Impact Of Row Spacing On Yield And Its Components On Lentil Varieties Under The Agroecological Conditions Of Quetta

Dad Jan[1], Abdul Razzaq Rekki[1], Abdul Ghaffar[2], Dr Nanak Khan[1], Nouman Irshad[1], Naseeruddin[3*], Nadeem Sadiq[4], Saaduddin[5], Muhammad Saddam[1], Muhammad Wasil Khan[6], Dr Zaffarullah Malghani[1], Amal Khan[7]

[1]Department of Agronomy Balochistan Agriculture College Quetta
[2]Director Pulses Agriculture Research Institute Quetta.
[3]Department of Agronomy Sindh Agriculture University Tandojm Pakistan.
[4]Director General BARDC Quetta
[5]Department of Soil Science Balochistan Agriculture College Quetta
[6]Department of Horticulture Sindh Agriculture University Tandojm
[7] Department of Environmental Sciences, BUITEMS Quetta.

***Corresponding Author**: Naseeruddin
*Email: nasir657@gmail.com

ABSTRACT
A field experiment conducted at the Balochistan Agriculture Research Institute (ARI) in Quetta on November 15, 2022, assessed the impact of varying row spacings on the growth and yield of two lentil varieties: Local Panjgur Black and Dasht-21. The study utilized a Randomized Complete Block Design (RCBD) with three replications, examining five row spacings: 20 cm, 25 cm, 30 cm, 35 cm, and 40 cm. Results showed that at 60 days, Local Panjgur Black exhibited a higher average leaf count (10.86 leaves per plant) compared to Dasht-21 (8.53 leaves). The widest row spacing of 40 cm resulted in the maximum number of leaves (18.49 leaves), while the narrowest spacing of 20 cm had the fewest (11.33 leaves). Local Panjgur Black had more branches (8.0 branches per plant) than Dasht-21 (6.73 branches). The 40 cm row spacing yielded the highest branch count (8.00 branches), whereas the 20 cm spacing had the lowest (6.16 branches). The tallest plants were observed in Local Panjgur Black (34.00 cm). Increasing row spacing led to taller plants, with the 40 cm spacing producing the tallest plants (38.00 cm) and the 20 cm spacing the shortest (27.33 cm). Local Panjgur Black produced more pods per plant (57.60) than Dasht-21 (38.00). The 40 cm row spacing resulted in the highest number of pods (44.33), while the 20 cm spacing had the fewest (22.8). Local Panjgur Black achieved a higher seed yield (1,411.7 kg/ha) compared to Dasht-21 (1,170.1 kg/ha). The 40 cm row spacing yielded the most seeds (1,616.5 kg/ha), whereas the 20 cm spacing had the lowest yield (1,002.5 kg/ha). In conclusion, adopting wider row spacings, such as 40 cm, can significantly improve the growth and yield of lentil varieties like Local Panjgur Black. This practice offers a viable strategy for enhancing lentil productivity in similar agro-climatic regions.

Keywords: Lentil varieties; row spacing, growth and yield.

INTRODUCTION

Lentils are widely grown in Pakistan and are both irrigated and rainfed. Lentils, one of the oldest known food crops, contain critical nutrients and so serve as an important nutritional supplement. Lentil cultivation began about 8,500 years ago in the Near East and expanded throughout the Mediterranean, Asia, Europe, and finally to the Western Hemisphere. The flowering pattern of lentil plants advances from bottom to top, with blooms varying from white to pale blue. Seed pods usually contain one or two seeds and come in various hues, including tan, brown, black, or purple and black speckled. Seed surfaces are normally smooth, but can seem wrinkled on bigger seeds (Singh *et al.*, 2015; Janlooa *et al.*, 2016; Rita *et al.*, 2018).

Several variables impact lentil production, with plant spacing identified as an important component in improving structures and boosting photosynthetic capacity (Schaefer *et al.*, 2018; Pabuayon *et al.*, 2020). Plant density influences light absorption, moisture availability, wind movement, plant height, architecture, behavior, crop maturity, and total yield. Adjusting row spacing may affect input costs, fluff production, and fiber quality, with low plant density possibly increasing yield quantity but decreasing yield quality (Chapepa *et al.*, 2020; Shah *et al.*, 2021). Row spacing is one of the most important parameters determining lentil production since it has a significant impact on agronomic performance (Nadeem *et al.*, 2020). Various studies (Kraska *et al.*, 2019) have supported high row spacing for seed production because it improves primary umbel production. However, despite the potential benefits, getting high lentil yields per acre is difficult because to inadequate row spacing and input application (Kraska *et al.*, 2019). Row spacing is critical to effective lentil production management strategies (Feleke *et al.*, 2018). It has a major impact on lentil content and quality attributes, and controlling row spacing is critical for utilizing the full renewable resource and encouraging harmonious crop growth (Ouji *et al.*, 2016). Row spacing also influences plant light response by influencing leaf area index (LAI), which in turn impacts photosynthesis rates. Higher row spacing enhances light availability for photosynthesis but may result in higher competition between plants, possibly impairing vegetative and reproductive adaptability (Ali, 2020; Faqeer *et al*., 2020).

Lentil yield may be increased by adjusting the planting timing and row spacing. Improved methods for implanting period, row spacing, and advanced yielding modifications may boost lentil seed yield. On the other hand, the plants cannot use the reserve efficiently after growing up low and placed dispersed, resulting in minimal output (Singh *et al*., 2009; Faqeer *et al*. 2020). Therefore, the present study evaluated the impact of different row spacing on the growth and yield of various lentil varieties.

MATERIALS AND METHODS

The field experiment was conducted at the Balochistan Agricultural Research Institute (ARI), Quetta, during the period starting on November 15th, 2022. The research was carried out in an open field at ARI Quetta.

TREATMENTS

a. VARIETIES

V1 = Dasht-21
V2 = Local Panjgur Black

b. Row Spacing

L1 = 20cm
L2 = 25cm
L3 = 30cm
L4 = 35cm
L5 = 40cm

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The treatment combinations were randomly assigned to the replications. The length of all plots was 3.6 m, with the width determined by the specific row spacing of each treatment. The experiment included ten treatments. The plot size was as follows.

