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# Effect of consecutive sowings and spacing on growth and yield of radish

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**Abstract**
An experiment was conducted at College of Horticulture, Dapoli, Ratnagiri (Dist.), during the period Rabi season to study the effect of consecutive sowings and spacing on growth and yield of radish.The study was conducted with three consecutive sowings of radish viz. $C_1$- Sowing during second fortnight of October., $C_2$-Sowing during second fortnight of November and $C_3$- Sowing during second fortnight of December having four row spacings viz., $T_1$-20 cm spacing between two rows., $T_2$-30 cm spacing between two rows., $T_3$-40 cm spacing between two rows and $T_4$-Broadcasting. The results indicated that $C_3$ i.e.,sowing during second fortnight of December was performed better and found significantly superior over other sowing time in respect of plant height and yield per plot . However, days to germination, number of leaves, average leaf area, weight of plant and dry matter of leaves was found significantly superior in $C_1$i.e. Sowing during second fortnight of October. In respect of spacing, the wider spacing $T_1$ i.e. 20 cm row spacing was found significantly superior in plant height and dry matter of leaves, while average leaf area found significantly superior in $T_2$. In respect of interaction of consecutive sowings and spacing, the treatment combination $C_3T_3$ was found significantly superior in plant height and yield per plot. While average leaf area significantly superior in $C_3T_4$. Hence, the treatment $C_3T_3$ (December sowing with 40 cm row spacing) was found to be most profitable.

**Keywords:** Radish, consecutive sowings, spacings, yield

## Introduction
Radish (*Raphanus sativus* L.) is a member of Crucifer. It is a popular salad crop for home gardening and fresh market. The eastern Mediterranean region, China, and middle Asia are considered to be the Origin of Radish. Radish is a quick growing cool season root vegetable. Good source of Vitamin C, potassium and magnesium, plus trace amounts of other nutrients, for radishes supplies 5 kilocalories. World production of radish roots is estimated at 7 million ton per year, about 2% of the total world production of vegetables (Schippers 2004).
The average land holding of farmers in Konkan is very small and majority of farmers are marginal farmers. Moreover the available land is again scattered and are having scanty irrigation back up which is usually available up to January to February, afterwards the availability of irrigation water for growing crops. Considering all this limitation, farmer has to adapt intensive repeated cultivation by consecutive sowing of these crops in same piece of land. The effect of 6 such consecutive sowing on the growth of leafy vegetables have not been studied so for. In vegetables, spacing is a non-monetary input, but it plays a vital role by changing the magnitude of competition. There is a need to manipulate the row spacing to minimize competition and to increase the plant productivity especially in leafy vegetables. The competitive ability of a plant depends greatly upon the density of plants per unit area and soil fertility status (Shekhawat *et al*., 2012) [16].
Hence, considering the importance of these aspects the present investigation was taken on radish at College of Horticulture, Dapoli, Ratnagiri (Dist.) during the *rabi* season to determine the suitable sowing time and optimum spacing in order to have maximum vegetative growth and higher yield.

## Materials and Methods
A field experiment was conducted at Experimental field of College of Horticulture, Dapoli. Dist. Ratnagiri during rabi season, 2020-2021. The experiment was designed to study the effect of consecutive sowings and spacing on growth and yield of radish.

The experiment was laid out in a factorial randomised block design with three replications having 12 treatment combinations. The treatments comprised of the combination of three consecutive sowings ($C_1$- Sowing during second fortnight of October. $C_2$-Sowing during second fortnight of November and $C_3$- Sowing during second fortnight of December and four row spacings ($T_1$-20 cm spacing between two rows., $T_2$-30 cm spacing between two rows., $T_3$-40 cm spacing between two rows and $T_4$-Broadcasting)
The beds (3.6 m x 1.8 m) were prepared and fertilizers were applied to the experimental plot according to recommended dose. Seeds were sown in well-prepared land by opening small shallow furrows with pick axe. The furrows were made according to the spacing *i.e*., in $T_1$ plot, 20 cm spacing between rows was maintained due to which 18 rows were obtained likewise in $T_2$ (30 cm spacing between two rows) 12 rows and in $T_3$(40 cm spacing between two rows) 9 rows were obtained. In $T_4$ plot seeds were broadcasted uniformly. After emergence of seedling, other intercultural operations like weeding, irrigation were followed as per recommendation for better growth and development of the plant. The observations were recorded on growth and yield parameters and data was analyzed by using the standard methods as described by Panse and Sukhatme (1995) [10].

