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QUALITY ATTRIBUTES OF RADISH AS AFFECTED BY GENOTYPES AND DATES OF SOWING

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Summary

The present investigation was carried out to evaluate root quality of radish as affected by genotypes and dates of sowing. The analysis of variance revealed that the mean sum of squares due to genotypes was significant at P=0.01 for all three characters studied under all the six dates of sowing. The pooled analysis of variance indicated that all its components viz. the mean sum of squares due to genotypes, dates of sowing and the interaction between genotypes x dates of sowing were significant at P=0.01 for all the three characters studied. The data revealed that the highest dry matter was produced by Punjab Safed in D_2, D_5 and D_6; by Mino Early Long White in D_1, D_2 and D_4 and by Punjab Safed and Pusa Chetki in D_2. Punjab Pasand produced the highest minerals content irrespective of dates of sowing. Leaf was most pungent under four dates of sowing namely D_3, D_4, D_5 and D_6. Punjab Safed had maximum pungency factor under D_1 and Pusa Himani under D_2.

सारांश

मूली के जड़ की गुणवत्ता पर प्रभेदों एवं बुआई के समय के प्रभाव का अध्ययन किया गया। प्रभेदों में सभी गुणों के लिए प्रभावी भिन्नता पायी गयी। पंजाब सफेद में डी2, डी5 तथा डी6 में ज्यादा शुष्क पदार्थ पाया गया। पंजाब पसंद में सबसे ज्यादा मिनिरल पया गया। पंजाब सफेद में तीखापन भी सबसे जयादा पाया गया।

Introduction

Radish is an important salad root vegetable grown throughout the world. Short growing season of radish fits well in multiple and companion cropping systems. Though, it is a winter season crop but with proper selection of varieties, it can be grown out of its normal growing season. Success of radish cultivation, therefore, depends upon selecting a season specific variety.

Dry matter, total minerals and isothiocyanate content constitute important quality attributes in radish. High concentration of glucosinolates is also reported to cause goiter (Greer, 1995). The characteristic pungent flavour, which is not relished by many people, is determined by volatile isothiocyanates. The pungency is higher in summer grown radishes than in winter grown radishes (Diana et al, 1985, Ishii and Saijo, 1987 and Nijjar et al, 1996). Radish grown under high temperature (Nieuwhof, 1976) and high light intensity conditions (Sarkar et al, 1978) accumulated higher dry matter in the roots than the ones grown under low-light and low-temperature conditions.

Sufficient information is available on the production of radish in the main growing season. But it is lacking under sub-optimal climatic conditions. The present investigation was carried out to evaluate root quality of radish on six genotypes in six dates of sowing.

Materials and Methods

The present investigations were carried out at the Vegetable Research Farm and the Biochemistry Laboratory of the Department of Vegetable Crops, Punjab Agricultural University, Ludhiana during the year 2003- 04. The experiment comprised two main parameters, namely the dates of sowing and the genotypes. Sowing was done on six dates viz. 15th January (D_1), 15th March (D_2), 15th May (D_3), 15th July (D_4), 15th September (D_5) and 15th November (D_6). The eight genotypes evaluated were Punjab Ageti (G_1), Punjab Pasand (G_2), Punjab Safed (G_3), Pusa Chetki (G_4), Pusa Himani (G_5), Palak Leaf (G_6), All Seasons White Long (G_7) and Mino Early Long White (G_8). The experiment was laid out in an BBD with six replications in each season. Each genotype was represented by a single row of 5m length. Spacing was maintained at 60cm between rows and 5cm between plants. Spacing between plants was maintained by thinning at 2- 3 leaf stage. Data were recorded on dry matter (%), total minerals (%) and isothiocyanate content (mg per100g) as described below;

Dry matter (%): One hundred grams fresh root weight taken was cut into pieces and was put in a petri-dish.

The sample was dried in an oven at 65°C till constant weight was obtained and dry matter was expressed in percent.

Total minerals (%): The oven dried root sample was ground to powder. One gram powder was transferred to crucible. The crucible was placed in a Muffle furnace at 800°C for eight hours. The weight of ash left in the crucible was recorded and expressed in percent.

Isothiocyanate content (mg per 100g): Isothiocyanate content was estimated following the procedure of Diana et al (1995).

The data were subjected to statistical analysis following the computer software package 'CPCS', developed by Singh and Cheema (1985). The total variation exhibited was partitioned into genotypes, environments (dates of sowing) and interaction between genotypes x dates of sowing. Duncan's Multiple Range test (Duncan 1955) was applied to test significance of differences between two means.