Field	20_{cm}	25_{cm}	30_{cm}	35_{cm}	40_{cm}
Width (m)	1.4	1.6	1.9	2.3	2.6
Length (m)	3.6	3.6	3.6	3.6	3.6
Total area (m^{-2})	5.04	5.76	6.84	8.28	9.3

GRWOTH PARAMETERS

Five plants were selected randomly from each unit plot for recording data on crop parameters. Number of leaves per plant were counted at different days after sowing of crop duration. Leaves number per plant were recorded from randomly selected 5 plants by counting all leaves and the mean was calculated. Data was taken at 45, 60, and 75 days after growth. On different days after growth i.e., at 45, 60, and 75, all the primary branches were counted from 5 plants of each plot, and their average value was taken as the number of branches per plant. The height of the plant was recorded in centimeters (cm) on different days after transplanting of crop duration. Data was recorded as the average of 5 plants selected at random from each row. The height was measured from the ground level to the tip of the leaves on a meter scale. Data was taken at 45, 60, and 75 days after growth.

YIELD PARAMETERS

Days to the first (1st) flowering were recorded from the date of growth to when 1st flower appeared in the plant. The length of the pod was measured with a digital slide caliper in centimeters from the neck of the pod to the bottom of the pod. It was measured from each row and their average was calculated in centimeters. The breadth of the pods was measured at the middle portion of 20 randomly selected pods from each row with the slide calipers in centimeters and then their average was taken as the breadth of the pods. The total pod number was counted from 5 selected plants from 1st day to harvest and the average number was calculated as the number of pods per plant. From the first harvest to the last harvest total pod number and weight were counted from 5 plants to determine single pod weight. By using the following formula, single pod weight was calculated and expressed in gram.

$$\text{Single pod weight} = \frac{\text{Weight of individual pod (g)}}{\text{Total number of pods from 5 selected plants}}$$

Total pod yield was counted from 5 selected plants from 1st day to maturity and average yield was calculated as pod yield per plant and was expressed in yield $ha^{-1.}$ After harvesting the crop from each, the total seed production was recorded and converted to Kg $ha^{-1.}$ After harvesting the crop from each plot using the quadrate technique, the biological yield was calculated in Kg ha-$^{1.}$.

Statistical Analysis

The collected data was subjected to statistical analysis using Statistix 8.1. The LSD test at p=0.05 was applied to compare treatments' superiority, where necessary.

RESULTS AND DISCUSSION

Number of Leaves Plant^{-1} (at 45 days): The effect of different row spacing on the number of leaves per plant of two lentil varieties (Dasht-21 and Local Panjgur Black) was checked. The results showed the number of leaves was significantly varied (P<0.05) among both varieties. The number of leaves was significantly varied (P<0.05) due to different row spacing. However, the interaction of both varieties and row spacing on the number of leaves was non-significant (P>0.05). The figure 1 shows that among varieties the highest number of leaves were noted in the case of Local Panjgur Black (9.467 leaves), while the lowest were noted in Dasht-21 (98.067 leaves). Among row spacing, the maximum number of leaves were noted at a row spacing of 40 cm, which were 11.67 leaves, followed by 35 cm row spacing (10.167 leaves), 30 cm row spacing (10.00 leaves), 25 cm row spacing (6.33 leaves), and the lowest was noted in 20 cm row spacing (6.16 leaves). Increasing row spacing in lentil plants can result in more leaves per plant by boosting light penetration and ventilation. Wider spacing enables plants greater sunshine exposure, which boosts photosynthesis and leaf output. It also improves air circulation, which lowers the danger of illness and allows plants to devote more energy to leaf growth. Finally, greater row spacing promotes healthy plant development and increases leaf count. Similar findings were reported by Bernhard & Below, (2020) who observed an increase in maize leaf count with wider row spacing.

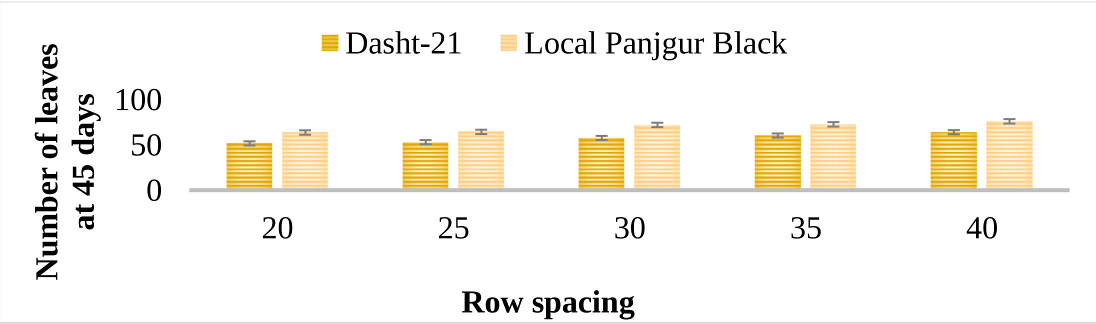

Figure: 1. Effect of row spacing on number of leaves per plant of two lentil varieties (at 45 days)

Number of Leaves Plant^{-1}(at 60 days): The study investigated the effect of different row spacing on the number of leaves per plant for two lentil varieties: Dasht-21 and Local Panjgur Black. The results indicated a significant variation in the number of leaves (at 60 days) between the two varieties (P<0.05) and across different row spacing. Moreover, the interaction between the varieties and row spacing had significant results (P<0.05), as detailed in Appendix 2. Figure 4.2 highlighted that the Local Panjgur Black variety had the highest average number of leaves (at 60 days), with 10.86 leaves per plant, while Dasht-21 had the lowest, with 8.53 leaves. Regarding row spacing, the maximum number of leaves was observed at a spacing of 40 cm, averaging 18.49 leaves, followed by 35 cm spacing with 14.65 leaves, 30 cm with 14.35 leaves, 25 cm with 11.35 leaves, and the lowest at 20 cm spacing, which recorded also 11.33 leaves. Moreover, the interaction of row spacing and varieties showed that the highest number of leaves were noted in the case of the Local Panjgur Black variety sown at a space of 40 cm (16.33 leaves) the lowest were noted in Dasht-21 sown at 25, and 20 cm row spacing (7.33 leaves). The results revealed that row spacing of 40 cm produced the most leaves when compared to other row spacings. Gashaw & Sheway, (2020) observed similar results, indicating that increasing row spacing leads to an increase in the number of lettuce leaves.