## Result and Discussion

### Days to germination

The data presented in Table 1 reported that days to germination was significantly influenced by sowing dates. The minimum days to germination were recorded in $C_1$ (2.60) and the maximum days to germination in $C_3$ (3.58). This may be due to decrease in minimum temperature during 3rd sowing as a result of which seed germination period was increased. Similar result of effect of temperature on germination were reported by Jyrwa *et al*. (2016) [3] and Prasad (2020) [12]. Regarding spacing, there were non-significant results observed on days to germination. The minimum days to germination were recorded in $T_1$ (2.80) while, maximum days to germination were recorded in $T_3$ (3.20). This might be due to the fact that different spacings took the same number of days to germinate because of factors like soil moisture, temperature, seed vigour and dormancy of seed which conventionally influence the days to germinate and germination percentage. This is in acceptance with the findings of Pervez *et al.,* (2004) [11] and Lavanya *et al*., (2017) [6]. Interaction between the consecutive sowing and row spacing on days to germination was found non-significant. The minimum days to germination were recorded in $C_1T_1$ (2.24) whereas, the maximum days to germination were recorded in $C_3T_3$ (4.10).

**Table 1:** Effect of consecutive sowing and row spacing on days to germination and plant height (cm) at harvest ofradish

| Consecutive Sowings | Days to germination | | | | | Plant Height at harvest (cm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Row Spacing | | | | | | | | | |
| | $T_1$ | $T_2$ | $T_3$ | $T_4$ | MEAN | $T_1$ | $T_2$ | $T_3$ | $T_4$ | MEAN |
| $C_1$ | 2.24 | 2.45 | 2.61 | 3.10 | 2.60 | 25.84 | 27.40 | 27.41 | 24.33 | 26.24 |
| $C_2$ | 2.80 | 2.86 | 2.88 | 2.99 | 2.88 | 26.50 | 23.51 | 24.64 | 25.62 | 25.07 |
| $C_3$ | 3.35 | 3.50 | 4.10 | 3.36 | 3.58 | 31.47 | 31.78 | 32.63 | 29.51 | 31.35 |
| MEAN | 2.80 | 2.94 | 3.20 | 3.15 | 2.94 | 27.93 | 27.57 | 28.23 | 26.48 | 27.55 |
| | S.E.m± | | CD at 5% | | F-test | S.E.m± | | CD at 5% | | F-test |
| C | 0.08 | | 0.24 | | SIG | 0.38 | | 1.11 | | SIG |
| T | 0.10 | | 0.28 | | NS | 0.44 | | 1.28 | | SIG |
| CXT | 0.17 | | 0.49 | | NS | 0.76 | | 2.22 | | SIG |

### Plant height

Consecutive sowing had significant influenced on the plant height of radish at harvest. The treatment $C_3$ (31.35 cm) recorded maximum plant height whereas, the minimum plant height was recorded by $C_2$ (25.07 cm). It might be due to the reason that the radish is a cool season crop, so cooler temperatures may lead to more vigorous vegetative growth. Similar variation in effect of consecutive sowings on plant height of radish obtained by Salam *et al*., (1999) [14] and Sahu G. (2018) [13]. The plant height was found significant due to different spacings. The maximum plant height was recorded in $T_3$ (28.23 cm) which was at par with $T_1$ (27.93 cm) whereas, the minimum was recorded in $T_4$ (26.48cm). This might be due to the availability of adequate moisture, plant nutrient, space and other growth promoting factor was more in wider spacing. Similar results were also reported by Okut *et al*. (2005) [9] in coriander and Bairagi (2014) [1] in fenugreek. The interaction effect of consecutive sowings and spacing showed significant variation on plant height. The maximum plant height of radish was recorded in $C_3T_3$ (32.78 cm) which was at par with $C_3T_2$ (32.63 cm) and the minimum was recorded in $C_2T_2$ (23.51 cm).

