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Evaluation of Radish Genotypes for Microgreens Production under Red and Laterite Zone of West Bengal

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***Abstract*:** Radish is widely highlighted root vegetable due to its availability, nutrient content and potential health benefits. However, the adaptability of radish microgreens has not been explored much. Based on this an experiment was conducted to assess the performance of fourteen radish varieties (Palak Patta, White Cone, Indian Radish China Queen, NBR-Indian Queen, Bahar 32, Kashi Hans, Kashi Ardra, Pusa Chetki Long, Improved Radish Rajni, Sundar Lal Aush, Chinese Pink, Local 1, Local 2 and Local 3) at microgreen stage for different morphological and physicochemical traits. Variation was observed among the genotypes for plant height, hypocotyl length, root length, fresh weight, yield and different phytochemical parameters. Radish cv. NBR-Indian Queen produced maximum microgreen yield (661.38 g/m^2). Yield was positively correlated with plant height and hypocotyl length. Indian Radish China Queen recorded maximum amount of total phenol (145.67 mg GAE/100 g FW); whereas maximum ascorbic acid (202.587 mg/100 g FW) and beta carotene (19.98 µg of carotene/100 g FW) was in Pusa Chetki Long. The variation of morphological and nutrient composition among the different genotypes of radish offers the scope of selection of genotype. Radish cv. NBR-Indian Queen can be promoted to the growers for microgreen production.

***Keywords*:** *Raphanus sativus*, Yield, Phenol, Beta carotene, Ascorbic acid

Microgreens are the new specialty food products which have acquired popularity and attention in recent years. These are young and tender cotyledonary leaves with a range of colour, texture and flavour. Now, they are widely recognised as source of health and longevity, making them a popular choice of culinary use. A wide array of crops can be grown as microgreen such as cabbage, broccoli, radish, amaranth, beet, *palak*, onion, etc. They are rich source of nutrients (K, Ca, Fe, Mg, Zn, Mo) as well as phytoactive compounds (α tocopherol, β carotene, ascorbic acid, phylloquinine, phenolic antioxidants, anthocyanins, glucosinolates, carotenoids, lutein, violaxanthin) which help to fight against various dreadful diseases such as cardiovascular, etc (Paradiso et al 2018, Xiao et al 2012). A small amount of microgreens contains 40 times higher concentration of elements (bioactive substances, vitamins and minerals) than their mature counterpart (Xiao et al 2012). Priti et al., 2021 noticed a wide variation in phytochemical composition, nutrient contents and antioxidant capacities in diverse genotypes of mungbean and lentil at microgreen stage. Variation in yield and nutrient composition provides a wide range of options for breeder to select suitable genotype to address specific need of growers and consumers.

Radish (*Raphanus sativus* L., Family Brassicaceae) is one of the important and popular root vegetable grown widely in tropical, subtropical and temperate regions. Radish roots and leaves are good source of several minerals and vitamins (Mallikarjunarao et al 2015, Singh et al 2017, Gamba et al 2021). On the other hand, radish microgreens are much enriched source of chlorophyll, carotenoids, anthocyanin, total phenolics, antioxidants (Zhang et al 2019). Because of crispy taste and presence of nutrients radish microgreens are quite popular. These are also regarded as immunostimulants due to antimicrobial action and anti-carcinogenic properties (Mlinerac et al 2023). India is the land of good source of radish genotypes. A number of varieties and hybrids have been developed by various public institutes and private companies. Many scientists have reported morphological and bio-chemical variation of root and shoot of radish. Tilahun et al(2023 mentioned the variation in yield, dry matter, chlorophylls, vitamin C, total phenolic, flavonoids and anthocyanin, K, Ca, Mg, and Na content in radish varieties in Korea. However, nutritional profiling of radish microgreens has yet not done properly in India. Keeping the above context, present experiment was conducted with the objective to study the performance of different radish genotypes for microgreens production with respect to vegetative characters and bio-chemical composition.