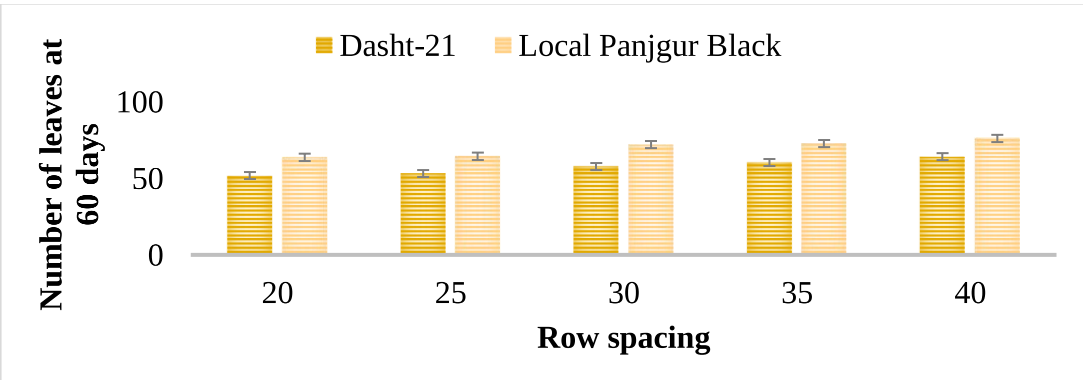

Figure: 2. Effect of row spacing on the number of leaves per plant of two lentil varieties (at 60 days)

Number of Leaves Plant^{-1} (at 75 days): The study investigated the effect of different row spacing on the number of leaves per plant for two lentil varieties: Dasht-21 and Local Panjgur Black. The results indicated a significant variation in the number of leaves (at 75 days) between the two varieties (P<0.05) and across different row spacing. However, the interaction between the varieties and row spacing had non-significant results (P>0.05). Figure 3 highlighted that the Local Panjgur Black variety had the highest average number of leaves (at 75 days), with 20.80 leaves per plant, while Dasht-21 had the lowest, at 18.53 leaves. Regarding row spacing, the maximum number of leaves was observed at a spacing of 40 cm, averaging 22.67 leaves, followed by 35 cm spacing with 22.00 leaves, 30 cm with 20.50 leaves, 25 cm with 17.0 leaves, and the lowest at 20 cm spacing, which recorded also 16.167 leaves. Increasing row spacing in lentil plants can result in more leaves per plant by boosting light penetration and ventilation. Wider spacing enables plants greater sunshine exposure, which boosts photosynthesis and leaf output. It also improves air circulation, which lowers the danger of illness and allows plants to devote more energy to leaf growth. Finally, greater row spacing promotes healthy plant development and increases leaf count. Bernhard & Below (2020) observed similar results, noting that greater row spacing increased the number of maize leaves. The results revealed that row spacing of 40 cm produced the most leaves when compared to other row spacing. Gashaw & Sheway, (2020) observed similar results, stating that increasing row spacing leads to an increase in the number of lettuce leaves. The finding is similar to Hailu, (2021) and Gemechu & Solomon, (2021) findings, which revealed that higher spacing increased the number of branches per plant in mung and common beans, respectively.

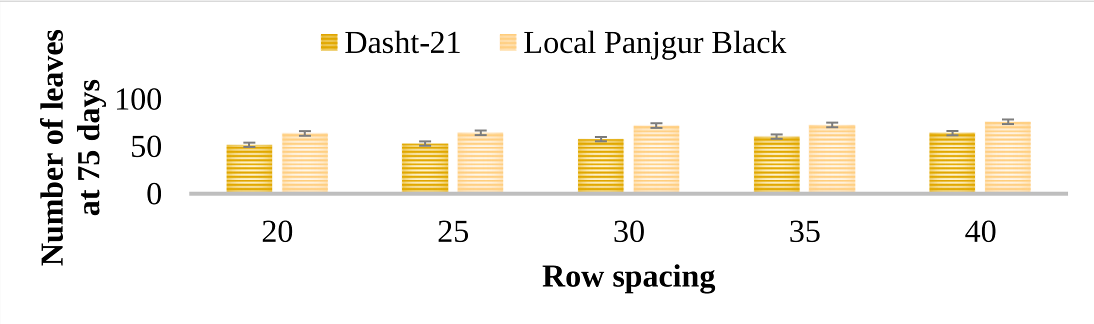

Figure: 3. Effect of row spacing on number of leaves per plant of two lentil varieties (at 75 days)

Number of Branches Plant-1(at 45 days): The study examined how different row spacing influenced the number of branches per plant in two lentil varieties namely Dasht-21 and Local Panjgur Black, at 45 days of post-sowing. The findings revealed significant differences in branch counts between the varieties (P < 0.05) and across various row spacing (P<0.05). However, the interaction between the varieties and row spacing yielded non-significant results (P>0.05). According to Figure 4, the Local Panjgur Black variety exhibited the highest average branched count at 1.46 branches per plant, while Dasht-21 had a lower average of 1.00 branches. In terms of row spacing, the greatest number of branches was recorded at 40 cm, with an average of 2.00 branches. This was followed by 35 cm spacing, which averaged 1.5 branches, and 30 cm spacing with 1.33 branches. Row spacing of 25 cm and 20 cm yielded similar results, averaging 0.67 branches per plant. The variety with the most branches was local Panjgur Black. This might be related to genetic variation. Islam *et al*. (2020) found similar findings, seeing a considerable variation in the number of branches across various varieties. Mishra (2003) also found comparable results. The number of branches in lentil plants is determined by the space between rows. at general, lentil plants grow more branches at a larger row spacing, such as 40 cm, than in a tighter row spacing, like 20 cm. Wider row spacing promotes greater branching and total plant development by improving air circulation and light penetration around the plants. Conversely, plant congestion and competition for resources can occur from narrow row spacing, which can stunt development and diminish the number of branches. Because of these favorable circumstances, which promote good branching and plant development, lentil plants with 40 cm row spacing have the most branches. Devi *et al*. (2022) observed similar findings, noting that more branches result from increased row spacing.

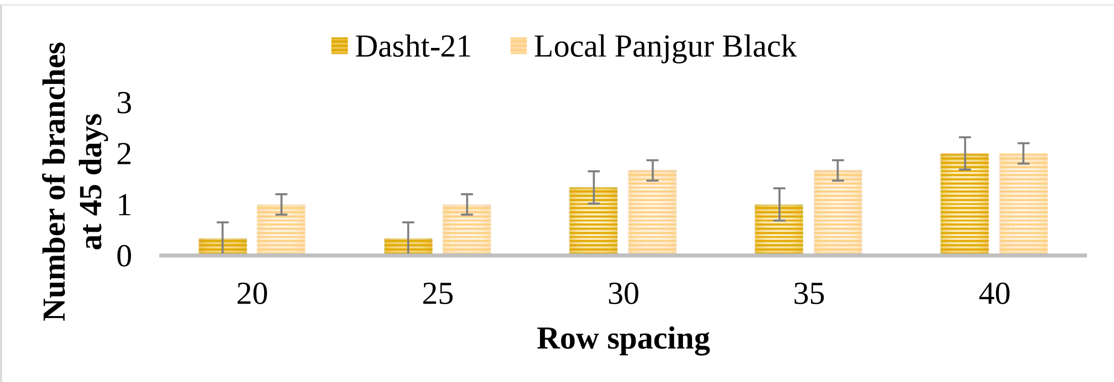

Figure: 4. Effect of row spacing on the number of branches per plant of two lentil varieties (at 45 days)

