Response of Turnip to Sowing Dates and Phosphorus Levels

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The present experiment entitled "Response of turnip to sowing dates and phosphorus levels" was conducted during (2020-2021) at the Horticulture Research Farm, The University of Agriculture, Peshawar. The experiment was carried out using a Randomized Complete Block Design with a split-plot arrangement having three replications. Different sowing date's i.e., (1st, 15th, 30th October), were taken in the main plot while phosphorus levels, i.e., (0, 25, 50, 75, and 100 kg ha^{-1}), were taken in the sub plot. The data was observed on days to emergence, number of leaves, leaves weight, root length, root weight, root diameter, yield plot^{-1}, and yield (tons ha^{-1}). Sowing dates and phosphorus levels have significantly affected all the studied parameters. Maximum number of leaves plant^{-1} (13), leaves weight (172.8 g), root length (12.8 cm), root weight (206.1 g), root diameters (8.9 cm), yield plot^{-1} (9.4 kg), and yield (20.1 tons ha^{-1}) with minimum days to emergence (4) were recorded in plants sown on 1st October. Highest number of leaves (14), leaves weight (177.9 g), root length (14 cm), root weight (213.6 g), root diameters (9.4 cm), highest yield plot^{-1} (10.1 kg) and yield (21.8 tons ha^{-1}) with minimum days to emergence (5) were recorded in plants treated with phosphorus at 100 kg ha^{-1}. The interaction between sowing dates and phosphorus levels was found to be non-significant. It is concluded that seed sown on (1st October) and phosphorus levels (100 kg ha^{-1}) have significantly improved the growth and yield parameters of turnip and hence are recommended for turnip growers in Peshawar.

Keywords: Turnip (*Brassica Rapa L.*), Sowing Dates, Phosphorus Levels, Root Length, Yield.

Introduction:

Turnip (*Brassica Rapa L.*) is a nutritious and flavorful root vegetable belonging to the Crucifereae family. It is one of the most widely recognized species of this family and is believed to have originated in Europe and West Asia, where it was also extensively cultivated [1]. It is primarily cultivated in temperate regions, where larger varieties are typically grown for animal feed, while numerous other types are mainly cultivated for human consumption [2]. Turnip contains calcium, iron, protein, carbohydrates, vitamins A, B, and C [3]. The climatic conditions of Khyber Pakhtunkhwa (KPK) are highly suitable for turnip cultivation, offering significant potential for growers in the region [4].

Turnip cultivation is predominantly concentrated in the plain region of Pakistan [5]. During 2019-2020, Pakistan produced approximately 275,686 tonnes of turnip across an area of 15,780 hectares. In Khyber Pakhtunkhwa (KPK), turnips were cultivated on 1,579 hectares, yielding a total production of 18,495 tons [6]. Achieving high yield and quality in any crop requires effective management practices that ensure the proper application of all essential nutrients in appropriate amounts. Turnips grow in fertile, clay-loam soil because they need a lot of nutrients to promote rapid development in a short length of time. The growth and development of vegetable crops require significant quantities of nutrients. Using fewer nutrients during the plant's early development stage results in reduced growth [7].

Turnips have a relatively short growing season; therefore, the use of water-soluble fertilizers, particularly those containing phosphorus, is recommended. Phosphorus is a vital macronutrients that play a key role in promoting healthy plant growth and development [8]. Phosphorus enhances the growth of roots, flowers, seeds, and strong stems. Additionally, phosphorus encourages the development of crop uniformity, early maturity, and disease resistance [8]. A deficiency of phosphorus hinders plant growth and delays maturity, ultimately reducing overall development and productivity [9][10]. Higher phosphorus levels are necessary for turnips and tuberous root development [11]. Phosphorus had a major role in early root development and plant maturity [12]. It also enhances seed production, leaf area, and contributes to greater dry matter accumulation [13]. However, a soil's ability to retain nutrients depends on several factors, with balanced fertilizer application being one of the most important. The right amount of fertilizer helps a crop grow and develop while also ensuring that other vital nutrients are available to the plant [14]. The phosphorus requirements of plants vary depending on the nutrient content of the soil. A deficiency of phosphorus restricts plant growth, resulting in stunted and immature development [15].

