**Study on effect of transplanting time and varieties on growth parameters of knolkhol (*Brassica oleracea var. gongylodes*) in baratract geographical belt of Southern Gujarat**

**Abstract**

The experiment was carried out for two consecutive years during 2022-23 and 2023-24, to study the effects of various transplanting time and varieties on growth parameters of knolkhol. The experiment was conducted at Horticulture Nursery Farm, College of Agriculture, Navsari Agricultural University Campus Bharuch, Gujarat (India), during the Rabi seasons of year 2022 and 2023.The experiment was laid out in Split Plot Design (SPD), which included twelve treatments consisting of combination of three time of transplanting (T1: 1st week of November, T2: 3rd week of November, T3: 1st week of December) and four varieties (V1: Purple Vienna, V2: Pusa Virat, V3: Early White Vienna and V4: White Vienna). All the twelve treatment combinations transplanted with four replications. The result revealed that the treatment 3rd week of November transplanting recorded maximum plant height (27.42 cm, 27.06 cm and 27.24 cm), plant spread East–West (38.66 cm, 37.95 cm and 38.04 cm), plant spread North–South (36.61 cm, 37.68 cm and 36.95 cm) and leaf area (272.58 cm², 271.61 cm² and 272.09 cm²). While for the different varieties, White Vienna (V4) had maximum plant height (26.90 cm, 26.54 cm, 26.72 cm), plant spread N-S (35.91 cm, 36.93 cm, 36.42 cm), plant spread E-W (37.98 cm, 37.23 cm, 37.61 cm) and leaf area (265.41 cm², 266.87 cm², 266.14 cm²) in 2022–23, 2023–24, and pooled means respectively.

**Key words:** Growth, Transplanting time, Varieties, Knolkhol

**Introduction:**

Cole crops, a vital group of vegetables within the family *Brassicaceae*, include economically important species such as cabbage (*Brassica oleracea* var. *capitata*), cauliflower (*B. oleracea* var. *botrytis*), broccoli (*B. oleracea* var. *italica*) and knolkhol (*B. oleracea* var. *gongylodes*). These crops are cultivated globally due to their high nutritional value, versatility in culinary applications and significant contribution to food and nutritional security. Among these, knolkhol (also known as kohlrabi or *ganthgobi* in Hindi) is a lesser-known but highly nutritious and fast-maturing member of the group. Taxonomically classified as *Brassica oleracea* var. *gongylodes* L., it is a biennial herbaceous plant grown annually for its edible, enlarged stem, commonly referred to as the “knob.” Knolkhol is recognized not only for its widely adaptable and short growing period but also for its remarkable nutritional and medicinal properties. This knob is harvested for human consumption as raw or cooked vegetable for making salad and pickles, young leaves are also cooked as vegetable (Talukder *et al*., 2013). Knolkhol has enormous nutritional and medicinal values. The crop has tremendous medicinal properties like, acidosis, asthma, cancer, cholesterol level, heart problems, indigestion, muscle and nerve functions, prostate and colon cancer, skin problems, weight loss *etc*. (Chauhan *et al*., 2016). The presence of sulforaphane and other isothiocyanates which act as anti-oxidant and are believed to stimulate the production of protective enzyme in the body (Mishra *et al.*, 2012). Time of transplanting is one of the important factors influence on the growth, yield and quality of crop. Atmospheric factors affects adversely on growth of the crop. Timely transplanting ensures that the knolkhol crop experiences optimal environmental conditions during its vegetative and knob development stages, promoting vigorous growth, efficient nutrient utilization and enhanced knob formation. Varietal selection plays a vital role in knolkhol cultivation, as different varieties vary in their adaptability, growth duration, yield potential and quality characteristics. The performance of a variety is influenced by local agro-climatic conditions, making it essential to choose one that is well-suited to the specific environment. Gujarat particularly in South Gujarat official records on knolkhol cultivation remain scant, although the agro-climatic conditions of the region are conducive to its successful production. The increasing interest in protected cultivation and government subsidies for vegetable crops further enhance the scope for expanding knolkhol cultivation in non-traditional areas.