Number of Branches Plant^{-1}(at 60 days): The effect of different row spacing on the number of branches per plant of two lentil varieties (Dasht-21 and Local Panjgur Black) was checked. The results showed the number of branches was significantly varied (P<0.05) among both varieties. The number of branches was significantly varied (P<0.05) due to different row spacing. Moreover, the interaction of both varieties and row spacing on the number of branches was also significant (P<0.05). The figure 5 shows that among varieties the highest number of branches was noted in the case of Local Panjgur Black (5.4 branches), while the lowest were noted in Dasht-21 (3.8 branches). Among row spacing, the maximum number of branches was noted at a row spacing of 40 cm, which were 5.33 branches, followed by 35 cm row spacing (4.83 branches), 30 cm row spacing (4.50 branches), 25 cm row spacing (4.00 branches), and the lowest was noted in 20 cm row spacing (3.33 branches). Furthermore, the interaction between row spacing and varieties revealed that the Local Panjgur Black variety, which was seeded at a 40 cm spacing, produced the most leaves (5,33 branches), while Dasht-21, which was sown at a 20 cm spacing, produced the fewest (2.33 branches). Overall, the findings indicated that the maximum number of branches under both varieties was 40 cm apart. At greater row spacing, there may be less competition between the plants. Ferreira *et al.* (2018) corroborate our study's findings by pointing out that plants often grow more branches when row spacing is broader.

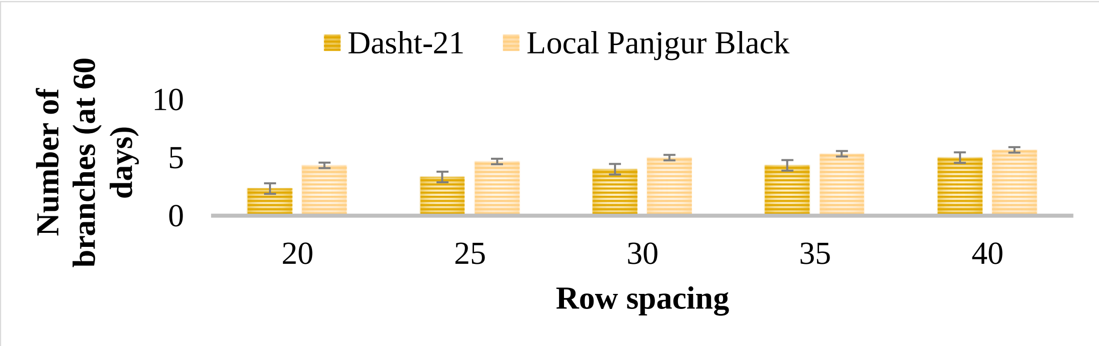

Figure: 5. Effect of row spacing on the number of branches per plant of two lentil varieties (at 60 days)

Number of Branches Plant^{-1}(at 75 days): The effect of different row spacing on the number of branches per plant of two lentil varieties (Dasht-21 and Local Panjgur Black) was checked. The results showed the number of branches was significantly varied (P<0.05) among both varieties. The number of branches was significantly varied (P<0.05) due to different row spacing. Moreover, the interaction of both varieties and row spacing on the number of branches was also significant (P<0.05). The figure 6 shows that among varieties the highest number of branches was noted in the case of Local Panjgur Black (8.0 branches), while the lowest were noted in Dasht-21 (6.73 branches). Among row spacing, the maximum number of branches was noted at a row spacing of 40 cm, which was 8.00 branches, followed by 35 cm row spacing (8.00 branches), 30 cm row spacing (7.65 branches), 25 cm row spacing (6.67 branches), and the lowest was noted in 20 cm row spacing (6.16 branches). Moreover, the interaction of row spacing and varieties showed that the highest number of leaves were noted in the case of the Local Panjgur Black variety sown at a space of 40 cm (8.66 branches) were as lowest were noted in Dasht-21 sown at 20 cm row spacing (5.3 branches). The local Panjgur Black variety has the most branches of any kind. Genetic diversity might be the cause of this. Similar findings were reported by Islam *et al.* (2020), who observed a nofigure difference in the number of branches among various kinds. Generally speaking, lentil plants have the most branches when the row spacing is widest (40 cm), and the smallest (20 cm). The reason for this is that greater airflow and light exposure surrounding the plants are made possible by wider row spacing, which encourages branching and general plant development. Narrow row spacing, on the other hand, might cause competition for resources and increasing population, which could restrict development and result in fewer branches. Thus, the ideal branching of lentil plants is facilitated by the favorable conditions of larger row spacing. Basso *et al.* (2021) found similar findings, pointing out that plant branches are a result of increasing row space. Similar findings were also reported by Kizil & Toncer (2005), who found that the highest number of branches was observed with more row spacing.

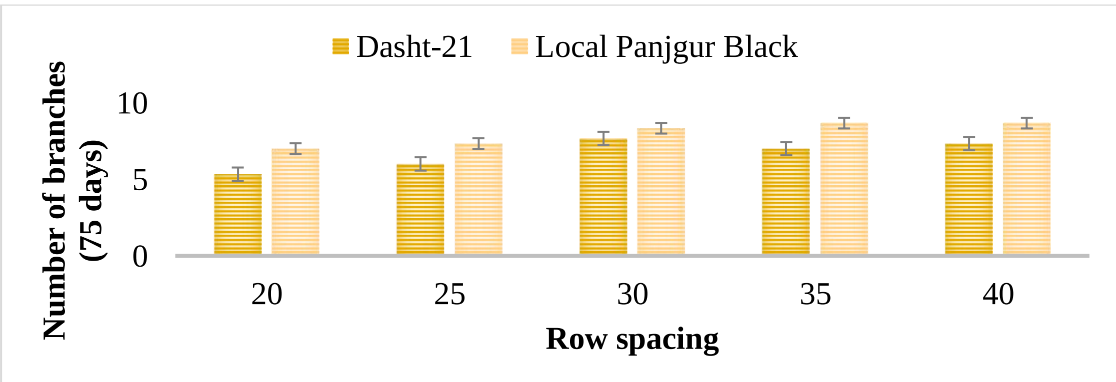

Figure: 6. Effect of row spacing on the number of branches per plant of two lentil varieties (at 75 days)

