Plant Archives Vol. 25, Supplement 1, 2025 pp. 934-942 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2025.v25.supplement-1.126

IMPACT OF SOWING DATES AND IRRIGATION LEVELS ON BEETROOT (*BETA VULGARIS* L.): INSIGHTS INTO GROWTH DYNAMICS, YIELD ATTRIBUTES AND QUALITY PARAMETER

Raj D. Rupareliya[1*], Mihir B. Modh[2], D. B. Patoliya[2], Kameshwar P. Patel[3] and H. H. Sitapara[3]
[1]Department of Agricultural Meteorology, B. A. College of Agriculture,
Anand Agricultural, University, Anand 388 110, Gujarat, India.
[2]Department of Agronomy, B. A. College of Agriculture, Anand Agricultural University,
Anand 388 110, Gujarat, India.
[3]Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University,
Anand 388 110, Gujarat, India.
*Corresponding author E-mail: rajrupareliya121@gmail.com
(Date of Receiving : 25-08-2024; Date of Acceptance : 21-10-2024)

ABSTRACT

This research investigates the impact of sowing dates and irrigation levels on the cultivation of beetroot (*Beta vulgaris* L.), focusing on growth dynamics, yield attributes and quality parameters conducted during the *rabi* season of 2022-23 at Anand Agricultural University, Gujarat, India, The study employed a Factorial Randomized Block Design with twelve treatments comprising three sowing dates (1st October, 16th October, 1st November) and four irrigation levels (I_1: 1.00 IW:CPE ratio, I_2: 0.85 IW:CPE ratio, I_3: 0.70 IW:CPE ratio and I_4: As per recommended irrigation). Various growth parameters *viz.*, plant height, dry weight of plants and roots, leaf area index, root diameter and yield attributes *viz.*, root length, fresh weight and dry weight were assessed. Statistical analysis revealed significant effects of both factors on beetroot growth and yield. The findings provide insights into optimizing cultivation practices for enhanced beetroot production under varying environmental conditions. Later sowing date (S_3) and recommended irrigation levels (I_4) generally improved beetroot growth, yield and quality. S_3 led to taller plants, increased dry weight, larger leaf area index and thicker roots. I_4 supported overall growth and yield by ensuring optimal moisture, with minimal interaction between sowing dates and irrigation levels noted.

Keywords: Yield attributes, Quality parameter, *Beta vulgaris* L.

Introduction

The cultivation of beetroot (*Beta vulgaris* L.) holds significant agricultural importance owing to its nutritional value and versatile applications in the food industry. As root vegetable rich in essential nutrients, including vitamins, minerals and antioxidants, beetroot has garnered attention for its potential health benefits and culinary versatility. Beetroot has high sugar content, but are still having a very a smaller number of calories. Beetroot (per 100 g) provides 9.96 g carbohydrates, 43 Kcal energy, 0.18 g fat, 1.68 g proteins, 16 mg calcium, 38 mg phosphorus, 0.79 mg Iron, 23 mg magnesium, 77 mg sodium, 2 305 mg potassium and 3.6 mg Vitamin C (Chhikara *et al.* 2019). Consequently, optimizing the growth conditions to enhance its yield and quality attributes is of paramount importance.

Among the various factors influencing beetroot cultivation, irrigation levels and sowing dates stand out as crucial determinants of growth dynamics, yield and quality attributes. Irrigation plays a pivotal role in providing adequate moisture levels essential for plant growth, while sowing dates dictate the developmental stages and overall productivity. Understanding the

interplay between these factors is essential for devising efficient cultivation practices and maximizing beetroot production.

This research aims to analyse the effects of sowing dates and irrigation levels on beetroot cultivation comprehensively. By investigating growth dynamics, yield attributes and quality parameters, this study seeks to provide valuable insights into the optimization of cultivation practices for beetroot production. Through empirical analysis and data-driven conclusions, this research endeavours to contribute to the sustainable enhancement of beetroot cultivation methods, thereby addressing the increasing demand for this nutritious and versatile vegetable.

Materials and Methods

The present investigation, titled "Analysing the Effects of Sowing Dates and Irrigation Levels on Beetroot (*Beta vulgaris* L.): Insights into Growth Dynamics, Yield and Quality Attributes," was conducted at Agronomy Farm, B.A. College of Agriculture, Anand Agricultural University, Anand, Gujarat, India (22°35' N latitude, 72°55' E longitude, and 45.1 m above mean sea level) during the *rabi* season of 2022-23. This location is within the Middle Gujarat Agro-Climatic Zone (AES-III), characterized by a semi-arid, subtropical climate with dry, hot summers, a monsoon season from June to September and a fairly cold winter from November to February.