**Materials and methods**

The present study was carried out at Horticulture Nursery Farm (latitude of 22° N and a longitude of 72.5° E, with an altitude of 16.5 meters above the mean sea level), College of Agriculture, Navsari Agricultural University, Campus Bharuch during *Rabi*, 2022-23 and 2023-24. The experiment was laid out in Split Plot Design (SPD), which comprised three transplanting time treatments in main plot namely, T1: 1st week of November, T2: 3rd week of November, T3: 1st week of December and four varieties in sub plot namely, V1: Purple Vienna, V2: Pusa Virat, V3: Early White Vienna and V4: White Vienna. All the twelve treatment combinations repeated four times. The seeds of each varieties was sown one month before transplanting. One month old with 8-10 cm healthy seedlings were used for main field transplant. The transplanting was carried out at three different times to study the effect of transplanting date on the growth, yield, and quality of knolkhol. As per treatments, the transplanting was done on 2nd November, 16th November, and 2nd December during 2022-23 and 4th November, 18th November, and 4th December during 2023-24. The selected seedlings were carefully transplanted into the field, ensuring proper spacing and depth to promote healthy root establishment. During Rabi 2022–23 and 2023–24, the meteorological parameters were recorded at the Agrometeorological Observatory, Regional Cotton Research Station, NAU, Bharuch. In 2022–23, the mean monthly maximum and minimum temperatures ranged from 28.8°C to 37.0°C and 9.0°C to 24.8°C, respectively, with relative humidity varying between 22.1% and 75.7%. Except for 58 mm of rainfall recorded during the second week of October, no significant precipitation occurred, resulting in a total seasonal rainfall of 58.0 mm across 1 rainy day. During 2023–24, the maximum and minimum temperatures ranged from 27.0°C to 38.8°C and 13.0°C to 25.2°C, respectively, with relative humidity between 30.7% and 59.05%. Rainfall events were limited to 47 mm in November and 8.2 mm in early December, contributing to a total of 55.2 mm over 2 rainy days during the season.

**Result and discussion**

**Plant Height (cm)**

The data presented in Table 1 indicates that transplanting time and varietal differences significantly influenced the plant height of knolkhol during both 2022–23 and 2023–24 seasons, as well as in pooled analysis. However, the interaction between transplanting time and varieties was found non-significant. The plant height of knolkhol was recorded at the time of final harvest. Among the transplanting times, T₂ (3rd week of November) recorded the maximum plant height (27.42 cm in 2022–23, 27.06 cm in 2023–24, and pooled mean of 27.24 cm), which was significantly superior over T₁ (1st week of November) and T₃ (1st week of December). The minimum plant height was observed in T₃, with pooled average of 23.98 cm. This enhanced plant growth under T₂ might be due to more favorable agro-climatic conditions such as optimum temperature, better light interception, and appropriate soil moisture prevailing during the third week of November. These factors possibly enhanced vegetative growth and photosynthetic activity during the early establishment phase. Similar trends were also reported by Kumar *et al*. (2020), who observed significantly taller plants of knolkhol when transplanted in mid-November under North Indian plains due to congenial environmental conditions. With respect to varieties, White Vienna (V₄) exhibited the maximum plant height (26.90 cm in 2022–23, 26.54 cm in 2023–24, and 26.72 cm pooled), which was significantly superior to all other varieties tested. The minimum height was recorded in Pusa Virat (V₂) with a pooled mean of 24.36 cm. The superior performance of White Vienna may be attributed to its genetic potential for vigorous growth, efficient resource utilization, and better adaptability to local agro-ecological conditions. This finding is in agreement with the reports of Hossain *et al*. (2011) in broccoli, Ara *et al.* (2009), Yadav *et al*. (2013) in cauliflower, Uddain *et al.*, (2012) in kholrabi and Singh (2010) in cabbage.

Although the interaction effect between transplanting time and variety was statistically non-significant, numerically higher plant height was consistently observed in White Vienna when transplanted during the 3rd week of November, further confirming the synergistic influence of optimal planting window and genotype.