MATERIAL AND METHODS

The present investigation was carried out in a room specially designed for growing microgreens in Horticulture

Farm and Departmental Laboratory, Sriniketan during January 2023. The experimental room (6.0 m x 2.5 m) was fitted with netted windows and fans for proper ventilation. Shelves fitted with several compartments (97 cm x 34 cm each) were used to keep microgreen trays. Artificial light was provided by using LED lights of an average of 1900 ± lux capacity with a photoperiod of 12 hours in each compartment of shelf. Microgreens were raised in HDPE tray of 1.5 ft x 2 ft with a depth of 5 cm.

Fourteen different radish genotypes (Palak Patta, White Cone, Indian Radish China Queen, NBR-Indian Queen, Bahar 32, Kashi Hans, Kashi Ardra, Pusa Chetki Long, Improved Radish Rajni, Sundar Lal Aush, Chinese Pink, Local 1, Local 2 and Local 3) were taken for growing microgreens. The experiment was conducted following completely randomized design considering fourteen radish varieties as treatments with three replications. Before sowing, the trays were sterilized with the help of sodium hypochlorite (0.1%). Eight seeds per square inch were sown in mixed soilless substrate of cocopeat, perlite and vermiculite (3:1:1 ratio). The filled trays were placed in iron stacks for next seven days. Trays were watered as per the requirement by feel method to maintain optimum moisture level in the substrate. Radish microgreens were harvested at 1 cm above the substrate on seventh day after sowing and different morphological and physico-chemical parameters were observed.

The plant height, hypocotyl length, root length and leaf area were recorded. Total yield was calculated by harvesting all the microgreens and calculated per square metre. Fresh weight was computed by weighing ten healthy microgreens. Moisture content was estimated using formula after drying the fresh microgreens at 105°C for 3-4 hours and then taking the weight. Dry matter (%) was calculated and expressed as percentage of fresh weight. Total chlorophyll was assessed using Dimethyl sulfoxide (DMSO; Merck Life Science Private Limited, India) adopting the method of Hiscox and Israelstam (1979). Total phenol content was determined spectrophotometrically by using Folin-Ciocalteu reagent (Sisco Research Laboratories Pvt. Ltd., India) as described by Singleton et al (1999). Ascorbic acid content was estimated by titration method using meta phosphoric acid (Loba Chemi Pvt. Ltd., India) following the standard biochemical method (AOAC 1990). Beta carotene was estimated spectrophotometrically using β carotene (Sisco Research Laboratories Pvt. Ltd., India) as standard (Davis 1976). The total variation among the genotypes for different characters was tested for significance with Duncan's Multiple Range Test (IBM SPSS Statistics V22.0 Software) was used.

RESULTS AND DISCUSSION

Vegetative parameters: There were statistically significant differences in plant height, hypocotyl length and root length (Table 1). However, no significant difference in leaf area. The mean plant height was 7.56 cm. Radish varieties NBR-Indian Queen, Improved Radish Rajni and Kashi Hans recorded maximum plant height, which were statistically at par with each other. NBR-Indian Queen and Kashi Hans recorded

Table 1. Vegetative parameters of different radish microgreens

Treatment details	Plant height (cm)	Hypocotyl length (cm)	Root length (cm)	Leaf area (cm^2)	Fresh weight of 10 microgreens (g)	Yield (g/m^2)
Palak Patta	6.98^{fg}	5.80^{j}	3.63^{efgh}	1.28	1.42^{a}	576.11^{b}
White Cone	7.87^{cd}	6.57^{efg}	3.43^{gh}	1.20	1.00^{e}	419.55^{g}
Indian Radish China Queen	7.40^{def}	6.50^{fgh}	3.70^{efg}	1.17	1.17^{cd}	387.62^{h}
NBR-Indian Queen	8.77^{a}	7.87^{a}	4.60^{b}	1.31	1.41^{a}	661.38^{a}
Bahar 32	8.07^{bc}	7.16^{cd}	3.87^{de}	1.18	1.22^{bcd}	590.10^{b}
Kashi Hans	8.43^{ab}	7.67^{ab}	3.43^{gh}	1.29	1.02^{e}	468.47^{f}
Kashi Ardra	7.80^{cd}	6.93^{cdef}	3.39^{h}	1.20	1.32^{ab}	482.58^{f}
Pusa Chetki Long	7.42^{def}	7.02^{cde}	4.11^{cd}	1.20	1.22^{bcd}	550.63^{cd}
Improved Radish Rajni	8.66^{a}	7.27^{bc}	5.05^{a}	1.14	1.29^{abc}	532.10^{de}
Sundari Lal Aush	6.20^{h}	5.17^{k}	3.53^{fgh}	1.20	1.38^{a}	565.82^{bc}
Local 1	6.57^{gh}	5.98^{ij}	3.81^{ef}	1.26	1.15^{cd}	517.62^{e}
Local 2	7.23^{ef}	6.40^{ghi}	4.27^{c}	1.33	0.99^{e}	588.79^{b}
Chinese Pink	6.97^{fg}	6.67^{defg}	3.60^{efgh}	1.29	1.02^{e}	462.49^{f}
Local 3	7.53^{de}	6.03^{hij}	3.67^{efgh}	1.27	1.15d	438.81^{g}

