35), PS(37.76),MRH-111(35.28),IW(34.77)and CP(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 toleaf 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})
PC	4.43	22.14	5.81	29.03
PM	3.85	19.27	3.64	18.2
PS	3.76	18.8	7.55	37.76
PG	4.54	22.68	4.23	21.13
PJ	5.48	27.4	4.03	20.16
KH	3.56	17.82	7.65	38.26
KM-40	5.12	25.6	7.63	38.13
KL	4.67	23.37	7.69	38.44
CP	4.28	21.39	6.84	34.22
MRH-111	3.86	19.28	7.06	35.28
SW	4.36	21.81	7.27	36.35
ME	5.33	26.65	7.41	37.02
IW	4.03	20.15	6.95	34.77
R-30	3.84	19.22	7.51	37.55
PP (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. KL 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, PM 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
PC	2,90,333.30	2,13,373.70	2.21
PM	1,82,033.30	85,240.34	0.88
PS	3,77,626.70	2,80,833.70	2.90
PG	2,11,273.70	1,14,480.70	1.18
PJ	2,01,552.70	1,04,759.70	1.08
KH	3,82,571.70	2,85,778.70	2.95
KM-40	3,81,278.30	2,84,485.30	2.94
KL	3,84,373.30	2,87,580.30	2.97
CP	3,42,166.70	2,45,373.70	2.54
MRH-111	3,52,833.30	2,56,040.30	2.65
SW	3,64,065.00	2,67,272.00	2.76
ME	3,70,176.70	2,73,383.70	2.82
IW	3,47,666.70	2,50,873.70	2.59
R-30	3,75,533.30	2,81,500.30	2.91
PP (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

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 deduced that KLwas observed to be the highest yielding variety which was at par with KH, KM-40, R-30 and ME. The morphological studies also revealed high variations in these varieties suggesting that the selection of these varieties could be beneficial for wide cultivations in Bastar as well as northern region of Chhattisgarh.

References

Anonymous. 2020. Directorate of Horticulture and Farm Forestry, (https://agriportal.cg.nic.in/horticulture/Statistics/Area & Production 2019-20.pdf.)

Anonymous. 2020. National Horticulture Board, (http://nhb.gov.in/StatisticsViewer.aspx?enc=MWoUJibk35dW2g36TUJWAoZqESmAYFi7h2irlsmjlINTcFl1rG/kLbq8ZQbWUvuM#)

Black, C. A., Evans, D. D., Ensminger, L. E., White, J. L., and Clark, F.E. 1965.Methods of soil analysis. II. ASA, Allison LE Organic carbon. In: Madison, :1374–1376.

Black, C.A. 1965. Method of soil analysis.Amar.Agron.Inc. Madeson, Wisconsin, USA. pp. 131-137.

Blackman, V.H., 1919. The compound interest law and plant growth. Annals of botany, 33(131): 353-360.

Burton, G.W. and Devane, D.E., 1953. Estimating heritability in tall fescue (*Festucaarundinacea*) from replicated clonal material. *Agronomy journal*, 45(10): 478-481.

Dahal, K.M., Bhattarai., D.R., Sharma, M.D. and Poudel, B. 2021. Evaluation of radish (*Raphanussativus*L.) varieties under shade-net condition for yield and quality. Nepalese Horticulture, 15: 16-23.

Dongarwar, L.N., Kashiwar, S.R., S. M., Ghawade, S.M. and Dongarwar, U.R. 2017.Performance of different radish (*Raphanussativus*L.) varieties in black soils of Vidharbha-Maharashtra.Int. J. of Plant & Soil Sci., 20(5): 1-9.

Gomez, K.A. and Gomez, A.A. 1984. Statistical procedures for Agricultural Research. John Wiley and Sons, Inc., New York.

Gyewali, B., Maharjan, B., Rana, G., Pandey, R., Pathak, R. and Poudel, P.R. 2020. Effect of different organic manures on growth, yield, and quality of radish(*Raphanussativus*L.*)*. SAARC J. Agric., 18(2): 101-114.

Hosneara, Mian, M.A.K., Rahman, O., Rashid, M.H. and Zeba, N. 2012. Comparative analysis of newly released bu hybrid mula-1 with standard radish (*Raphanussativus*L.) varieties. J. Expt. Biosci., 3(2):85-90. Int. J. of Agric. Sci., 8(63): 3591-3593.