Plant Height (cm): The effect of different row spacing on the height of two lentil varieties (Dasht-21 and Local Panjgur Black) was checked. The results showed the height was significantly varied (P<0.05) among both varieties. The plant height was significantly varied (P<0.05) due to different row spacing. However, the interaction of both varieties and row spacing on the number of branches was non-significant (P>0.05). The figure 7 shows that among varieties the maximum plant height was noted in the case of Local Panjgur Black (34.00 cm), while the minimum was noted in Dasht-21 (32.67 cm). Among row spacing, the maximum plant height was noted at a row spacing of 40 cm, which was 38.00 cm, followed by 35 cm row spacing (36.67cm), 30 cm row spacing (32.67 cm), 25 cm row spacing (30.50 cm), and the lowest was noted in 20 cm row spacing (27.33 cm). Local Panjgur Black has the tallest plants among the kinds. Genetic diversity might be the cause of this. The intrinsic variables may be the cause of this variation in plant height. Farghali & Hussein (1995) found similar results on plant height. Similar findings were reported by Islam *et al*. (2020), who observed a nofigure difference in plant height across types. This might be because plants that are spaced farther apart have a higher chance of getting the lightest, space, and nutrients, which allows them to develop more branches and pods per plant. These findings were consistent with those of Devi *et al*. (2021) in rice beans and So heir (2001), who reported comparable results in fababean.

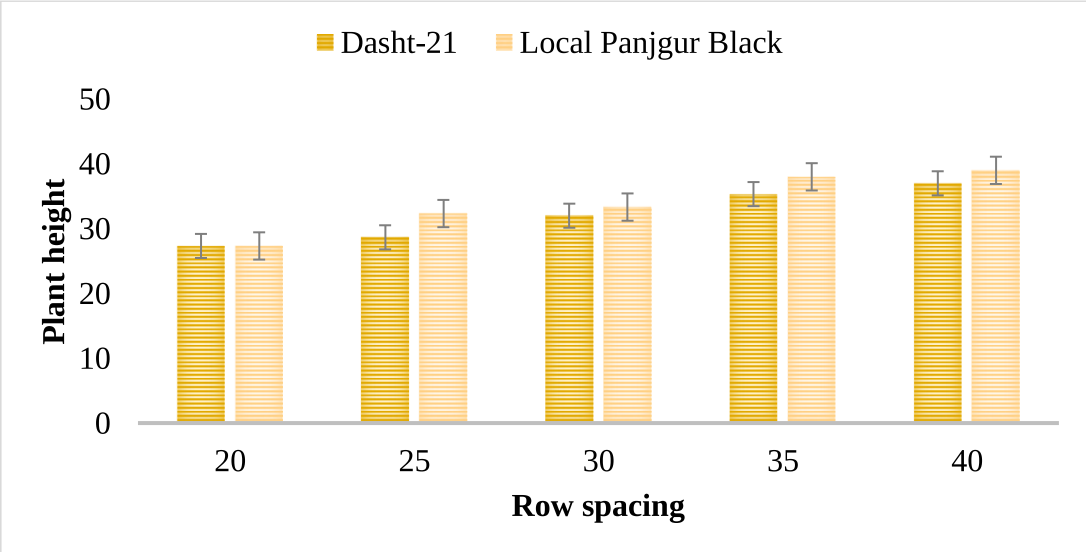

Figure: 7. Effect of row spacing on height of two lentil varieties

Days to 1st Flowering: The effect of different row spacing on the time taken by two lentil varieties (Dasht-21 and Local Panjgur Black) to bloom was checked. The results showed the time taken by varieties to bloom was significantly varied (P<0.05) among both varieties. The blooming time period was also significantly varied (P<0.05) due to different row spacing. However, the interaction of both varieties and row spacing on the blooming time was non-significant (P>0.05). The figure 8 shows that among varieties the minimum time to bloom was noted in the case of Local Panjgur Black 69.73 days), while the maximum time was noted in Dasht-21 (57.33 days). Among row spacing, the minimum time to bloom was noted at a row spacing of 40 cm, which was 70.00 cm, and the maximum was noted at 20 cm row spacing (57.67 days). When compared to Dasht-21, the Local Panjgur Black takes fewer days to blossom. According to their development characteristics, leaf size, stem branching, and duration to maturity following blooming, different varieties have different vegetative structures (Kakahy *et al*. 2012). Olle *et al*. (2019) reported similar findings. By encouraging improved light penetration and lessening competition among plants for resources like water and nutrients, wider row spacing might cause plants to blossom earlier. Each plant gets more direct sunlight when they are spaced farther apart, which may encourage the synthesis of hormones that cause blooming. Wider rows also provide plants more access to resources, which enables them to focus their efforts on developing flowers earlier. Additionally, plants can mature more quickly and begin flowering earlier due to less competition for resources. In general, greater row spacing produces ideal growth conditions that may promote plants to blossom earlier. Because there is more nutritional space available in the wider row spacing, the crop may have flowered earlier than in the tighter spacing, which might explain the fewest days to blooming. Furthermore, fewer days to blooming may have resulted from wider spacing since it had greater light interception than narrow row spacing. This outcome supports the findings of Abubaker (2008), who found that beans sown at lower planting densities needed a greater number of days for flowering.

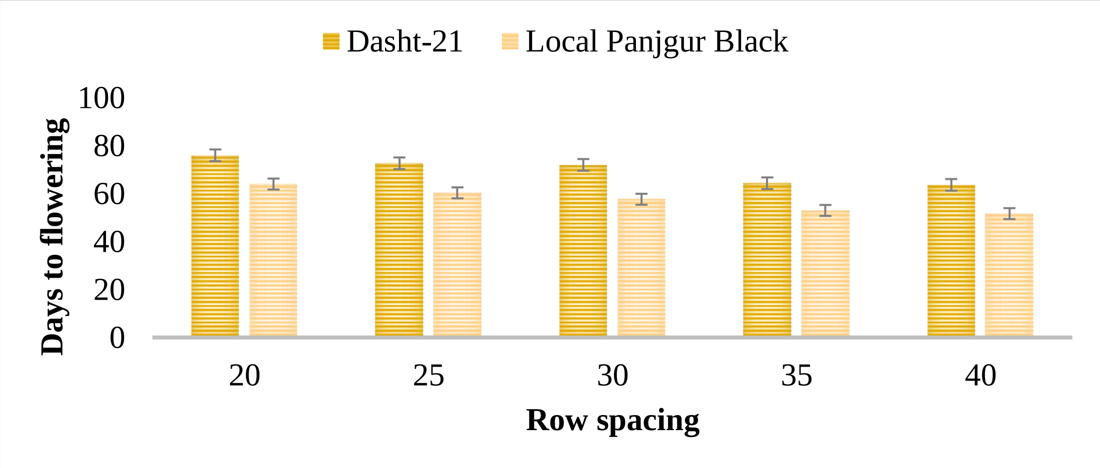

Figure: 8. Effect of row spacing on days to flowering (1st) of two lentil varieties