NS means statistically non-significant at 5% level of significance; Means with at least one letter common in a column are statistically at par using Duncan's Multiple Range Test

maximum hypocotyl length. The microgreen hypocotyl length varied from 5.17 cm to 7.87 cm. Similar range of hypocotyl length for radish in different cultivar and growing conditions was also reported by Li et al (2021) and Shibaeva et al (2022). The mean root length of radish microgreens was 3.86 cm; while maximum root length was registered in Improved Radish Rajni. Fresh weight of 10 microgreen plants varied from 1.00 g to 1.42 g. Maximum fresh weight was in Palak Patta, which was statistically similar to NBR-Indian Queen and Sundari Lal Aush. Tilahun et al (2023) observed significant difference among the five radish cultivars in fresh weight. The mean yield for radish microgreen was 517.29 g/m^2. The maximum yield (661.38 g /m^2) was achieved in NBR-Indian Queen. Greater plant height, more hypocotyl and root length and greater fresh weight of the seedlings might contribute towards more yield in the present experiment. Yield variation in radish microgreens due to genotypes was also reported by Tilahun et al (2023). Palmitessa et al. (2020) also confirmed the variation in microgreen yield in different *Brassica* species. Bulgaria et al (2021) recorded yield variation in basil varieties.

Physico-chemical parameters: Significant variation was noted for different physico-chemical parameters under the present study (Table 2). Moisture content of radish microgreens varied from 87.16 to 94.10%, while dry matter content was ranged from 5.90 to 12.84%. Maximum moisture content was in Kashi Ardra (94.10%), which was statistically at par with Sundari Lal Aush, Palak Patta and NBR- Indian Queen. Kowitcharoen et al (2021) observed moisture content of 91.88, 93.19 and 93.50% in purple radish, radish and rat tail radish microgreens respectively. *Brassica* microgreens, especially radish have thicker stem and leaves as compared to others, which resulted higher biomass content. The maximum dry matter content was observed under genotype Pusa Chetki Long (12.84 %) which was statistically similar to genotype Local 3 (12.28 %) followed by White Cone and Chinese Pink. The mean dry matter was 9.31%. Similar dry matter content was reported by Amitrato et al (2023) in radish and Kyriacau et al (2020) in knolkhol microgreens. Improved Radish Rajni showed maximum total chlorophyll content (3.28 mg/g microgreen FW) which was statistically similar with Bahar 32. This indicates the elevated chlorophyll content in several radish genotypes. Higher chlorophyll content gave a good lustre and vibrant leaf colour which enhances the visibility of microgreens. The chlorophyll is also associated with antioxidant activity (Lanfer-Marquez et al 2005). The total phenol, ascorbic acid and beta carotene were varied for different genotypes. The mean values of total phenol, ascorbic acid and beta carotene were 97.28 mg GAE/100 g FW, 146.65 mg/100 g FW and 11.07 µg of carotene/100g FW respectively. The concentration of phenol varies distinctly from genotype to genotype with the range of 55.97 to 145.67 mg GAE/100 g fresh weight. Maximum phenol content was in Indian Radish China Queen. Tan et al (2020) observed the presence of phenolic compounds were associated with the taste and flavour of the crop. Microgreens from Brassicaceae family posses good amount of phenolic antioxidants (Paradiso et al 2018). Saleh et al. (2022) observed higher