Table 1: Weather data recorded during crop season of the year 2022-23 (weekly mean).

Month & Year	Std. Met. Week	Temperature (°C)		Average Relative Humidity (%)	Bright Sunshine Hours/day	Wind Speed (km/hrs.)
		Max.	Min.			
October	40	34.1	25.5	67.1	8.8	5.9
	41	32.6	24.1	75.8	5.8	2.9
	42	34.6	21.1	58.1	10.1	2.7
	43	34.4	18.6	56.0	10.0	2.4
November	44	34.6	17.6	56.1	9.8	1.8
	45	34.8	19.0	61.1	9.2	1.5
	46	32.4	16.5	57.2	9.1	2.3
	47	30.7	13.5	50.4	9.5	2.9
December	48	30.6	15.1	57.0	9.4	3.1
	49	29.6	16.2	58.7	8.6	3.6
	50	29.9	18.5	60.8	7.8	5.1
	51	31.3	16.1	59.6	8.4	1.9
	52	23.4	11.1	55.1	8.0	3.3
January	1	25.0	12.5	60.8	8.5	6.3
	2	27.8	12.4	62.6	9.0	2.9
	3	25.6	10.0	57.7	9.5	3.9
	4	25.5	11.5	63.8	8.7	4.4
February	5	27.2	14.1	63.9	7.4	4.6

The soil, classified as sandy loam and locally known as "*Goradu* Soil," is alluvial in origin, light brown, well-drained and has good moisture retention capabilities. The experimental design was a Factorial Randomized Block Design with three replications, involving twelve treatments. These treatments combined three sowing dates (S_1: 1st October, S_2: 16th October, S_3: 1st November) with four irrigation levels (I_1: 1.00 IW:CPE ratio, I_2: 0.85 IW:CPE ratio, I_3: 0.70 IW:CPE ratio, I_4: As per recommended irrigation). Fertilizers were applied at recommended dosage of 60-100-100 N-P-K kg/ha along with 10 t/ha of vermicompost. The entire quantity of N, P, and K was uniformly distributed as a basal dose across all plots. Seeds were sown on ridges at a depth of 1.5 cm, covered with soil using a rake, and irrigated promptly to ensure minimal disturbance. Initial irrigation was applied uniformly across all plots for seed germination, followed by common irrigation for 30 days. Subsequent irrigation was tailored according to the IW:CPE ratios. Irrigation water was applied at specific intervals based on cumulative pan evaporation, with a fixed depth of 50 mm when thresholds of 50 mm (1.0 ratio), 58.82 mm (0.85 ratio) and 71.42 mm (0.70 ratio) were reached. Daily pan evaporation was measured using a USWB Class 'A' open pan evaporimeter near the experimental plots. The quantity of irrigation water was measured using a 7.5 cm head Parshall flume. The treatment-wise irrigation schedule for the *rabi* season of 2022-23 is detailed in Table 2.

Table 2: Treatment-wise Irrigation Calendar during *Rabi* 2022-23

Sowing Date	Treatment	Number of Irrigations	Common Irrigation Dates	Specific Irrigation Dates	Total Irrigations	Irrigation Water (mm)
01/10/2022	I_1	7	01/10, 04/10, 16/10, 28/10	17/11, 02/12, 18/12	7	350
	I_2	7	01/10, 04/10, 16/10, 28/10	19/11, 08/12, 25/12	7	350
	I_3	6	01/10, 04/10, 16/10, 28/10	23/11, 15/12	6	300
	I_4	9	01/10, 04/10, 16/10, 28/10	08/11, 19/11, 28/11, 08/12, 18/12	9	450
16/10/2022	I_1	7	16/10, 19/10, 01/11, 15/11	01/12, 16/12, 02/01	7	350
	I_2	6	16/10, 19/10, 01/11, 15/11	04/12, 21/12	6	300
	I_3	6	16/10, 19/10, 01/11, 15/11	08/12, 30/12	6	300
	I_4	8	16/10, 19/10, 01/11, 15/11	28/11, 08/12, 18/12, 30/12	8	400
01/11/2022	I_1	6	01/11, 04/11, 17/11, 30/11	16/12, 01/01	6	300
	I_2	6	01/11, 04/11, 17/11, 30/11	19/12, 06/01	6	300
	I_3	5	01/11, 04/11, 17/11, 30/11	22/12	5	250
	I_4	7	01/11, 04/11, 17/11, 30/11	08/12, 18/12, 30/12	7	350