Pod Length (cm): The effect of different row spacing on the pod length of two lentil varieties (Dasht-21 and Local Panjgur Black) was checked. The results showed the pod length was significantly varied (P<0.05) among both varieties. The pod length was also significantly varied (P<0.05) due to different row spacing. However, the interaction of both varieties and row spacing on the pod length was non-significant (P>0.05). The figure 9 shows that among varieties the highest pod length was noted in the case of Local Panjgur Black (20.133 cm), while the minimum pod length was noted in Dasht-21 (18.267 cm). Among row spacing, the maximum pod length was noted at a row spacing of 40 cm, which was 20.00 cm, and the lowest was noted in a 20 cm row spacing (16.00 cm). Local Panjgur Black had the longest pod length among the types, whereas Dasht-21 had the shortest, which may be related to the genetic composition of the latter. The differences in pod length across the several varieties were also documented by Olle *et al.* (2019). These findings are consistent with those of Parvez *et al.* (2013), who found that pod length varied throughout cultivars. The genetic composition of the types may be the likely cause of this discrepancy. The reason for the increase in pod length with increased interrow spacing may be that the fenugreek plant's reproductive growth was gradually improved at wider interrow spacing. This recommendation is in line with Reza, (2021) findings, which showed that fenugreek pod length rose continuously as separation increased. Beze1 & Shumbulo2 reported similar findings in 2024.

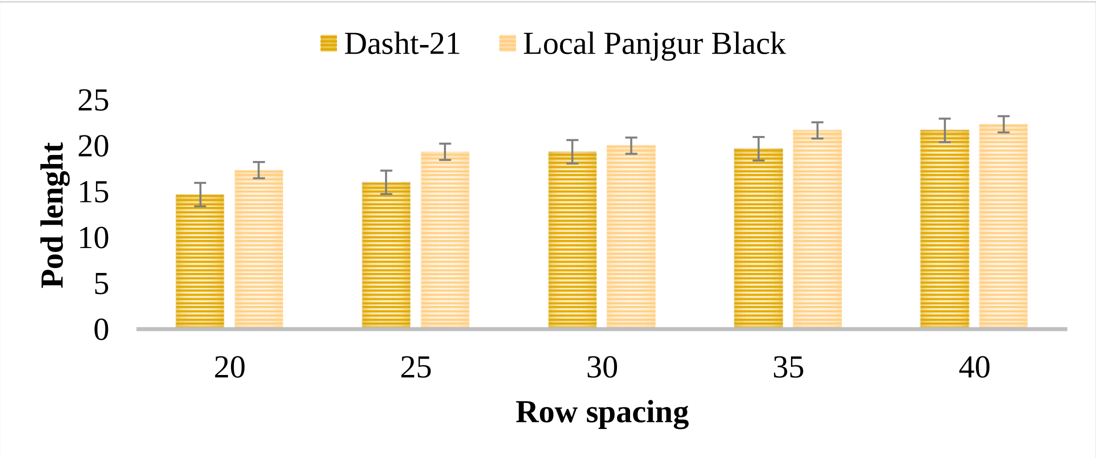

Figure: 9. Effect of row spacing on pod length of two lentil varieties

Pod Diameter: The effect of different row spacing on the pod diameter of two lentil varieties (Dasht-21 and Local Panjgur Black) was checked. The results showed the pod diameter was significantly varied (P<0.05) among both varieties. The pod diameter was also significantly varied (P<0.05) due to different row spacing. However, the interaction of both varieties and row spacing on the pod diameter was non-significant (P>0.05). The figure 10 shows that among varieties the highest pod diameter was noted in the case of Local Panjgur Black (11.33 cm), while the minimum pod diameter was noted in Dasht-21 (9.67 cm). Among row spacing, the maximum pod diameter was noted at a row spacing of 40 cm, which was 11.83 cm, and the lowest was noted in a 20 cm row spacing (8.83 cm). Local Panjgur Black had the longest pod length among the types, whereas Dasht-21 had the shortest, which may be related to the genetic composition of the latter. The differences in pod length across types were also noted by Olle *et al.* (2019). These findings are consistent with those of Yadav *et al.* (2023), who found that pod length varied among cultivars. The genetic composition of the types may be the likely cause of this discrepancy. As the in-row distance rose, so did the pod diameter. This might be because plants grow at greater row spacing and have less competition, producing pods with a larger diameter. Falodun & Ogedegbe (2016) published similar findings, describing the variance in pod width in plants sown at varying row spacing.

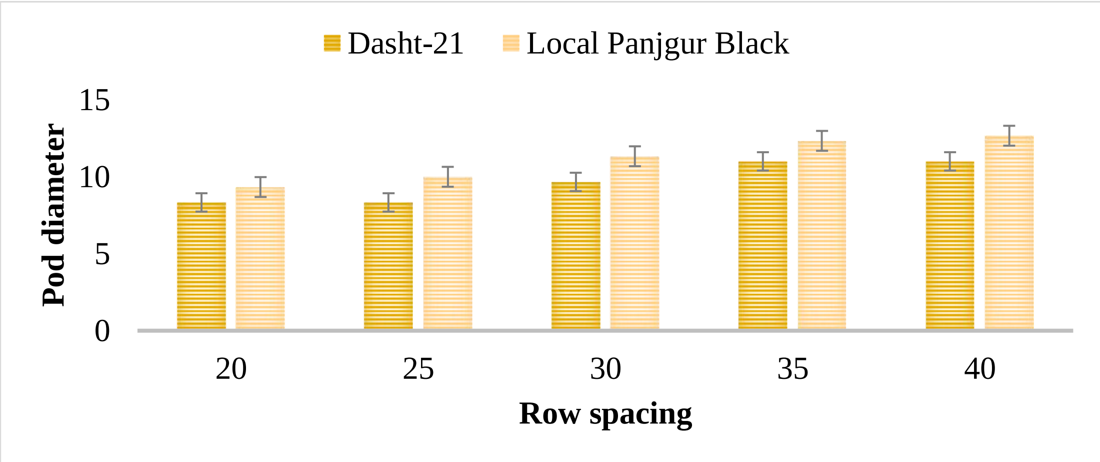

Figure: 10. Effect of row spacing on the number of pod diameters of two lentil varieties