Table 2. Physicochemical parameters of different radish microgreens

Treatment details	Moisture (%)	Dry matter (%)	Total chlorophyll (mg/g microgreen FW)	Total phenol (mg GAE/100 g FW)	Ascorbic acid (mg/100 g FW)	Beta carotene (µg of carotene/100g FW)
Palak Patta	93.61^{ab}	6.39^{e}	1.13^{e}	90.37^{e}	188.06^{c}	5.85^{fg}
White Cone	89.27^{e}	10.73^{b}	1.09^{e}	55.97^{g}	107.42^{j}	3.52^{g}
Indian Radish China Queen	92.6^{c}	7.40^{d}	1.18^{de}	145.67^{a}	81.04^{l}	23.23^{a}
NBR-Indian Queen	93.75^{ab}	6.25^{e}	1.52^{cd}	133.19^{b}	176.73^{e}	7.93^{ef}
Bahar 32	92.18^{c}	7.82^{d}	3.01^{a}	91.23^{e}	132.94^{f}	13.36^{bc}
Kashi Hans	92.34^{c}	7.66^{d}	0.60^{f}	127.67^{b}	118.48^{h}	12.33^{bcd}
Kashi Ardra	94.10^{a}	5.90^{e}	0.67^{f}	91.57^{e}	125.45^{g}	9.55^{def}
Pusa Chetki Long	87.16^{f}	12.84^{a}	1.14^{e}	94.55^{e}	202.587^{a}	19.98^{a}
Improved Radish Rajni	92.83^{bc}	7.17^{d}	3.28^{a}	102.77^{d}	178.49^{e}	13.85^{b}
Sundari Lal Aush	94.08^{a}	5.92^{e}	2.42^{b}	96.45^{de}	183.28^{d}	9.52^{def}
Local 1	91.21^{d}	8.79^{c}	1.45^{cde}	76.74^{f}	199.07^{b}	8.49^{ef}
Local 2	90.92^{d}	9.08^{c}	2.31^{b}	116.51^{c}	177.72^{e}	9.13^{def}
Chinese Pink	89.91^{e}	10.09^{b}	1.68^{c}	58.48^{g}	83.81^{k}	9.97^{cde}
Local 3	87.72^{f}	12.28^{a}	1.15^{e}	80.74^{f}	98.02^{j}	8.24^{ef}

Means with at least one letter common in a column are statistically at par using Duncan's Multiple Range Test (p=0.05).

phenolic content under various species of Brassicaceae family (Pak choi, Kale). The ascorbic acid content of radish microgreens has been ranged from 81.04 mg/100g FW (Indian Radish China Queen) to 202.58 mg/100 g FW (Pusa Chetki Long). Marchioni et al. (2021) also reported a wider variation in ascorbic acid content in different Brassica microgreens (broccoli, daikon, mustard, rocket salad and water cress). The beta carotene content was highest in Indian Radish China Queen (23.23 µg of carotene/100g FW), which was statistically at par with Pusa Chetki Long. Xiao et al (2012, 2019) reported variation in beta carotene content in different radish and other species of Brassicaceae family. Variation in beta carotene and ascorbic acid was also noted by Kamal et al (2020) in different species of *Brassica* such as different types of cabbages (cabbage green, cabbage red, cabbage savoy), mustard (mustard dijon, mustard red), kale (Kale Chinese, Kale red, Kale Tuscan), etc. Kowitcharoen et al (2021) found the variation in bioactive compounds in three different types of radish (purple radish, radish and rat tail radish). Variation in mineral composition of cabbage was reported by Podsedek et al (2023). Their study revealed that red cabbage microgreens had higher total chlorophyll, total carotenoid and total phenol as compared to the white cabbage. Yadav et al (2018) observed variation in total phenol and ascorbic acid in three types of *Amaranthus* microgreens.