Cultural operations were meticulously carried out to ensure optimal growth conditions for beetroot. Detailed observations were recorded on various growth, yield and quality parameters. The growth characteristics measured included plant height (cm), dry weight of plants (g/plant), dry weight of root (g/plant), leaf area index (LAI) and root diameter (cm). Yield attributing characters included root length (cm), fresh weight of root (g/plant), dry weight of root (g/plant), root: shoot ratio (%), root yield (kg/plot and t/ha) and harvest index (%). Quality parameters were assessed by measuring total soluble solids (°Brix). Beetroots were harvested at a diameter of 5-6 cm while still tender, based on the sowing date. Light irrigation was applied a day before harvesting for easier root extraction. Roots were pulled out, washed to remove soil particles, and their characteristics were observed.

Result and Discussion

Growth Dynamics

Plant Height

Effect of Sowing Dates

The later sowing dates (S_2: 16th October, S_3: 1st November) consistently resulted in taller beetroot plants compared to earlier sowing (S_1: 1st October) at all growth stages (Table 3). At harvest, plant heights were 40.78 cm (S_1), 44.22 cm (S_2) and 48.03 cm (S_3). Significant differences were observed at all stages. The variation in plant height of the respective planting date might be due to the effect of temperature (seasonal mean temperature of sowing date S_1 (1st October): 25.1°, S_2 (16th October): 24.1 °, S_3 (1st November): 22.9°) on the level and activity of gibberellins, substances responsible for elongation of flower stalk. Earlier reports indicated that low temperature

treatments resulted in both quantitative increase and qualitative changes in gibberellic acid (GA) levels (Kruzhilin and Shvedsksya 1960; Thomas *et al*., 1972; Jones, 1973). Similar results were also obtained by Mengistu & Yamoah (2010) and Sandipan & Rawat (2020).

Effect of Irrigation Levels

Different irrigation levels also significantly affected on plant height. At 30 DAS, plant height ranged from 18.01 cm (I_2: 0.85 IW ratio) to 18.97 cm (I_1: 1.00 IW ratio), with no significant differences. However, at later stages, I_4 (recommended irrigation) consistently resulted in the tallest plants, reaching 48.48 cm at harvest. Significant differences were noted at all stages except 30 DAS. Later sowing dates and the recommended irrigation level (I4) significantly increased plant height at different growth stages. The interaction between date of sowing and irrigation levels was found non-significant.

Dry Weight of Plants

Effect of Sowing Dates

The later sowing dates increased the dry weight of beetroot plants. At 30 DAS, S_3 (1st November) had the highest dry weight (2.24 g plant^{-1}), followed by S_2 (16th October) and S_1 (1st October) (Table 3). This trend continued through all growth stages, with S_3 consistently having the highest dry weight, reaching 39.74 g plant^{-1} at harvest. The data shows significant differences at all crop growth stages. This might be due to favourable conditions experienced during the crop growing period. Similar results were obtained by Ghormade *et al*. (1989), Kanwar (1993) and Gill and Gill (1995) under different climatic conditions.

Effect of Irrigation Levels

Irrigation levels also affected on dry weight significantly. At 30 DAS, dry weight ranged from 2.04 g plant^{-1} (I_2: 0.85 IW ratio) to 2.15 g plant^{-1} (I_1: 1.00 IW ratio), with no significant differences, it might be due to common irrigation up to 30 days after sowing. From 45 DAS onward, I_4 (recommended irrigation) consistently resulted in the highest dry weight, reaching 38.56 g plant^{-1} at harvest. Significant differences were noted at all stages except 30 DAS. The dry matter accumulation in plant parts *viz*. leaf, stem, pod and root were more with higher irrigation frequency at all the stages of crop growth in radish (Sharma & Batra, 2018). Similar result was also obtained by Patel *et al*. (2019).

In summary, later sowing dates and I_4 (recommended irrigation) significantly increased plant dry weight at all growth stages, with no significant interaction effects observed.