**Plant Spread (North–South) (cm)**

The results presented in Table 1 revealed that transplanting time and varietal differences had a significant influence on the North–South plant spread of knolkhol during both years of study (2022–23 and 2023–24) as well as in pooled analysis. However, the interaction between transplanting time and varieties was statistically non-significant. At the time of final harvest, the plant spread of knolkhol was measured from the net plot area of each treatment. The measurement was taken in centimeters using a meter scale, by recording the distance between the tips of the outermost leaves in two perpendicular directions North-South (N-S). The average plant spread in each direction was then computed and recorded for further analysis.  
Among the transplanting times, the 3rd week of November (T₂) recorded the maximum plant spread (36.61 cm in 2022–23, 37.68 cm in 2023–24, and 36.95 cm pooled), which was significantly superior to both early (T₁ – 1st week of November) and late (T₃ – 1st week of December) transplanting. The minimum plant spread was recorded in T₃ with a pooled average of 32.76 cm. This increase in horizontal canopy expansion under T₂ might be due to better synchronization between crop growth stages and prevailing environmental conditions, such as optimal temperature, humidity, and solar radiation, which enhance leaf development and laminar expansion. Similar findings were reported by Verma *et al*. (2019), who observed maximum plant spread in knolkhol when transplanted during the mid-November period, attributing it to improved microclimatic suitability for vegetative growth. The wider plant spread under timely transplanting may also be due to efficient nutrient uptake and enhanced leaf area, supporting greater photosynthetic activity and biomass accumulation. Regarding varietal performance, White Vienna (V₄) showed significantly wider plant spread (35.91 cm in 2022–23, 36.93 cm in 2023–24, and pooled mean of 36.42 cm) compared to the other varieties. The minimum spread was noted in Pusa Virat (V₂) with a pooled mean of 33.33 cm. The superior spreading habit of White Vienna could be attributed to its genetic vigor and strong apical growth, leading to enhanced lateral expansion and robust plant architecture. These findings are supported by Ngullie *et al*. (2014) in broccoli.

Though the interaction between transplanting time and variety was not significant, a consistent trend of maximum spread was observed when White Vienna was transplanted in the 3rd week of November, indicating a promising genotype × environment combination for optimal vegetative development.

**Table 1: Effect of transplanting time and varieties on plant height and Plant spread**

**(N-S) (cm) of knolkhol**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Treatments** | **Plant Height (cm)** | | | **Plant spread (N-S) (cm)** | | |
| **2022-23** | **2023-24** | **Pooled** | **2022-23** | **2023-24** | **Pooled** |
| **Transplanting time (T)** | | | | | | |
| T1 :1st week of November | 24.25 | 23.93 | 24.09 | 32.38 | 33.40 | 32.89 |
| T2 : 3rd week of November | 27.42 | 27.06 | 27.24 | 36.61 | 37.68 | 36.95 |
| T3 : 1st week of December | 24.16 | 23.81 | 23.98 | 32.25 | 33.27 | 32.76 |
| S.Em. ± | 0.43 | 0.43 | 0.30 | 0.57 | 0.56 | 0.39 |
| C. D. at 5% | 1.49 | 1.48 | 0.94 | 1.99 | 1.95 | 1.20 |
| C.V. % | 6.81 | 6.88 | 6.85 | 6.81 | 6.50 | 6.46 |
| **Varieties (V)** | | | | | | |
| V1 : Purple Vienna | 24.83 | 24.58 | 24.70 | 33.15 | 34.19 | 33.41 |
| V2 : Pusa Virat | 24.58 | 24.15 | 24.36 | 32.82 | 33.85 | 33.33 |
| V3 : Early White Vienna | 24.80 | 24.48 | 24.64 | 33.11 | 34.15 | 33.63 |
| V4 : White Vienna | 26.90 | 26.54 | 26.72 | 35.91 | 36.93 | 36.42 |
| S.Em. ± | 0.45 | 0.44 | 0.31 | 0.60 | 0.63 | 0.43 |
| C. D. at 5% | 1.31 | 1.27 | 0.89 | 1.75 | 1.82 | 1.22 |
| **Interaction effect (T×V)** | | | | | | |
| S.Em. ± | 0.78 | 0.76 | 0.54 | 1.05 | 1.09 | 0.74 |
| C. D. at 5% | NS | NS | NS | NS | NS | NS |
| CV % | 6.20 | 6.07 | 6.13 | 6.20 | 6.26 | 6.14 |
| **Pooled interaction** | | | | | | |
| Source | Y×T | Y×V | Y×T×V | Y×T | Y×V | Y×T×V |
| S.Em. ± | 0.43 | 0.44 | 0.76 | 0.55 | 0.60 | 1.05 |
| C. D. at 5% | NS | NS | NS | NS | NS | NS |