Association of morpho-biochemical parameters: There was strong relation between plant height and hypocotyl length and positive correlation was observed among yield and hypocotyl length. Ampim et al (2021) also observed similar trend in Egyptian spinach and vegetable amaranth microgreens. Similarly, strong correlation was observed among yield and root length. Fresh weight of 10 seedlings was negatively correlated to hypocotyl length and leaf area. The hypocotyl length and yield was also negatively correlated with the dry matter. This was in agreement with the study of Toscano et al (2023). Yield was positively correlated with total chlorophyll, total phenol and ascorbic acid. The total phenol was positively correlated with ascorbic acid and ascorbic acid with beta carotene. Ghoora et al (2020) mentioned that phytochemical quality of microgreens is related to total phenol content and ascorbic acid content. However, present study showed that ascorbic acid and total chlorophyll were negatively associated with hypocotyl length. Jones-Baumgardt et al (2021) reported that some phytochemical properties such as ascorbate of *Brassica* microgreens had altered relation with the hypocotyl length.

The presence of variability among radish genotypes in morphological as well as biochemical characteristics have helped to select the desirable one (Kumar & Sharma 2011, Kurina et al 2021). Bokhan et al (2015) stated that the

Table 3. Estimation of correlation coefficients among vegetative attributes and physicochemical attributes of different radish microgreens

	Plant height (cm)	Hypocotyl length (cm)	Root length (cm)	Leaf area (cm^2)	Fresh weight of 10 microgreens (g)	Yield (g/m^2)	Moisture (%)	Dry matter (%)	Total Chlorophyll (mg/g microgreen FW)	Total Phenol (mg GAE/100 g FW)	Ascorbic acid (mg/100 g FW)	Beta carotene (µg of carotene /100g FW)
Plant height (cm)	1.0000											
Hypocotyl length (cm)	0.8928	1.0000										
Root length (cm)	0.4647	0.4143	1.0000									
Leaf area (cm^2)	-0.1129	0.0053	-0.0820	1.0000								
Fresh weight of 10 microgreens (g)	0.0197	-0.0947	0.2510	-0.2458	1.0000							
Yield (g/m^2)	0.0962	0.1468	0.5372	0.2790	0.5368	1.0000						
Moisture (%)	0.1071	0.0429	0.0648	-0.0909	0.5802	0.3416	1.0000					
Dry matter (%)	-0.1071	-0.0429	-0.0648	0.0909	-0.5802	-0.3416	-1.0000	1.0000				
Total Chlorophyll (mg/g microgreen FW)	0.0472	-0.0364	0.6081	-0.3163	0.1504	0.4562	0.1922	-0.1922	1.0000			
Total Phenol (mg GAE/100 g FW)	0.3610	0.3692	0.3367	0.0538	0.2232	0.2103	0.4527	-0.4527	-0.0057	1.0000		
Ascorbic acid (mg/100 g FW)	-0.1651	-0.1283	0.4917	0.0746	0.4864	0.7629	0.1725	-0.1725	0.3000	0.0888	1.0000	
Beta carotene (µg of carotene/100g FW)	0.0901	0.2484	0.1975	-0.4757	-0.0001	-0.1959	-0.0884	0.0884	0.0762	0.5303	-0.1010	1.0000

concentration of chemical composition differs according to species and varietal characteristics.

CONCLUSION

The intake of microgreens is associated with the profuse presence of beneficial elements which have to improve immune system of our body. The variation of nutrient composition among the different genotypes of radish offers the scope of selection of genotype. Among the studied radish genotypes, the production performance of NBR-Indian Queen was good with high yield potential. The genotype Pusa Chetki Long and Indian Radish China Queen showed good presence of ascorbic acid, total phenol and beta carotene, which are regarded as valuable antioxidant compounds. However, these two genotypes were average yield performer. Thus more radish accession should be screened to identify genotype(s) which produce more biomass as well as high bioactive compounds. Such genotypes can also be developed through transgressive breeding using the identified genotypes. It is suggested that the selection of radish genotypes for microgreen production need to be done based on the yield and nutritional composition, which will be economical for the growers and beneficial for the consumers. However, based on the present study radish cv. NBR-Indian Queen can be promoted to the growers for microgreen production.

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