Dry Weight of Root

Effect of Sowing Dates

Among the different sowing dates, later sowing showed higher dry weight of roots. At 30 DAS, S_3 (1st November) had the highest root dry weight (0.29 g plant^{-1}), followed by S_2 (16th October) and S_1 (1st October) (Table 3). This trend continued through all growth stages, with S_3 consistently having the highest dry weight. At harvest, dry weight was 14.70 g plant^{-1} (S_1), 16.60 g plant^{-1} (S_2), and 18.52 g plant^{-1} (S_3). Significant differences were observed at all stages. This could be due to the fact that low temperature provides better soil condition for radish root growth (Singh *et al.,* 2021).

Effect of Irrigation Levels

Different irrigation levels significantly affected on root dry weight. At 30 DAS, Dry root weight ranged from 0.26 g plant^{-1} (I_4: recommended irrigation) to 0.27 g plant^{-1} (I_1: 1.00 IW ratio and I_3: 0.70 IW ratio), with no significant differences, it might be due to common irrigation up to 30 days after sowing. From 45 DAS onward, I_4 consistently resulted in the highest root dry weights, reaching 22.78 g plant^{-1} at harvest. Significant differences were noted at all stages except 30 DAS. Similar results were also obtained by Sharma & Batra (2018). The later sowing dates and I_4 (recommended irrigation) significantly increased root dry weight at all growth stages.

Leaf Area Index

Effect of Sowing Dates

The later sowing dates increased LAI in beetroot plants. At 60 DAS, S_3 (1st November) had the highest LAI (2.02), followed by S_2 (1.73) and S_1 (1.04). At harvest, S_3 again had the highest LAI (2.51), with significant differences at all stages. Similar results were reported by Lavanya *et al.* (2014) in radish.

Table 3 : Growth characters of beetroot as influenced by different date of sowing and irrigation levels

Treatment	Plant height (cm)					Dry Weight of Plant (g plant^{-1})					Dry Weight of Root (g plant^{-1})					Leaf Area Index (LAI)			Root Diameter (cm)				
	30 DAS	45 DAS	60 DAS	75 DAS	At harvest	30 DAS	45 DAS	60 DAS	75 DAS	At harvest	30 DAS	45 DAS	60 DAS	75 DAS	At harvest	60 DAS	75 DAS	At harvest	30 DAS	45 DAS	60 DAS	75 DAS	At harvest
Sowing Dates (S)																							
S_1 : 1st October	14.86	29.42	34.03	38.67	40.78	1.90	7.04	17.46	28.04	32.80	0.24	3.37	8.95	13.01	14.70	1.04	1.46	1.84	0.36	1.55	3.16	5.47	6.58
S_2 : 16th October	20.08	33.53	40.24	43.81	44.22	2.12	9.24	20.67	34.32	35.97	0.27	3.57	10.35	16.43	16.60	1.73	2.10	2.15	0.54	2.56	5.23	7.38	7.52
S_3 : 1st November	20.74	34.16	41.87	-	48.03	2.24	9.57	26.59	-	39.74	0.29	3.68	13.82	-	18.52	2.02	-	2.51	0.83	3.65	6.25	-	7.66
S.Em.±	0.400	0.763	1.163	1.133	1.163	0.041	0.183	0.256	0.584	0.861	0.006	0.050	0.163	0.295	0.405	0.014	0.016	0.040	0.008	0.038	0.054	0.104	0.129
CD at 5 %	1.17	2.24	3.41	3.44	3.41	0.12	0.54	0.75	1.77	2.52	0.02	0.15	0.48	0.89	1.19	0.04	0.05	0.12	0.02	0.11	0.16	0.32	0.38
Irrigation Levels (I)																							
I_1 : 1.00 IW:CPE ratio	18.97	32.88	39.35	41.67	44.74	2.15	8.67	22.03	32.61	37.17	0.27	3.64	11.55	15.02	17.55	1.62	1.84	2.24	0.59	2.66	5.06	6.60	7.36
I_2 : 0.85 IW:CPE ratio	18.01	31.54	37.13	39.89	43.48	2.04	8.25	20.97	30.15	35.33	0.26	3.38	10.26	13.18	14.06	1.57	1.75	2.09	0.58	2.53	4.72	6.22	7.11
I_3 : 0.70 IW:CPE ratio	18.37	30.32	35.94	37.50	40.67	2.06	7.77	20.14	27.77	33.61	0.27	3.21	9.66	11.21	12.03	1.45	1.60	1.93	0.58	2.31	4.43	6.00	6.93
I_4 : As per recommended irrigation	18.89	34.73	42.43	45.89	48.48	2.10	9.77	23.16	34.19	38.56	0.26	3.92	12.68	19.46	22.78	1.75	1.94	2.40	0.57	2.83	5.31	6.87	7.61
S.Em.±	0.462	0.881	1.343	1.602	1.343	0.048	0.211	0.296	0.826	0.994	0.007	0.057	0.188	0.417	0.467	0.016	0.023	0.046	0.009	0.044	0.062	0.147	0.149
CD at 5 %	NS	2.58	3.94	4.86	3.94	NS	0.62	0.87	2.51	2.91	NS	0.17	0.55	1.26	1.37	0.05	0.07	0.14	NS	0.13	0.18	0.45	0.44
Interaction (S×I)																							
S.Em.±	0.801	1.526	2.327	2.266	2.327	0.083	0.366	0.513	1.168	1.721	0.012	0.099	0.326	0.589	0.810	0.027	0.033	0.080	0.016	0.076	0.107	0.208	0.258
CD at 5 %	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.08	NS	NS	NS	NS	NS	NS	NS
CV %	7.47	8.17	10.41	9.52	9.09	6.86	7.35	4.12	6.49	8.24	7.61	4.87	5.11	6.93	8.45	2.93	3.18	6.38	4.85	5.07	3.80	5.60	6.16