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|  |
| **Fig. 1: Effect of transplanting time and varieties on plant height** |
|  |
| **Fig. 2: Effect of transplanting time and varieties on plant spread (N-S)** |

**Plant Spread (East–West) (cm)**

The data in Table 2 clearly indicate that transplanting time and varietal differences significantly influenced the East–West plant spread of knolkhol during both 2022–23 and 2023–24 seasons, as well as in the pooled analysis. However, the interaction between transplanting time and variety was statistically non-significant. Among the transplanting times, the 3rd week of November (T₂) resulted in the maximum plant spread (38.66 cm in 2022–23, 37.95 cm in 2023–24, and 38.04 cm pooled), which was significantly higher than the spread observed under both early (T₁) and late (T₃) transplanting. The minimum spread was recorded under T₃ (pooled: 33.73 cm). The enhanced lateral spread under T₂ could be attributed to favorable agro-climatic conditions such as moderate temperatures, optimal radiation, and adequate moisture availability during the early vegetative phase, promoting robust leaf expansion and canopy development. These findings are in agreement with those of Kumar *et al.* (2021), who reported increased canopy spread in cole crops when transplanted in mid-November due to synchronization with conducive environmental conditions, where timely transplanting promoted vegetative growth through improved photosynthetic activity. With regard to varietal performance, White Vienna (V₄) exhibited the widest E–W plant spread (37.98 cm in 2022–23, 37.23 cm in 2023–24, and 37.61 cm pooled), which was significantly superior to the other varieties. Pusa Virat (V₂) recorded the least spread (pooled: 34.26 cm). The superior performance of White Vienna may be attributed to its genetic potential for vigorous vegetative growth, wider leaf lamina, and greater adaptability to prevailing environmental conditions. These results are consistent with the findings of Olaniyi *et al.* (2011) in cabbage.

Although the interaction between transplanting time and varieties was statistically non-significant, the data revealed that the widest E–W spread was consistently observed when White Vienna was transplanted in the 3rd week of November, indicating a promising genotype × environment combination for enhanced vegetative development.

**Leaf Area (cm²)**

The leaf area of knolkhol was significantly influenced by transplanting time and varietal differences across both years of study and in the pooled data (Table 2). However, the interaction between transplanting time and varieties was statistically non-significant. Leaf area was measured at final harvest to assess the effect of different treatments on knolkhol plants. Fully expanded mature leaves were collected from the plants, and their surface area was determined using a Leaf Area Meter (Model: Systromics Leaf Area Meter 211), which provides an accurate and non-destructive measurement. The area of each individual leaf was recorded and summed to obtain the total leaf area per plant. The mean leaf area was then calculated and expressed in square centimeters (cm²).

Among the transplanting times, the 3rd week of November (T₂) recorded the maximum leaf area, with 272.58 cm² in 2022–23, 271.61 cm² in 2023–24, and 272.09 cm² in pooled analysis. This was significantly superior to both early (T₁) and late (T₃) transplanting times. The minimum leaf area was observed under the 1st week of December transplanting (T₃) with a pooled mean of 238.79 cm². The superior performance under T₂ may be attributed to optimal climatic conditions such as moderate temperatures, increased photosynthetically active radiation, and favorable soil moisture during early plant development, which enhance physiological activity and leaf expansion. In terms of varieties, White Vienna (V₄) exhibited significantly greater leaf area (265.41 cm² in 2022–23, 266.87 cm² in 2023–24, and 266.14 cm² pooled) compared to other varieties. The lowest leaf area was recorded in Pusa Virat (V₂) with a pooled mean of 243.33 cm². The superior performance of White Vienna may be due to its genetic potential for vigorous vegetative growth, broader leaf lamina, and higher chlorophyll content, which enhance radiation interception and photosynthetic assimilation. Similar findings were reported by Cebula *et al.* (1996) in white cabbage, Hossain *et al*. (2011) in broccoli and Ozbakir *et al.* (2009) in knolkhol, who highlighted the superior vegetative vigour and leaf development in White Vienna under varied climatic conditions.