### Number of leaves

It is presented that the effect of consecutive sowings on number of leaves was found significant the treatment $C_1$ (7.57) recorded highest number of leaves whereas, the minimum number of leaves was recorded by $C_3$ (6.25).Non-significant variation was found in respect of number of leaves by different row spacing. However, the maximum number of leaves were recorded in $T_4$ (7.33) and the minimum were recorded in $T_2$ (6.87).The interaction effect between consecutive sowing and spacing on number of leaves was found to non-significant. The maximum number of leaves of radish were recorded in $C_1T_1$ (7.93) whereas, the minimum was recorded in $C_3T_2$ (5.96).Similar results were obtained by Prasad (2020) [12] in amaranthus.

**Table 2:** Effect of consecutive sowing and row spacing on number of leaves at harvest and leaf area ($cm^2$) at harvest of radish

| Consecutive Sowings | Number of leaves (at harvest) | | | | | Average leaf area ($cm^2$) at harvest | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Row Spacing | | | | | | | | | |
| | $T_1$ | $T_2$ | $T_3$ | $T_4$ | MEAN | $T_1$ | $T_2$ | $T_3$ | $T_4$ | MEAN |
| $C_1$ | 7.93 | 7.86 | 6.68 | 7.81 | 7.57 | 450.08 | 565.26 | 431.71 | 268.49 | 428.88 |
| $C_2$ | 7.83 | 6.79 | 7.52 | 7.66 | 7.45 | 562.35 | 530.91 | 552.94 | 496.94 | 535.79 |
| $C_3$ | 6.08 | 5.96 | 6.44 | 6.51 | 6.25 | 551.57 | 546.21 | 463.12 | 581.97 | 535.72 |
| MEAN | 7.28 | 6.87 | 6.88 | 7.33 | 7.09 | 521.33 | 547.46 | 482.59 | 449.13 | 500.13 |
| | S.E. m± | | CD at 5% | | F-test | S.E. m± | | CD at 5% | | F-test |
| C | 0.13 | | 0.37 | | SIG | 20.50 | | 60.12 | | SIG |
| T | 0.15 | | 0.43 | | NS | 23.67 | | 69.42 | | SIG |
| CXT | 0.25 | | 0.74 | | NS | 41.00 | | 120.25 | | SIG |

**Average leaf area**

Average leaf area under study varied significantly due to consecutive sowing.The treatment $C_2$ (535.79 $cm^2$) recorded significantly maximum average leaf area, but remained at par with $C_3$ (535.72 $cm^2$) whereas, the minimum was recorded by $C_1$ (428.88 $cm^2$). The effect of spacing on average leaf area of radish was found to be significant. The maximum average leaf area of radish was recorded in $T_2$ (547.46 $cm^2$) and the minimum was recorded in $T_4$ (449.13 $cm^2$).The interaction between consecutive sowings and spacing showed significant effect on average leaf area of radish. The maximum average leaf area of radish was recorded in $C_3T_4$ (581.97 $cm^2$) whereas, the minimum was recorded in $C_1T_4$ (268.49 $cm^2$).

The maximum leaf area with respect to time of sowing might be attributed due to cooler temperatures may lead to more vigorous vegetative growth further with respect to spacing the maximum girth of plant reported with treatment $T_3$ can be attributed to space availability for the growth of plant irrespective time of sowing. The similar trends of also been represented in interaction effect of month of sowing and spacing. The results are close conformity with Lavanya *et al*. (2017) [6] in radish and Prasad (2020) [12] in amaranthus.