After nitrogen, phosphorus is the second most important nutrient limiting plant growth and productivity. It is also widely recognized that phosphorus enhances a plant's tolerance to drought stress and helps mitigate the adverse effects of dry conditions. The fundamental issue with plants in dry period stress conditions is their insufficient absorption of P from soils [16]. Phosphorus helps reduce the severity of drought stress through various mechanisms, including the stimulation of root system development. However, due to the formation of insoluble complexes with iron, aluminum, and calcium, approximately 75-90% of the phosphorus applied as chemical fertilizer in agro-ecosystems remains unavailable to plants [17]. Phosphorus plays an important function in the creation of energy-rich compounds, including AMP, ADP, and ATP, which are necessary for photosynthesis and respiration [18].

Objectives:

The present experiment aimed to determine the optimal sowing time and appropriate phosphorus levels for achieving maximum growth, production, and yield of turnip. To study the interactive effects of sowing time and phosphorus levels on the growth and yield of turnip.

Novelty Statement:

Turnip cultivar "Purple top" sown on 1st October showed better growth and seed yield by the application of Phosphorus at the rate of 100 kg ha$^{-1,}$ and hence recommended for climate change and growers of district Peshawar. Further research is suggested using other turnip cultivars, sowing dates, and phosphorus levels above 100 kg.

Materials and Methods:

Experimental Site Characteristics:

A field experiment on the response of turnip to different sowing dates and phosphorus levels was conducted at Horticulture Research Farm, Malakandher, The University of Agriculture, Peshawar, during 2020-21. The study aimed to identify the optimal sowing dates and phosphorus levels for enhanced seed production and yield of turnip. The experimental site is located in a semi-arid region, located between 71.25–72.75 E longitudes and 33.75–34.50 N latitudes at an elevation of 331 meters above sea level. During summer (May to September), the mean maximum temperature is around 40 °C and the mean minimum is approximately 27 °C. In winter, the mean maximum temperature is 17.4 °C while the mean minimum drops to around 4 °C. The region receives an annual rainfall of about 400 mm. The highest average winter rainfall was recorded in March (78.4 mm), while the highest average summer rainfall was recorded in August (67.7 mm).

Table 1. Temperature and rainfall data during the experimental season

Months	Average Temperature (°C)	Average Precipitation (mm)
October, 2020	19.5	11.2
November, 2020	17.6	12.3
December, 2020	12.5	23.3
January, 2021	11.2	26
February, 2021	12.9	42.7
March, 2021	17.4	78.4

Source: http://www.peshawar.climatemps.com/precipitation/temperature.php

Treatment and Field Research:

The experiment was conducted using a Randomized Complete Block Design (RCBD) with a split-plot arrangement, comprising two factors and replicated three times. The field was initially plowed using a cultivator to a depth of 10–15 cm, followed by a rotavator to a depth of 20 cm to achieve a fine soil tilt. The treatments included three sowing dates (1st, 15^{th,} and 30th October) and five phosphorus levels (0, 25, 50, 75, and 100 kg ha^{-1}). Sowing dates were assigned to the main plots, while phosphorus levels were allocated to the subplots. The turnip variety *Purple Top* was used for the experiment. Appropriate wedding and other cultural practices were performed as needed. Nitrogen and potassium were applied at basal doses at rates of 100 and 50 kg ha^{-1}, respectively. Before sowing, a full dose of K and a half dose of N were applied, while the remaining half of the N dose was applied a month after planting.

Parameters Studied:

Table 2. Parameters and methods used for assessing growth and yield attributes of turnip under different treatments.

S. No.	Parameters	Method
1.	Days to emergence	The number of days from seedling to emergence was recorded for each treatment and replication, and the average value was subsequently calculated.
2.	Number of leaves in plant^{-1}	The average number of leaves in randomly chosen plants was counted.
3.	Leaf weight (gm)	Leaves from five randomly selected plants were detached from the roots, weighed using a balance, and the average leaf weight was calculated.