Results and Discussion

The estimates of mean sum of squares for three characters obtained from the Analysis of variance for each of the six dates of sowing is given in Table 1. It revealed that the mean squares due to genotypes were significant for all the three characters studied under six dates of sowing. This suggested that there existed significant differences among genotypes in their mean performance for all the characters studied. Due to their variable performance for various characters, the variety to be grown in a specific environment, therefore, is to be selected precisely.

The pooled analysis of variance over the six dates of sowing for dry matter (%), total minerals (%) and Isothiocyanate content is given in Table 2. The analysis indicated that all its components viz the mean sum of squares due to genotypes, dates of sowing and the interaction between genotypes and dates of sowing were significant at P = 0.01 for all the three characters studied. This indicated that apart from varieties, change of environment also contributed significantly in mean performance of the genotype. Further, the genotypes responded differently to the change of environment. The analysis further indicated that isothiocyanate content was the most affected by dates of sowing and dates x genotypes interaction. This was followed by dry matter and total minerals was the least affected. This also implies that different varieties have to be cultivated under different dates of sowing. Earlier reports also indicated same findings (Rajgopal et al, 1979, Dixit et al, 1980, Singh and Gupta, 1984, Nijjar et al 1996) and environmental (Singh and Gupta, 1984, Ishii and Saijo, 1987, Diana et al 1985, Rao and Manohar, 1990 and Nijjar et al, 1996).

Table 2: Pooled analysis of variance for dry matter, total minerals and isothiocyanate content in radish over different dates of sowing

Source	Mean Sum of Squares			
	d.f.	Dry matter (%)	Total minerals (%)	Isothiocyanate content (µg/ 100g)
Replications	30	0.87	0.02	29.21
Genotypes	7	3.06**	40.94**	50735.1**
Dates of sowing	5	16.27**	11.85**	405478.0**
G x D interaction	35	1.20**	1.31**	18397.8
Error	210	0.01	0.02	15.79

**Significant at P=0.01

Performance of radish varieties with respect to three biochemical characters studied under different dates of sowing along with their respective critical differences are given in Tables 3 to 5 and are discussed character-wise.

Dry matter, %: Dry matter production was significantly influenced by the sowing dates as was indicated by significance of mean sum of squares due to dates of sowing. It was evident from the data that

Table 1: Estimates of mean sum of squares due to genotypes for dry matter, total minerals and isothiocyanate content in radish under different date of sowing

Character	Mean sum of squares					
	D_1	D_2	D_3	D_4	D_5	D_6
Dry matter %	2.74**	2.64**	0.30**	1.41**	1.13**	0.43**
Total minerals %	5.58**	8.27**	8.90**	6.16**	5.74**	12.8**
Isothiocyanate content (µg/100g)	34257.4**	31560.0**	28241.7**	22554.6**	13059.0**	13101.7*

**Significant at P = 0.01

environment-wise, D_5 i.e. 15th September sown crop recorded highest content of dry matter (6.15%). This was followed by D_4 (5.53%), D_2 (5.43%), D_1 (4.92%) and D_3 (4.74%). D_6 i.e. 15th November sown crop recorded the lowest dry matter content of 4.67%. All the means corresponding to dates of sowing were statistically different from each other at P=0.01. The dry matter content produced by the different varieties over dates of sowing varied from 4.19% in Pusa Chetki in D_1 to 6.68% in Palak Leaf in D_5. However, Punjab Safed that produced dry matter of 6.64% also in D_5 was statistically at par with Palak Leaf. Wide range of dry matter % produced under different dates of sowing in Punjab Safed (4.57 – 6.64%) and Mino Early Long White (4.40- 6.42%) indicated that the genotypes are more sensitive to changing environmental conditions. The narrowest range was found in Punjab Ageti with the lowest dry matter content of 4.41% in D_1 to the highest of 5.35% in D_5. This revealed that there was little effect of changing dates of sowing on the performance of Punjab Ageti and, therefore, produced more consistent performance under all the six dates of sowing as compared with other genotypes.

Over the environments, Mino Early Long White recorded the highest dry matter content of 5.71% followed by Punjab Safed (5.45%), All Seasons White Long (5.42%), Palak Leaf (5.36%), Pusa Himani (5.26%), Pusa Chetki (5.15%) and Punjab Ageti (4.87%). Punjab Pasand recorded minimum dry matter of 4.86%. However, the DMRT revealed that the varieties Punjab Safed and All Seasons White Long; Punjab Ageti and Punjab Pasand were statistical at par.