Number of pods plant^{-1} : The effect of different row spacing on several pods per plant of two lentil varieties (Dasht-21 and Local Panjgur Black) was checked. The results showed the number of pods per plant was significantly varied (P<0.05) among both varieties. The number of pods per plant was also significantly varied (P<0.05) due to different row spacing. However, the interaction of both varieties and row spacing on the number of pods per plant were non-significant (P>0.05). The figure 11 shows that among varieties the highest number of pods per plant was noted in the case of Local Panjgur Black (57.60), while the minimum was noted in Dasht-21 (38.00). The greatest number of pods per plant was seen at 40 cm row spacing, while the smallest number was observed at 20 cm row spacing. There were more pods per plant in the local Panjgur Black cultivar. Its genetic potential may be the cause of this. Similar findings were reported by Yadav *et al*. (2023), who observed that various cultivars had varying numbers of pods per plant. Increased spacing may be linked to more intense plant completion and less overground area for light interaction (Zaman 2022). This might be because plants that were spaced farther apart had a greater chance of getting the lightest, space, and nutrients, which allowed them to develop more branches and pods per plant. These outcomes were consistent with the rice bean research conducted by Devi *et al*. in 2021. According to Seyyed *et al*. (2014), the reduction in the overground area for light interception and branch-bearing, as well as the increased competition among plants, maybe the cause of this loss of pod quantity per plant with decreased row spacing. This can be explained by plants producing more auxiliary branches and the dominating influence of terminal buds diminishing at lower densities. As a result, they are better able to use the environment and yield more blossoms. As a result, there are more pods per plant. Pod formation was relatively lower than that of low seeding rates, which led to increased competition for light, space, and nutrients. This effect of seedling rate on pod number per plant may be caused by a higher number of plants per unit row length, which may have negatively impacted pod development. The maximum seed output was obtained by increasing plant spacing, according to Idris (2008), which also increased the number of pods per plant.

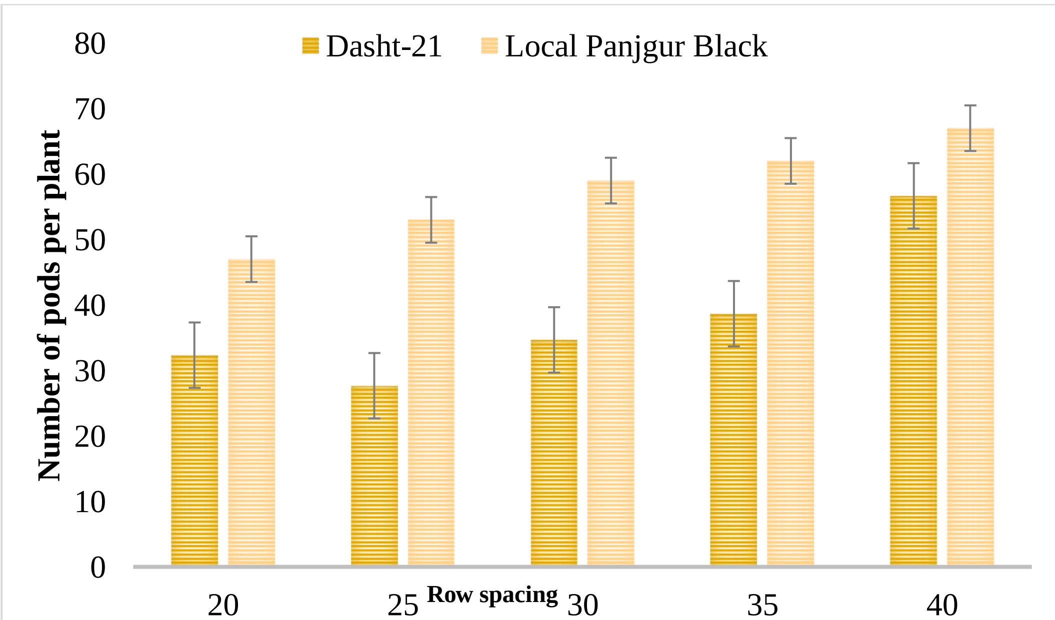

Figure: 11. Effect of row spacing on number of pods per plant of two lentil varieties

Single Pod Weight: The effect of different row spacing on the pod weight of two lentil varieties (Dasht-21 and Local Panjgur Black) was checked. The results showed the weight was not significantly varied (P>0.05) among both varieties. The weight was also non-significantly varied (P>0.05) due to different row spacing. Moreover, the interaction of both varieties and row spacing on the pod weight was non-significant (P>0.05).

Pod Yield Per Plant: The study investigated the effect of different row spacing on the pod yield per plant for two lentil varieties: Dasht-21 and Local Panjgur Black. The results indicated a significant variation in pod yield between the two varieties (P<0.05) and across different row spacing. Moreover, the interaction between the varieties and row spacing had significant results (P<0.05). Figure 12 highlights that the Local Panjgur Black variety had the highest number of pods with 36.5 pods per plant, while Dasht-21 had the lowest, at 31.13 pods. Regarding row spacing, the maximum number of pods was observed at a spacing of 40 cm, averaging 44.33 pods, followed by 35 cm spacing with 48.3 pods, 30 cm with 37.00 pods, 25 cm with 24.176 pods, and the lowest at 20 cm spacing, which recorded also 22.8 pods. Moreover, the interaction of row spacing and varieties showed that the highest number of pods were noted in the case of the Local Panjgur Black variety sown at a space of 40 cm (46.33 pods) were as lowest were noted in Dasht-21 sown at 20 cm row spacing (21.67 pods). The Local Panjgur Black cultivar has the highest yield of the two types. Genetic potential and environmental conditions may be the cause of the variance between types. Additionally, Derogar and Mojaddam (2014) examined yields from various varieties and found nofigure variations. According to Abdalla *et al*. (2015), the agroecological environment has a significant impact on the fava bean crop's yield. These findings are in line with those of Idri (2008) on fava beans and Seyyed *et al.* (2014) on lentils, which showed that increasing plant spacing led to more pods per plant and, as a result, maximum seed production. Because a larger plant population with 30 cm row spacing compensates for the yield, a greater yield was attained when the crop was seeded at 30 cm. However, with a 20-cm spacing between crops, there may be more competition for resources, which might lead to poor individual performance and a lower yield. Therefore, compared to crops that are closely spaced, where plants may have suffered from reciprocal shadowing in the case of contiguous rows, and more plants in the case of broader row spacing, optimal row spacing has successfully used the growth resources, especially solar radiation. These results were consistent with those of Murade *et al*. (2014) and Bhairappavar *et al*. (2005). The paddy is among the mulching by effectively utilizing sun radiation, nutrients, water, land, and air spaces, an ideal spacing can guarantee that the plant's aerial and subsurface components grow properly. It is advised to space outline sowing to maintain the necessary plant population and to carry out intercultural activities to harvest a larger yield. According to Ouji *et al*. (2016), increasing row spacing results in higher plant yields.