Effect of Irrigation Levels

Different irrigation levels significantly impacted on LAI. At 60 DAS, LAI ranged from 1.45 (I_3: 0.70 IW ratio) to 1.75 (I_4: recommended irrigation). At harvest, I_4 had the highest LAI (2.40), followed by I_1 (2.24). Significant differences were noted at all stages.

Interaction between Sowing Dates and Irrigation Levels

Significant interaction effects on LAI were observed at 60 DAS (Table 4). The highest LAI (2.18) was observed S_3I_4. At 75 DAS and harvest, no significant interaction effects were found.

Table 4 : Interaction effect on leaf area index at 60 DAS

	I_1	**I_2**	**I_3**	**I_4**
S_1	1.07	1.02	0.95	1.11
S_2	1.76	1.70	1.51	1.95
S_3	2.04	1.99	1.88	2.18
S.Em. ±	0.027			
CD at 5 %	0.079			

The later sowing date and recommended irrigation (I_4) significantly increased LAI, with significant interaction effects at 60 DAS.

Root Diameter

Effect of Sowing Dates

Later sowing dates increased beetroot root diameter consistently across growth stages. At 30 DAS, S_3 (1st November) had the largest root diameter (0.83 cm), followed by S_2 (0.54 cm) and S_1 (0.36 cm). This trend continued at 45 DAS, 60 DAS and 75 DAS, with S_3 consistently showing larger diameters. At harvest, root diameters of 6.58 cm (S_1), 7.52 cm (S_2) and 7.66 cm (S_3). Significant differences were observed at all stages. These results may be due to favourable meteorological factors for optimal germination, emergence and plant establishment, especially in the early stage of growth (Elwan & Helmy 2018).

Effect of Irrigation Levels

The different irrigation levels significantly influenced root diameter. I_4 (recommended irrigation) consistently produced the largest diameters, reaching 7.61 cm at harvest. Significant differences were noted at all stages except 30 DAS. Similar results were obtained by Moursi & Mansoury (2015) and Sharma *et al.* (2022).

In summary, later sowing dates and I_4 (recommended irrigation) significantly increased root diameter, with no significant interaction effects observed.

Yield and Yield Attributes

Effect of Sowings Dates

Different sowing dates significantly affected on different yield parameter *viz.,* root length, fresh weight of root, dry weight of root, root: shoot ratio, yield per plot and harvest index.