Earlier reports indicated that Pusa Chetki recorded the lowest dry matter content among the varieties evaluated (Rao and Manohar, 1990). Dry matter content of the roots increased with the increasing day length (Sarkar et al 1978) and temperature (Nieuwhof, 1976). Production of higher dry matter under high

Table 3: Effect of dates of sowing and genotypes on dry matter (%) in radish

Genotypes	Dates of sowing						
	D_1	D_2	D_3	D_4	D_5	D_6	Mean
Punjab Ageti	4.41^f	4.88^d	4.58^d	5.53^d	5.35^e	4.49^e	4.87^f
Punjab Pasand	4.32^f	4.82^d	4.53^d	4.80^f	6.00^d	4.69^c	4.86^f
Punjab Safed	4.57^e	6.24^a	4.97^{ab}	5.15^e	6.64^a	5.14^a	5.45^b
Pusa Chetki	4.19^g	5.03c	5.04^a	5.72^c	6.02^d	4.89^b	5.15^e
Pusa Himani	5.26^c	6.20^a	4.54^d	5.14^e	6.19^c	4.23^f	5.26^d
Palak Leaf	4.96^d	5.07^c	4.89^{bc}	5.93^b	6.68^a	4.62^{cd}	5.36^c
All Season's White Long	5.55^b	5.90^b	4.85^c	5.61^{cd}	5.93^d	4.68^c	5.42^b
Mino Early Long White	6.12^a	6.31^a	4.40^d	6.32^a	6.42^b	4.60^{cde}	5.71^a
Mean	4.92^d	5.43^c	4.74^e	5.53^b	6.15^a	4.67^f	

C.D. at p = 0.05
(i) Genotypes (G) = 0.05, (ii) Dates of sowing (D) = 0.04, (iii) G x D interaction = 0.12

Table 4: Effect of dates of sowing and genotypes on total minerals (%) in radish

Genotypes	Dates of sowing						
	D_1	D_2	D_3	D_4	D_5	D_6	Mean
Punjab Ageti	13.71^b	14.63^b	13.83^b	14.88^b	14.65^b	14.13^b	14.31^b
Punjab Pasand	14.45^a	15.01^a	14.40^a	15.10^a	15.21^a	15.08^a	14.88^a
Punjab Safed	12.21^f	13.51^c	12.05^d	13.60^c	13.65^c	13.11^c	13.02^c
Pusa Chetki	11.28^g	12.96^e	11.90^e	13.03^e	12.91^e	11.18^g	12.21^f
Pusa Himani	12.63^d	12.45^g	11.28^g	12.15^g	12.58^f	11.85^e	12.15^f
Palak Leaf	12.41^e	13.15^d	12.68^c	12.75^f	13.43^d	12.65^d	12.85^d
All Season's White Long	12.81^c	12.61^f	11.43^f	13.30^d	12.60^f	11.55^f	12.38^e
Mino Early Long White	12.40^e	11.40^h	11.08^h	13.25^d	12.85^e	11.01^h	12.00^g
Mean	12.74^c	13.22^b	12.33^e	13.50^a	13.49^a	12.57^d	

C.D. at p = 0.05
(i) Genotypes (G) = 0.06, (ii) Dates of sowing (D) = 0.05, (iii) G x D interaction = 0.15

temperature and high light intensity conditions has been attributed to higher production of photosynthates in the leaves and their translocation to the roots. However, the present investigation revealed that dry matter production increased with corresponding increase in temperature up to D_5 that happens to be the main growing season under local conditions.

Total minerals, %: Total minerals content was significantly influenced by the dates of sowing dates as was indicated by the pooled analysis of variance. It is evident from the data that D_4 i.e. 15th July sown crop and D_5 i.e. 15th September sown crop recorded highest content of total minerals i.e. 13.50% and 13.49% respectively. Both the observations were statistically at par. This was followed by D_2 (13.22%), D_1 (12.74%) and D_6 (12.57%). D_3 i.e. 15th May sown crop recorded the lowest content of total minerals (12.33%). The maximum day temperature during D_4 and D_5 dates of sowing was recorded to be around 33°C. The minerals content was significantly reduced under other dates of sowing when the maximum temperature happened to be either below or above 33°C.

Total minerals varied from 11.01% in Mino Early Long White in D_6 to 15.21% in Punjab Pasand in D_5. The widest range in Mino Early Long White (11.01 – 13.25%) indicated that the variety is most responsive to dates of sowing. Across the genotypes and dates of sowing, the performance of Punjab Pasand was significantly superior to all the other genotypes evaluated under all the six dates of sowing. It also recorded the narrowest range with the lowest total minerals content being 14.40% in D_3 and the highest of 15.21% in D_5. This revealed that there was little effect of changing environmental conditions on the performance of Punjab Pasand and, therefore, produced more consistent performance under all the six dates of sowing as compared to the other varieties.