Kori, D. 2014. Suitability and adoptability of different genotypes of radish (*Raphanussativus*L.) in malwa condition.MVSc Thesis, RVSKVV, Gwalior, College of Agriculture, Indore (M.P.), pp - 1-55.

Leopold, A.C. and Kriedemann, P.E., 1975. Plant Growth and Development. Tata Mc Grow Hill Pub. Co. Ltd., New Delhi, :545.

Miller, D. S. and Naismith, D. J. 1958. A correlation between sulphur content and net dietary-protein value. Nature, 182: 1786-1787.

Muhr, G. R., Datta, N. P., Subramoney, H., Leley, V. K. and Don ahue, R. L. 1965. Soil testing in India. United States Agronomy for International development mission on India, New Delhi.

Ola, A.L., Rana, D.K., andJhajhra, M.R. 2018. Evaluation of radish (*Raphaanussativus*L.) varieties under valley condition of Garhwalhills. *J. of Pharmacognosy and Phytochemistry*, 7(1): 2740-2743.

Olsen, S.R. and Cole, C.V. 1959. Phosphorus solubility in calcareous soils: II. Effects of exchangeable phosphorus and soil texture on phosphorus solubility. Soil Science Society of America Journal, 23(2): 119-121.

Piper, C. S. 1967.Soil and plant analysis. Bombay, New Delhi, Asia publishing house,:30-38.

Semba, S., Rana, R., Yumkhaibam, T., and Ramjan, M.D. 2019.Performance of different radish varieties under foothill region Dehradun, Uttrakhand, India.Int. J. Curr. Microbiol. App. Sci., 8(7): 869-877.

Sharma, M. And Singh, Y. 2020. Influence of frontline demonstrations on yield, yield contributing characters and economics of radish (*Raphanussativus*L.*)*. J. KrishiVigyan, 8 (2): 186-190.

Shrestha, S.L., Ghimire, D., Shrestha, Y.K. and Gautam, I.P. 2021. Assessment of radish (*Raphanus*sativus L.) cultivars for its yield and yield attributing characters at Central Mid-Hill (Kathmandu Valley) conditions of Nepal. Nepalese Horticulture, 15: 81-88.

Sinchana, B. R. 2021. Effect of sowing dates on different genotypes of radish (*raphanussativus*L.) Under organic and natural farming conditions.MVSc thesis, Chaudhary Sarwan Kumar Himachal Pradesh KrishiVishvavidyalayaPalampur – 176 062 (HP) India, :1-79.

Singh, A. 2020. Assessment of genetic varability, correlation and path analysis studies in radish (*Raphanussativus*L.). MVSc. Thesis.Dr.Yashwant Singh Parmar University Of Horticulture And Forestry Solan (NAUNI) HP, : 1-62.

Singh V.P, Singh, R., Pandey, S. and Singh, V. 2019.Effect of varietal performance on growth and yield parameter at different day stage in radish (*Raphanussativus*L.) crop. International Journal of Chemical Studies,7(2): 991-996.

Sivathanu, S., Mohammed, Y.G. and Kumar, S.R. 2014.Seasonal effect on variability and trait relationship in radish. Research in Environment and Life Sciences,7(4): 275-278.

Subbiah, B.V. and Asija, G. L. 1956.A rapid method for the estimation of nitrogen in soils. Current Science, 26: 259-260.

Thamburaj, S. and Singh, N. 2005.Vegetables, Tuber Crops and Spices. 1st Edition, Indian Council of Agriculture Research, New Delhi, p. 147.

Thorat, A.R. 2013. Performance of some improved and local varieties of radish *(Raphanussativus*L.).MVSc Thesis, College of Agriculture, LaturVasantraoNaikMarathwadaKrishiVidyapeeth, Parbhani India, : 1-53.

Watson, D. J. 1947. Comparative physiological studies on the growth of field crops.Variation in net assimilation rate and leaf area between species and varieties and within and between years.Annays of Botany, 11: 41-76.

Yogesh 2020.Effect of growth regulators and spacing on growth, yield and quality of radish (*Raphanussativus*L.).MVSc Thesis, College Of Horticulture And Forestry, Jhalrapatan City, Jhalawar - 326023 (Rajasthan) Agriculture University, Kota,:1-131.