- **Root Length:** S_3 (1st November) exhibited the longest root length at 17.41 cm, followed by S_2 (16th October) with 16.74 cm and S_1 (1st October) with 12.66 cm. This might be due to increased temperature during earlier sowing date growth period. Similar results were reported by Alam et al. (2010a) and Elwan & Helmy (2018).
- **Fresh Weight of Root:** 1st November sowing (S_3) revealed the highest fresh weight of root (210.52 g plant^{-1}), followed by S_2 (165.27 g plant^{-1}) and S_1 (145.35 g plant^{-1}). Similar results were reported by Elwan & Helmy (2018) in sugar beet, Sandipan & Rawat (2020) and Singh *et al.* (2021) in radish.
- **Dry weight of root:** Similarly, S_3 also showed the highest dry weight of root (18.52 g plant^{-1}), followed by S_2 (16.60 g plant^{-1}) and S_1 (14.70 g plant^{-1}). Similar result obtained by Singh *et al.* (2021) in radish and also revealed that this could be due to the fact that low temperature provides better condition for root growth.
- **Root: shoot ratio:** Sowing dates influenced the root: shoot ratio, with S_3 having the highest ratio of 1.65, indicating a higher allocation of biomass to roots compared to shoots. Similar result was obtained by Alla (2016).
- **Yield per plot:** The highest yield per plot at (11.66 kg plot^{-1}) was recorded under 1st Nov. sowing (S_3) followed by S_2 (10.25 kg plot^{-1}) and S_1 (4.79 kg plot^{-1}). This might be due to the favorable climatic conditions that prevailed during the growth period for the S_3 (1st November) sown crop. It was also found that the beetroot yields in the earlier sowings before S_3 (1st November) were very low. Lower yield with early sowing might be attributed to

higher temperature prevailed during active root development. The result might be due to more favourable environment for root development. In carrot and sugar beet similar results were reported by Patel *et al.* (2017), Elwan & Helmy (2018) and Sandipan & Rawat (2020).

- **Harvest Index:** S_3 (1st Nov. sowing) exhibited the highest harvest index at 66.79%, indicating efficient partitioning of biomass into harvestable parts.

Significant differences were observed among sowing dates for all parameters, highlighting the impact of planting timing on beetroot growth and yield.

Effect of Irrigation Levels

Irrigation levels significantly influenced the yield parameters of beetroot:

- **Root Length:** I_4 (recommended irrigation) resulted in the longest root length (19.57 cm), followed by I_1 (15.53 cm), I_2 (13.83 cm) and I_3 (13.05 cm). This might be due to plants that suffer a lack of water had an impact on the low assimilates due to closed stomata. As a result, the rate of plant growth decreases, including the process of root development and similar result was obtained by Suminarti *et al.* (2020).
- **Fresh Weight of Root:** I_4 also showed the highest fresh weight of root (216.06 g plant^{-1}), followed by I_1 (190.91 g plant^{-1}), I_2 (162.02 g plant^{-1}) and I_3 (125.86 g plant^{-1}).
- **Dry Weight of Root:** Similarly, I_4 had the highest dry weight of root at 22.78 g plant^{-1}, followed by I_1 (17.55 g plant^{-1}), I_2 (14.06 g plant^{-1}) and I_3 (12.03 g plant^{-1}). Similar result was also obtained by Sharma & Batra (2018).
- **Root: shoot ratio:** Different irrigation levels in beetroot did not show their significant effect on root: shoot ratio.
- **Yield per Plot:** The highest yield per plot (11.22 kg plot^{-1} as noted with irrigation as per recorded, followed by I_1 (9.57 kg plot^{-1}), I_2 (7.87 kg plot^{-1}) and I_3 (6.94 kg plot^{-1}). This might be due to the absorption of ample moisture throughout the growing period that facilitated lower soil strength, greater nutrient uptake and proper physical environment for better root growth and bulking these increased the volume of the root by both in length as well as diameter and ultimately increased the yield (Alam *et al.,* 2010b).

Table 5 : Yield parameters of beetroot as influenced by different date of sowing and irrigation levels