4.	Root length (cm)	Root length was measured with a measuring tape in randomly selected plants, and their average was calculated.
5.	Root weight (g)	Roots were collected by cutting the leaves from the roots in randomly selected plants and weighed through a weight balance, and their average was calculated.
6.	Root diameter (cm)	Root diameter was measured with a vernier caliper in randomly selected plants, and their average was calculated.
7.	Yield plot^{-1} (kg)	After harvesting, the turnips were weighed, and the yield per plot was calculated and expressed in kilograms (kg).
8.	Yield (tons ha^{-1})	On the basis of yield plot^{-1}, total yield tons ha^{-1} was calculated using the following formula. $\text{Yield (ton. ha}^{-1}) = \frac{\text{Plot yield (kg) x 10,000 m}^2}{\text{Plot area (m}^2)}$

Statistics Analysis:

The collected data were analyzed at a 5% level of significance, and the Least Significant Difference (LSD) test was used to determine the mean difference. Statistical analysis was performed using the software STATISTIX version 8.1 [19].

Results:

Days to emergence and number of leaves per plant^{-1} data are shown in Table 1. The analyzed data revealed that days to emergence were significantly affected by different phosphorus levels and date of sowing; however, the interaction between these two factors was found to be non-significant. Different sowing dates showed that seed sown on 30th October took the maximum days to emergence (6), which was statistically similar to seed sown on 15th October (6), whereas seed sown on 1st October took the least days (4) to emergence. Mean value of different phosphorus levels indicates that maximum days to emergence (6) were recorded in the plot, where no phosphorus was applied, which was statistically similar to plots fertilized with 25 and 50 kg ha^{-1} phosphorus. While the minimum days to emergence (5) were recorded in the plot treated with 75 kg ha^{-1} phosphorus, it was statistically similar to the days to emergence (5) in plots where phosphorus was applied at 100 kg ha^{-1}. Data regarding the number of leaves plant^{-1} as influenced by sowing dates and phosphorus levels showed that the number of leaves was significantly influenced by sowing dates as well as phosphorus levels, whereas the interaction of sowing dates and phosphorus levels was non-significant. Mean values regarding sowing dates show that the highest no of leaves (13) was produced by the plants sown on 1st October, while the lowest number of leaves (11) was produced by the plants sown on 30th October. The mean table of phosphorus levels revealed that maximum leaves (14) were recorded in plants treated with 100 kg ha^{-1} phosphorus, followed by those treated with 75 and 50 kg ha^{-1} phosphorus that produced (13) leaves. In contrast, the minimum number of leaves (10) was recorded in plants that received only water without any fertilizer application.

Table 3. Effect of Sowing Dates and Phosphorus Levels on Emergence and Leaf Development in Turnip

Phosphorus Levels (kg ha^{-1})	Days to emergence	Number of leaves plant^{-1}
0	6 a	10 d
25	6 a	11 c
50	6 a	13 b
75	5 b	13 b
100	5 b	14 a
LSD (0.05)/Significance	0.38	0.59
Sowing dates		
1st October	4 b	13 a
15th October	6 a	12 b
30th October	6 a	11 c
LSD(0.05)/Significance	0.38	0.46
Interactions	NS	NS

The mean data of leaf weight (g) and root length (cm) as influenced by sowing dates and phosphorus levels are presented in Table 2. The mean data indicated that the total leaf weight was significantly influenced by sowing dates and phosphorus levels, whereas their interaction was non-significant. Among the sowing dates, the highest leaf weight (172.8 g) was recorded in plants sown on 1st October, while the lowest leaf weight (157.2 g) was noted in plants sown on 30th October. The mean table of phosphorus levels showed that the highest leaf weight (177.9 g) was obtained from plants treated with 100 kg ha^{-1} phosphorus, followed by those receiving 75 kg ha^{-1} phosphorus, which produced a leaf weight of 173.5 g.. In contrast, the lowest leaf weight (147.8 g) was recorded in the control plot. Results regarding the root length as influenced by sowing dates and P levels show that the root length was significantly influenced by sowing dates as well as phosphorus levels, whereas the interaction between the sowing dates and phosphorus levels was non-significant. Mean values regarding sowing dates show that the maximum root length (12.8 cm) was recorded in plants sown on 1st October, while the minimum root length (12.3 cm) was noted in plants sown on 30th October. The mean table for phosphorus levels indicated that the longest root length (14 cm) was recorded in plants treated with 100 kg ha^{-1} of phosphorus, followed by those receiving 75 kg ha ^{1,} which produced a root length of 13.3 cm. The shortest root length (10.9 cm) was observed in the plot where no fertilizer was applied.