**Weight of plant**

Weight of the plant at harvest was significantly differed by consecutive sowings. The maximum plant weight of radish was observed in $C_1$ (45.17 g) while, the minimum plant weight was recorded in $C_3$ (40.01 g).Different row spacing showed significant variation on the weight of the plant. The maximum weight of plant in radish was recorded in $T_3$ (41.48 g) and the minimum weight of plant was recorded in $T_4$ (39.08 g). The interaction effect between consecutive sowings and spacing on plant weight of radish was found to be statistically significant. The maximum plant weight was recorded in $C_2T_3$ (48.77 g) which was at par with $C_3T_3$ (48.74 g) whereas, the minimum plant weight was recorded in $C_3T_1$ (36.06 g).

The maximum weight of plant of radish with respect to time of sowing might be attributed due to availability of more nutrients during first sowing which might have decreased during subsequent sowing as the crop was grown in same piece of land and due to rapid growth and favourable environmental condition during December further with respect to spacing the maximum weight of plant reported with treatment $T_3$ can be attributed to the space availability for the growth of plant and less competition for nutrient, sunlight and aeration. The similar trends also been reported in interaction effect of month of sowing and spacing. Similar results also reported by Sharma *et al.* (2016) [15] in coriander and Islam *et al.* (2014) [2] in Indian spinach.

**Table 3:** Effect of consecutive sowing and row spacing on weight of plant at harvest and yield per plot of radish

| Consecutive Sowings | Weight of plant (g) | | | | | Yield per plot (kg/plot) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Row Spacing | | | | | | | | | |
| | $T_1$ | $T_2$ | $T_3$ | $T_4$ | MEAN | $T_1$ | $T_2$ | $T_3$ | $T_4$ | MEAN |
| $C_1$ | 45.12 | 42.44 | 47.94 | 45.16 | 45.17 | 15.80 | 16.12 | 17.06 | 8.90 | 14.47 |
| $C_2$ | 36.98 | 39.30 | 48.77 | 36.05 | 40.28 | 18.14 | 19.27 | 19.21 | 6.61 | 15.80 |
| $C_3$ | 36.00 | 39.28 | 48.74 | 36.03 | 40.01 | 18.50 | 16.12 | 20.71 | 15.00 | 17.58 |
| MEAN | 39.37 | 40.34 | 48.48 | 39.08 | 41.82 | 17.48 | 17.17 | 18.99 | 10.17 | 15.95 |
| | S.E.m± | | CD at 5% | | F-test | S.E.m± | | CD at 5% | | F-test |
| C | 0.58 | | 1.71 | | SIG | 0.43 | | 1.26 | | SIG |
| T | 0.67 | | 1.98 | | SIG | 0.50 | | 1.46 | | SIG |
| CXT | 1.17 | | 3.43 | | SIG | 0.86 | | 2.52 | | SIG |

**Yield per plot**

The yield per plot significantly differ by consecutive sowings.The maximum yield per plot of radish was observed in $C_3$ (17.58 kg) and the minimum was recorded in $C_1$ (14.47 kg).The effect of different spacing significantly influenced in respect of yield per plot. The maximum yield per plot was recorded in $T_3$ (18.99 kg) whereas, the minimum was recorded in $T_4$ (10.17 kg). Similar variation in results obtained by Tahsin (2010) [17]. The interaction effect between consecutive sowings and spacing on yield per plot of radish was found to be significant. The maximum yield per plot was recorded in $C_3T_3$ (20.71 kg) whereas the minimum was recorded in $C_2T_4$ (6.61 kg).Similar results are obtained by Prasad (2020) [12].

The maximum yield per plot of radish with respect to time of sowing might be attributed due to cooler temperatures may lead to more vigorous vegetative growth further with respect to spacing the maximum yield per plot reported with treatment $T_3$ can be attributed to space availability and favourable environmental conditions for growth and development of plant irrespective time of sowing. The Similar trends of also been represented in interaction effect of month of sowing and spacing.