Although the T × V interaction was not statistically significant, the combination of White Vienna with 3rd week of November transplanting consistently produced the highest leaf area, indicating a favorable genotype × environment response for maximizing canopy development in knolkhol.

**Table 2: Effect of transplanting time and varieties on plant spread (E-W) and leaf area**

**of knolkhol**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Treatments** | **Plant spread (E-W) (cm)** | | | **Leaf area (cm²)** | | |
| **2022-23** | **2023-24** | **Pooled** | **2022-23** | **2023-24** | **Pooled** |
| **Transplanting time (T)** | | | | | | |
| T1 :1st week of November | 34.24 | 33.57 | 33.91 | 240.83 | 240.16 | 240.50 |
| T2 : 3rd week of November | 38.66 | 37.95 | 38.04 | 272.58 | 271.61 | 272.09 |
| T3 : 1st week of December | 34.06 | 33.39 | 33.73 | 238.68 | 238.91 | 238.79 |
| S.Em. ± | 0.64 | 0.60 | 0.43 | 4.71 | 4.33 | 3.24 |
| C. D. at 5% | 2.20 | 2.08 | 1.32 | 16.30 | 14.99 | 10.00 |
| C.V. % | 7.14 | 6.88 | 6.88 | 7.52 | 6.92 | 7.33 |
| **Varieties (V)** | | | | | | |
| V1 : Purple Vienna | 35.01 | 34.47 | 34.38 | 246.82 | 246.59 | 246.71 |
| V2 : Pusa Virat | 34.66 | 33.87 | 34.26 | 244.36 | 242.29 | 243.33 |
| V3 : Early White Vienna | 34.97 | 34.33 | 34.65 | 246.19 | 245.17 | 245.68 |
| V4 : White Vienna | 37.98 | 37.23 | 37.61 | 265.41 | 266.87 | 266.14 |
| S.Em. ± | 0.59 | 0.61 | 0.42 | 4.14 | 4.33 | 3.00 |
| C. D. at 5% | 1.71 | 1.78 | 1.18 | 12.02 | 12.58 | 8.50 |
| **Interaction effect (T×V)** | | | | | | |
| S.Em. ± | 1.02 | 1.06 | 0.72 | 7.17 | 7.51 | 5.19 |
| C. D. at 5% | NS | NS | NS | NS | NS | NS |
| CV % | 5.71 | 6.07 | 5.80 | 5.72 | 6.00 | 5.86 |
| **Pooled interaction** | | | | | | |
| Source | Y×T | Y×V | Y×T×V | Y×T | Y×V | Y×T×V |
| S.Em. ± | 0.60 | 0.58 | 1.02 | 4.58 | 4.23 | 7.34 |
| C. D. at 5% | NS | NS | NS | NS | NS | NS |

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| **Fig. 3: Effect of transplanting time and varieties on plant spread (E-W)** |

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|  |
| **Fig. 4: Effect of transplanting time and varieties on leaf area (cm²)** |

**Summary and conclusions**

It is concluded from the two years study that transplanting of knolkhol during the 3rd week of November significantly enhanced the vegetative growth attributes such as plant height, plant spread (north-south and east-west), and leaf area. The variety White Vienna was also found superior in terms of growth performance across all studied parameters. The treatment combination of 3rd week of November transplanting and White Vienna variety was found best in terms of maximum plant height (27.24 cm), plant spread (N–S: 36.95 cm, E–W: 38.04 cm), and leaf area (266.14 cm²).

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