Table 4. Effect of Sowing Dates and Phosphorus Levels on Leaf Weight (g) and Root Length (cm) of Turnip

Phosphorus Levels (kg ha^{-1})	Leaf weight (g)	Root length (cm)
0	147.8 e	10.9 e
25	160.9 d	11.8 d
50	167.9 c	12.7 c
75	173.5 b	13.3 b
100	177.9 a	14 a
LSD (0.05)/Significance	3.90	0.23
Sowing dates		
1st October	172.8 a	12.8 a
15th October	166.9 b	12.4 b
30th October	157.2 c	12.3 b
LSD(0.05)/Significance	1.84	0.21
Interactions	NS	NS

The mean data of root weight (g) and root diameter (cm) as influenced by sowing dates and phosphorus levels are presented in Table 3. The analysis revealed that total root weight was significantly influenced by both sowing dates and phosphorus levels, while their interaction effect was non-significant. The mean values for sowing dates indicate that the highest root weight (206.1 g) was recorded in plants sown on October 1st, whereas the lowest root weight (180.4 g) was recorded in plants sown on October 30th. The mean table of phosphorus levels reveals that maximum root weight (213.6 g) was recorded in the plant treated with 100 kg ha^{-1} phosphorus, followed by those treated with 75 kg ha^{-1} phosphorus that yielded 202.1 g root weight. Whereas the minimum root weight (177.6 g) was recorded in untreated plants. The Analysis of Variance revealed that both phosphorus levels and sowing dates had a significant effect on root diameter, while the interaction between phosphorus levels and sowing dates was non-significant. Mean value of different sowing times shows that maximum root diameter (8.9 cm) was recorded in plants sown on 1st October, which was statistically similar to plants sown on 15th October. The minimum root diameter (8.3 cm) was recorded in the plant sown on October 30th. Regarding phosphorus levels, the maximum root diameter (9.4 cm) was observed in the plot fertilized with 100 kg ha^{-1} of phosphorus, followed by those receiving 75 kg ha^{-1}. The minimum root diameter (7.7 cm) was recorded in plots where no phosphorus was applied.

Table 5. Root weight (g) and root diameter (cm) of turnip as influenced by sowing dates and phosphorus levels.

Phosphorus Levels (kg ha^{-1})	Root weight (g)	Root diameter (cm)
0	177.6 e	7.7 e
25	185.8 d	8.2 d
50	194.9 c	8.6 c
75	202.1 b	9.1 b
100	213.6 a	9.4 a
LSD (0.05)/Significance	3.17	0.35
Sowing dates		
1st October	206.1 a	8.9 a
15th October	197.9 b	8.7 a
30th October	180.4 c	8.3 b
LSD(0.05)/Significance	2.09	0.33
Interactions	NS	NS

The data regarding yield $plot^{-1}$ and yield (tons ha^{-1}) is presented in Table 4. Statistical analysis of the data indicated that yield per plot was significantly affected by both phosphorus levels and sowing dates; however, the interaction between phosphorus levels and sowing date was non-significant. Average data regarding different sowing dates shows that the maximum yield $plot^{-1}$ (9.4 kg) was recorded in the plant sown on 1st October, whereas the minimum yield $plot^{-1}$ (8.1 kg) was recorded in the plant sown on 30th October. The mean value of different phosphorus levels showed that the highest yield per plot (10.1 kg) was obtained from plots treated with 100 kg ha^{-1} phosphorus, while the lowest yield per plot (6.9 kg) was recorded in plots where no phosphorus was applied and only water was used. Mean data about yield (tons ha^{-1}) showed significant variation among sowing date and phosphorus level, while the interaction was non-significant.