**Dry matter of leaves (%)**

The effect of consecutive sowings on dry matter of leaves of radish was found to be significant. The maximum dry matter of leaves of radish was observed in $C_1$ (6.91 %) and the minimum was recorded in $C_2$ (5.47 %). Similar variation in results is obtained by Khan (2011) in carrot and Prasad (2020) [12] in radish. The spacing showed the non-significant effect on the dry matter of leaves of radish. The maximum dry matter of leaves was recorded in $T_1$ (6.34 %) and the minimum was recorded in $T_2$ (5.64 %).It is evident from the data the interaction effect between consecutive sowings and spacing on dry matter of leaves of radish was found to be non-significant. However, the maximum dry matter of leaves of radish was recorded in $C_1T_1$ (8.01 %) and the minimum was recorded in $C_2T_2$ (5.14 %) and $C_3T_1$ (5.14 %). The similar results obtained by Kabir *et al*. (2013) [4] and Islam *et al*. (2014) [2].

The maximum dry matter of leaves (%) with respect to time of sowing might be attributed due to availability of more nutrients during first sowing which might have decreased during subsequent sowing as the crop was grown in same piece of landand due to congenial climatic conditions further with respect to spacing the maximum dry matter of leaves reported with treatment $T_3$ can be attributed to the plant receives enough light and nutrients which leads to maximum assimilation of nutrients that leads to attain highest dry matter content of plant in wider spacing. The similar trends also been reported in interaction effect of month of sowing and spacing.

**Table 4:** Effect of consecutive sowing and row spacing on dry matter of leaves (%) of radish

| Consecutive Sowings | Dry matter of leaves (%) | | | | |
|---|---|---|---|---|---|
| | Row Spacing | | | | |
| | $T_1$ | $T_2$ | $T_3$ | $T_4$ | MEAN |
| $C_1$ | 8.01 | 5.98 | 6.66 | 6.98 | 6.91 |
| $C_2$ | 5.88 | 5.14 | 5.33 | 5.54 | 5.47 |
| $C_3$ | 5.14 | 5.80 | 6.50 | 6.10 | 5.89 |
| MEAN | 6.34 | 5.64 | 6.16 | 6.21 | 6.09 |
| | S.E.m± | | CD at 5% | | F-test |
| C | 0.14 | | 0.42 | | SIG |
| T | 0.17 | | 0.49 | | NS |
| CXT | 0.29 | | 0.85 | | NS |

**Table 5:** Comparative economics of radish cultivation

| Consecutive Sowings | B.C ratio | | | | |
|---|---|---|---|---|---|
| | Row Spacing | | | | |
| | $T_1$ | $T_2$ | $T_3$ | $T_4$ | MEAN |
| $C_1$ | 2.23 | 2.27 | 2.55 | 1.16 | 2.05 |
| $C_2$ | 2.46 | 2.38 | 2.74 | 1.00 | 2.15 |
| $C_3$ | 2.62 | 2.52 | 2.90 | 2.12 | 2.54 |
| MEAN | 2.44 | 2.39 | 2.73 | 1.43 | 2.25 |

**Economic analysis (B.C ratio)**

The data showed that the treatment $C_3$ (sowing during second fortnight of December) was found to be the economically profitable with respect to different sowing months whereas, the different spacing treatment $T_3$*i.e.* (40 cm spacing between two rows) was recorded highest BC ratio. Considering the interaction effect of different sowing months and spacing the treatment $C_3T_3$ (sowing during second fortnight of December with 40 cm row spacing) was found economically best.

**Conclusion**

Based on the present investigation, it may be concluded that the treatment $C_3$ (sowing during second fortnight of December) was found to be the most profitable with respect to different sowing months whereas, the different spacing treatment $T_3$*i.e.* (40 cm spacing between two rows) was found to be the most profitable. Considering the interaction effect of different sowing months and spacing the treatment $C_3T_3$ (December sowing with 40 cm row spacing) was found to be most profitable.

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