Over the environments, Punjab Pasand recorded highest content of total minerals (14.88) followed by Punjab Ageti (14.31%), Punjab Safed (13.02%), Palak Leaf (12.85%), All Seasons White Long (12.38), Pusa Chetki (12.21%) and Pusa Himani (12.16%). Mino Early Long White recorded the lowest content of total minerals (12.00%). However, the DMRT revealed that varieties Pusa Chetki and Pusa Himani were statistically at par.

Isothiocyanate content: It is evident from the data that environment wise, D_3 i.e. 15th May sown crop produced highest pungency content (425.81μg) followed by D_4 (403.32), D_2 (344.85), D_5 (320.88μg) and D_1 (257.88μg). The D_6 i.e. 15th November sown crop recorded the lowest pungency content (179.79μg). The temperature- pungency relationship indicated that with an increase in temperature prevailing during root development (the month following date of sowing), there was a corresponding increase in root isothiocyanate content and vice- versa. Earlier findings of Daina et al (1985), Ishi and Saijo (1987), Rao and Manohar, 1990 and Nijjar et al (1996) also indicated that root pungency was more at higher temperature prevailing during May- June.

Isothiocyanate content of radish varied from 108.36μg per 100g root weight in Punjab Pasand in D_6 to 536.24μg per 100g root in Palak Leaf in D_3. The widest range in Palak Leaf (189.74 – 536.24μg) indicated that

Table 5: Effect of dates of sowing and genotypes on isothiocyanate content (μg per 100g) in radish

Genotypes	Dates of sowing						
	D_1	D_2	D_3	D_4	D_5	D_6	Mean
Punjab Ageti	240.58^d	349.58^d	472.64^b	411.51^d	323.18^d	183.39^e	330.15^d
Punjab Pasand	255.61^c	309.79^f	341.32^g	332.32^b	300.59^f	108.36^g	274.67^g
Punjab Safed	388.91^a	425.53^b	467.94^b	362.68^e	308.32^e	198.37^d	358.63^b
Pusa Chetki	255.60^c	295.07^g	349.18^f	329.88^f	244.38^g	112.71^g	264.47^h
Pusa Himani	348.79^b	434.55^a	447.64^c	425.77^c	329.87^c	208.56^c	365.85^a
Palak Leaf	189.74^f	221.31^h	536.24^a	515.00^a	408.42^a	235.70^a	351.07^c
All Season's White Long	211.46^e	324.60^e	368.25^e	435.81^b	303.65^f	216.47^b	310.04^f
Mino Early Long White	172.38^g	398.35^c	423.23^d	413.55^d	348.59^b	174.75^f	321.81^e
Mean	257.88^e	344.85^c	425.81^a	403.32^b	320.88^d	179.79^f	

C.D. at p =_ 0.05

(i) Genotypes (G) = 1.86, (ii) Dates of sowing (D) = 1.61, (iii) G x D interaction = 4.55

the variety was more responsive to change in dates of sowing. The narrowest range was found in All Season's White Long with minimum isothiocyanate content of 21.46μg per 100g root weight under D_1 and the maximum of 435.81μg per 100g root in D_4. This shows that there was little effect of changing environmental conditions on the performance of All Seasons White Long and, therefore, produced more consistent performance under all the six dates of sowing as compared to the other varieties.

Over the environments Pusa Himani recorded highest pungency content (355.88 μg) followed by Punjab Safed (358.63μg), Palak Leaf (351.07μg), Punjab Ageti (330.15μg) Mino Early Long White (321.81μg), All Seasons White Long (310.04μg) and Punjab Pasand (274.67μg). Pusa Chetki recorded lowest pungency content of 264.47μg per 100g root.

The three quality attributes of radish viz. dry matter, total minerals and isothiocyanate content were found to vary with genotypes, dates of sowing and genotypes x dates of sowing interaction. Isothiocyanate content was most influenced by change in date of sowing and genotypes x dates of sowing interaction. This was followed by dry matter, whereas, total minerals was the least affected. Among the genotypes evaluated, Punjab Pasand was the most rich in total minerals irrespective of date of sowing. Dry matter and total minerals increased with corresponding increase in temperature up to certain levels and decreased there after. Temperature during root development was found to be positively correlated with root pungency.

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