Means of data showed that the maximum (20.1 tons) yield ha^{-1} was recorded in plants sown on 1st October, which was followed by plants sown on 15th October, while the minimum (17.3 tons) yield ha^{-1} was recorded in plants sown on 30th October. Means for phosphorus levels indicate that maximum yield ha^{-1} (21.8 tons) was observed in the plot treated with 100 kg phosphorus ha^{-1}, while minimum yield ha^{-1} (16.2 tons) was observed in the control.

Table 6. Yield plot^{-1} (kg) and yield (tons ha^{-1}) of turnip as influenced by sowing dates and phosphorus levels.

Phosphorus Levels (kg ha^{-1})	Yield plot^{-1} (kg)	Yield (tons ha^{-1})
0	6.9 e	16.2 e
25	8.1 d	16.9 d
50	9.1 c	18.2 c
75	9.6 b	19.5 b
100	10.1 a	21.8 a
LSD (0.05)/Significance	0.024	0.022
Sowing dates		
1st October	9.4 a	20.1 a
15th October	8.8 b	18.3 b
30th October	8.1 c	17.3 c
LSD(0.05)/Significance	0.018	0.020
Interactions	NS	NS

Discussion:

The difference in days to emergence amongst different sowing dates might be due to the cold soil temperature that influenced the emergence of the seed [18]. Seed sown on October 1st emerged first, followed by those sown on October 15th and 30th, respectively. Crops should be sown into a warm, moist seedbed. According to [20], soil temperatures in wet seedbeds are initially low, and as the soil warms, the moisture content gradually decreases. The current results are consistent with [19], who reported that low soil temperatures and limited soil moisture can restrict seed emergence. The variation in days to seed emergence among different phosphorus levels might be because the embryo in seeds of plants needs phosphorus to grow and develop. The current results are consistent with [19], who reported that low soil temperatures and limited soil moisture can restrict seed emergence. Additionally, plots with higher phosphorus levels showed earlier emergence compared to those fertilized with lower phosphorus [3], supporting [15], who stated that phosphorus deficiency restricted the plant growth. Current results are also in line with [16], who found that application of phosphorus increased emergence percentage in turnip crop. Turnip plants sown earlier produced a greater number of leaves compared to those sown late. Environmental factors such as temperature play a significant role in plant development and greatly influence the growth and yield of a plant [21].

The increase in the number of leaves in early sown plants might be due to the optimum temperature, growing season, and adequate soil moisture that favored the turnip growth. The present study reveals that the number of leaves significantly increased with the phosphorus @ 100 kg ha^{-1}. The increase in leaf number with phosphorus application may be attributed to its essential role in regulating plant metabolism and promoting growth [3]. Phosphorus is essential for plant growth, sugar and starch utilization, photosynthesis, nucleus formation, and cell division. Phosphate molecules store energy derived from photosynthesis and carbohydrate metabolism for later use, thereby promoting overall plant growth and production [22]. Current findings are in agreement with [23], who also reported the same results.

The plants of turnips sown on 1st October resulted in maximum fresh weight, while decreasing by delaying the sowing date. The increase in this trait with early sowing on 1st October may be because of the availability of suitable weather conditions during plant life that enhanced the photosynthesis and hence the growth and development of the plant [24]. These results are consistent with the findings of [25] and [26], who reported similar outcomes in turnip and fodder beet, respectively. The current study showed that the weight was significantly increased with the application of phosphorus @ 100 kg ha^{-1}. The increase in the weight of leaves by increasing the rate of phosphorus may be because of the nutrient facilitation of phosphorus in plants. Furthermore, phosphorus plays a key role in the normal functioning of the plant. It is found in each plant cell and is the main component of photosynthesises in plants. It is also responsible for the translocation of nutrients within the plants [27]. The present findings are further supported by [28], who reported that phosphorus application increased leaf weight in basil plants

The turnip plants sown earlier resulted in maximum root length in contrast to those sown later. This increase in root length of earlier sown plants might be attributed to the availability of the optimum growing season and utilization of a sufficient amount of nutrients from the soil that enhanced the overall growth of the plant and hence consequently, root length [29]. The current results are also supported by [25], who observed increased root length in turnip plants sown earlier. The current research demonstrates that root length was significantly increased with the application of phosphorus at 100 kg ha^{-1}. The increase in root length with higher phosphorus application may be attributed to the fact that phosphorus is a critical nutrient influencing plant reproductive growth, although turnip root might be because phosphorus is one of the most crucial nutrients that directly affect the reproductive growth of the plant, but turnip root development is primarily a vegetative growth process [30]. The provision of phosphorus in an adequate amount improves the vegetative and reproductive growth of the plant and hence results in higher yield. The present findings are in line with those, who reported similar results in turnip (*Brassica rapa* L.).