Treatment	Root length (cm)	Fresh weight of root (g plant^{-1})	Dry weight of root (g plant^{-1})	Root: shoot ratio	Yield		Harvest Index (%)
					(kg plot^{-1})	(t ha^{-1})	
Sowing Dates (S)							
S_1 : 1st October	12.66	145.35	14.70	1.49	4.79	11.08	56.68
S_2 : 16th October	16.74	165.27	16.60	1.58	10.25	23.73	63.99
S_3 : 1st November	17.41	210.52	18.52	1.65	11.66	26.99	66.79
S.Em.±	0.270	3.540	0.405	0.029	0.32	0.75	0.48
CD at 5 %	0.79	10.38	1.19	0.09	0.95	2.20	1.42
Irrigation Levels (I)							
I_1 : 1.00 IW:CPE ratio	15.53	190.91	17.55	1.59	9.57	22.14	62.54
I_2 : 0.85 IW:CPE ratio	13.83	162.02	14.06	1.56	7.87	18.21	62.38
I_3 : 0.70 IW:CPE ratio	13.05	125.86	12.03	1.55	6.94	16.07	61.60
I_4 : As per recommended irrigation	19.57	216.06	22.78	1.60	11.22	25.98	63.43
S.Em.±	0.311	4.087	0.467	0.034	0.37	0.87	1.532
CD at 5 %	0.91	11.99	1.37	NS	1.10	2.54	NS
Interaction (S×I)							
S.Em.±	0.539	7.079	0.810	0.059	0.65	1.50	2.653
CD at 5 %	NS	NS	NS	NS	NS	NS	NS
CV %	6.03	7.06	8.45	6.46	12.60	12.60	7.35

- **Harvest Index:** Different irrigation levels in beetroot did not show their significant influence on harvest index.

Interaction between Sowing Date and Irrigation Levels

The interaction effects between sowing dates and irrigation levels did not show any significant effect on yield parameter.

Quality Parameters:

Total soluble solids (°Brix):

Effect of Sowings Dates

The TSS content of beetroot was significantly influenced due to different sowing dates. Among the sowing dates 1st October recorded the highest TSS content (8.86°Brix), which was significantly superior to the other sowing dates. While the lowest TSS content was observed in 1st November, which was at par with 16th October sowing.

Effect of Irrigation Levels

The different irrigation levels did not exhibit any significant effect on the TSS content of beetroot. The TSS content was not significantly influenced by the irrigation treatments.

Interaction between Sowing Dates and Irrigation Levels

The interaction effect between sowing dates and irrigation levels did not reach the significance level in influencing the TSS content of beetroot.

Table 6 : Quality parameter of beetroot as influenced by different date of sowing and irrigation levels

Treatment	Total Soluble Solids (TSS) (°Brix)
Sowing Dates (S)	
S_1 : 1st October	8.86
S_2 : 16th October	8.49
S_3 : 1st November	7.94
S.Em.±	0.111
CD at 5 %	0.33
Irrigation Levels (I)	
I_1 : 1.00 IW:CPE ratio	8.64
I_2 : 0.85 IW:CPE ratio	8.17
I_3 : 0.70 IW:CPE ratio	8.34
I_4 : As per recommended irrigation	8.57
S.Em.±	0.129
CD at 5 %	NS
Interaction (S×I)	
S.Em.±	0.223
CD at 5 %	NS
CV %	4.58

Conclusion

Results indicate that later sowing date (S_3) and the irrigation level as per recommendation (I_4) generally promoted better growth dynamics, higher yield attributes and improved quality parameters. Specifically, later sowing date (S_3) contributed to taller plant, increased dry weight of plant and roots, larger leaf area index and thicker root diameter. Similarly, the recommended irrigation level (I_4) enhanced overall plant growth and yield, ensuring optimal moisture availability throughout the crop cycle. However, interaction between sowing dates and irrigation levels were minimal, suggesting independent effects on most parameters studied.

References

Alam, M.K., Farooque, A. M., Nuruzzaman, M., & Uddin, A. J. (2010a). Effect of sowing time on growth and yield of three radish (*Raphanus sativus* L.) varieties. *Bangladesh Res. Pub. J*, **3**(3), 998-1006.

Alam, M. S., Mallik, S. A., Costa, D. J., & Alam, A. (2010b). Effect of irrigation on the growth and yield of carrot (*Daucus carota* sp. Sativus) carrot in hill valley. *Bangladesh Journal of Agricultural Research*, **35**(2), 323-329.

Alla, H. N. (2016). Yield and quality of sugar beet as affected by sowing date, nitrogen level and foliar spraying with calcium. *Journal of Agriculturural Research Kafr El-Sheikh University*, **42**(1), 170-188.

Aly, M.S.M. (2012). Performance study of some sugar beet varieties under sowing and harvesting dates. *Journal of Plant Production*, **3**(9), 2439-2449.