The earlier sown turnip plants resulted in maximum root weight, while the root weight decreased by delaying the sowing date. The increase in root weight may be attributed to favorable environmental conditions that enhanced the plant growth cycle by promoting photosynthesis, leading to greater translocation of assimilates to the roots and consequently, increased root weight [31]. These results are also supported by the findings, who reported an increase in root weight of earlier sown turnip plants as compared to late sown. The present study demonstrates that root weight was significantly increased with the application of phosphorus at 100 kg ha^{-1}. This increase in root weight by increasing the rate of phosphorus may be because of the availability of an optimum amount of phosphorus that has been linked to higher growth and development; therefore, those plots that received the most phosphorus resulted in a greater root weight than the control plots. In addition, phosphorus is a vital component of nucleic acids; thus, it plays an important role in root and shoot growth [32]. These results are further supported by [33], who reported an increase in overall biomass of the maize plant with higher phosphorus levels.

The variation in sowing date might be because early-planted crops may have benefited from improved environmental circumstances, particularly from temperature and sun radiation, which led to the largest root diameter [34]. Similar results were obtained under different climatic conditions as influenced by sowing time [35][36], reported that maximum root yield and diameter were recorded in the radish plant that was sown on 1st October. The author in [25] reported that delayed sowing reduced both root length and diameter in forage turnip. The variation in root diameter among different phosphorus levels might be because phosphorus plays a crucial role in the root growth of plants. It is one of the important essential macro nutrients for the normal growth and development of plants [37]. In photosynthesis, which converts light energy into simple sugars by combining carbon dioxide and water in the presence of chlorophyll, phosphorus plays a crucial role [38]. Thus, sufficient application of phosphorus helps in enhancing the vegetative growth of the plant, which ultimately leads to the highest root diameter. Current results conform with [39], who reported that the maximum root diameter of radish was obtained with 100 kg ha^{-1} of phosphorus.

Turnip late planting has a negative impact on yield and yield components because it has a negative impact on growth since the turnip's various growth stages have had enough time to develop. [40], reported that the best sowing date was 11th October, as it produced a higher yield as compared to other sowing dates. The increase in yield $plot^{-1}$ might be because phosphorus increases the availability of other nutrients and improves the source and sink relationship, and hence increases the yield of the crop [37]. As a result, phosphorus plays a crucial role in photosynthesis, respiration, energy storage and transfer, cell division, cell elongation, and many other processes in living plants [40]. The author in [9] reported that the highest yield was recorded when 100 kg ha^{-1} phosphorus was applied. Another study [7] reported that a shortage of phosphorus fertilizer during early growth stages resulted in stunted plants.

The crop sown on 1st October resulted in higher growth compared to late sowing, which can be attributed to higher plant growth of more conversion of radiant energy. Early planting also provided a long period for photosynthesis and growth, which resulted in higher yield [41].

The variation in yield tons ha^{-1} among different sowing dates might be due to the conditions prevailing during the growing period when planted earlier, i.e., 1st October, and also due to longer growth experienced by plants resulting from the seeds sown earlier (1st October). This higher yield ha^{-1} under higher phosphorus levels was mainly associated with the number of leaves, leaf weight, root length, and root diameter. Phosphorus plays an important role in cell division, the development of new tissues, and promotes root growth [42]. [9], also reported that the highest yield and size of turnip root was obtained in response to 100 kg P ha^{-1} in Bangladesh.

Conclusions:

From the results, it is concluded that turnip cultivar “Purple top” sown on 1st October showed better growth and seed yield by the application of Phosphorus at the rate of 100 kg $ha^{-1,}$ and hence recommended for climate change and growers of district Peshawar. Further research is suggested using other turnip cultivars, sowing dates, and phosphorus levels above 100 kg.

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