Chhikara, N., Kushwaha, K., Sharma, P., Gat, Y., & Panghal, A. (2019). Bioactive compounds of beetroot and utilization in food processing industry, A critical review. *Food chemistry*, **272**, 192-200.

Elwan, A. M., & Helmy, S. A. (2018). Yield and technological characteristics of sugar beet as affected by sowing date, nitrogen level and harvesting age. *Journal of Plant Production,* **9**(4), 345-352.

Ghormade, B. G., P. B. Kale, L. V. Kulwal and P. P. Deshmukh (1989). Seed production studies in some varieties of radish as influenced by dates of steckling planting. *PKV Res. J.*, **13**(1), 34-38.

Gill, S. S. and B. S. Gill (1995). Seed yield in radish as influenced by the date of transplanting and steckling size. *Seed Res.*, **23**(1), 28-30.

Jones RL (1973). Gibberellins, Their physiological role. *Ann. Rev. Plant Physiol.*, **24**, 571-598.

Kanwar, J. S. (1993). Influence of spacing and time of sowing on growth and seed yield of radish. *Indian J. Agric. Sci.*, **63**(6), 351-353.

Kruzhilin AS, Shvedskaya ZM (1960). Differentiation of growing points in biennial root crops. *Sov. Plant Physiol.*, **7**, 361-365.

Lavanya, A. V. N., Sudhavani, V., Reddy, P. S., & Chaitanya, K. (2014). Effect of sowing dates and spacing on growth and root yield of radish cv. Pusa chetki. *Plant archives*, **14**(1), 619-623.

Mengistu, T., & Yamoah, C. (2010). Effect of sowing date and planting density on seed production of carrot (*Daucus carota* var. sativa) in Ethiopia. *African Journal of Plant Science*, **4**(8), 270-279.

Moursi, E.A., & EL-Mansoury, M.A., (2015). Effect of cultivation method and different irrigation levels on water relations for sugar beet crop north Nile delta region. *Journal of Soil Sciences and Agricultural Engineering*, **6**(8), 983-999.

Panse, V. G. & Sukhatme, P. V. (1967). Statistical methods of agricultural workers. 2nd Endorsement. ICAR Publication, New Delhi, India, 381.

Patel, H. T., Sharma, H. K., Joshi, P. C., Chaudhari, A. H., & Dave, P.P. (2017). Production and profitability of beetroot (*Beta vulgaris* L.) Cultivars to date of planting and spacing under north Gujarat conditions. *International Journal of Chemical Studies*, **5**(5), 1505-1510.

Patel, M.M., Joshi, H.K., Patel, V.A., & Usadadia, V.P., (2019). Effect of irrigation schedules on growth, yield, WUE and economics of fodder sugar beet (*Beta vulgaris* L.) varieties under coastal salt affected soils. *Forage Research*, **45**(1), 47-50.

Sandipan, T.S., & Rawat, M. (2020). Effect of different sowing dates and spacing on the growth and yield of radish-A review. *Journal of Pharmacognosy and Phytochemistry*, **9**(6), 1713-1716.

Sharma, A., Sharma, J.C., Gautam, K.L., & Namgial, J. (2022). Response of irrigation scheduling and nitrogen levels on growth and yield contributing parameters of radish (*Raphanus sativus* L.) under mid hills of Himachal Pradesh. *Environment Conservation Journal*, **23** (1&2), 172-182.

Sharma, D., & Batra, B.R. (2018). Effect of irrigation and fertility levels on phenology, partitioning of biomass, yield and quality of radish (*Raphanus sativus* L.) seed crop. *Journal of Pharmacognosy and Phytochemistry*, **7**(1S), 3274-3279.

Singh, A., Rattan, P., & Sharma, N. (2021). Effect of date of sowing and spacing on growth and yield of radish (*Raphanus sativus* L.) cv. Pusa chetki. *Indian Journal Pureand Applied Bioscience*, **9**, 211-221.

Suminarti, N.E., Dewi, T.N., & Fajrin, A.N. (2020). The combined effect of volume water supply and varieties on physiological aspects, growth, and yield of red beetroot (*Beta vulgaris* L.) in dryland jatikerto, indonesia. *International Journal of Environment, Agriculture and Biotechnology*, **5** (2).

Thomas, T.H., Lister, J.N., Salter, P.J. (1972). Hormonal Changes in the stem apex of the cauliflower plant in relation to curd development. *J. Hort. Sci.,* **47**, 449-455.