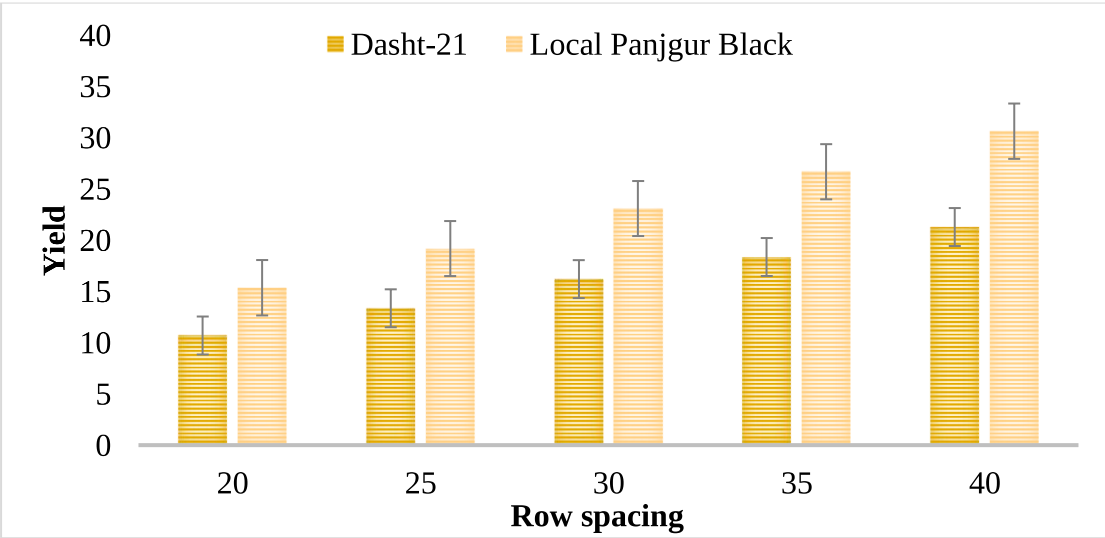

Figure: 12. Effect of row spacing on number of pod yield per plant of two lentil varieties

Seed Yield: The study investigated the effect of different row spacing on the yield of two lentil varieties (Dasht-21 and Local Panjgur Black). The results indicated a significant variation in seed yield between the two varieties (P<0.05) and across different row spacing. Moreover, the interaction between the varieties and row spacing had significant results (P<0.05). Figure 13 highlights that the Local Panjgur Black variety had the maximum seed yield (1411.7 kg/ha), while Dasht-21 had the lowest seed yield (1170.1 kg ha^{-1}). Regarding row spacing, the maximum yield was observed at a spacing of 40 cm (1616.5 kg ha^{-1}) followed by 35 cm spacing (1157 kg ha^{-1}), 30 cm (1200 kg/ha), 25 cm (1077 kg ha^{-1}), and the lowest at 20 cm spacing (1002.5 kg ha^{-1}). Moreover, the interaction of row spacing and varieties showed that the maximum seed yield was noted in the case of the Local Panjgur Black variety sown at a space of 40 cm (1709.7 kg ha^{-1}) were as lowest was noted in Dasht-21 sown at 20 cm row spacing (880.7 kg ha^{-1}). The maximum grain yield was seen in Local Panjgur black. There are various possible explanations for this, including large plant populations, genetic variety, and adaptation. According to Rathika and Ramesh (2023), increased plant population and genetic variety may be responsible for high yields of grains in green gram. Singh *et al.* (2003) also observed comparable findings.

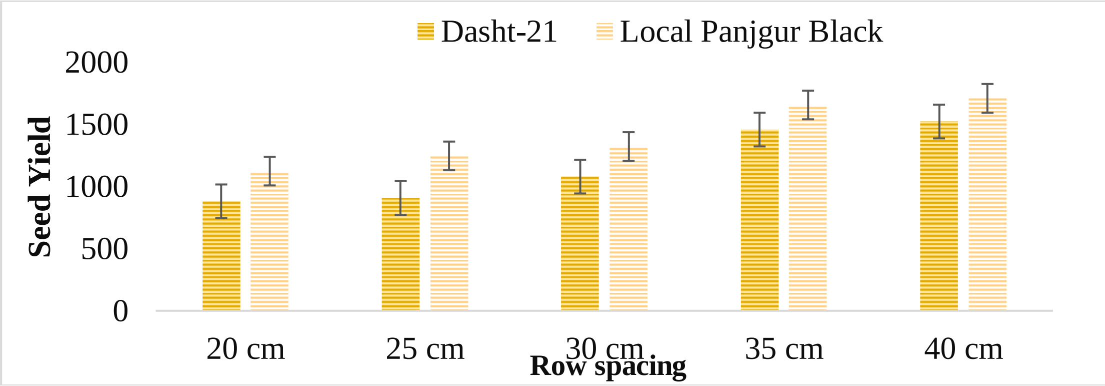

Figure: 13. Effect of row spacing on grain yield of two lentil varieties

Biological Yield (Kg/ha): The study investigated the effect of different row spacing on the yield of two lentil varieties: Dasht-21 and Local Panjgur Black. The results indicated a significant variation in biological yield between the two varieties ($P<0.05$) and across different row spacing. Moreover, the interaction between the varieties and row spacing had significant results ($P<0.05$). Figure 14 highlights that the Local Panjgur Black variety had the maximum biological yield, while Dasht-21 had the lowest biological yield. Regarding row spacing, the maximum yield was observed at a spacing of 40 cm followed by 35 cm spacing, 30 cm, 25 cm, and the lowest at 20 cm spacing. Moreover, the interaction of row spacing and varieties showed that the maximum seed yield noted in the case of the Local Panjgur Black variety sown at a space of 40 cm (46.33 pods) were as lowest was noted in Dasht-21 sown at 20 cm row. In the current study, local Punjgir demonstrated a high biological output, which may be attributed to high plant biomass production and varied genetic composition. Kindie and Nigusie (2018) reported similar results. Rathika and Ramesh (2023) reached a similar finding, stating that varying environmental conditions induce variances in yield performance across cultivars. The yield obtained from the studied cultivars clearly demonstrates the area's potential for production. The best biological yield was obtained when seeds were sowed at a row spacing of 40 cm. Optimal plant population density is a key aspect in realizing potential yields since it directly influences plant growth and development. Because there is minimal competition between adjacent plants when plants are widely spread, biological yields tend to grow linearly as plant density increases. In this study, total biomass might be obtained by growing more plants with higher plant population density. According to Ramroodi *et al.* (2008), correct plant density has a significant impact on agricultural output. Furthermore, proper plant density is critical, since having fewer plants per unit space may result in a poorer overall yield. Because of a greater leaf area index and improved solar radiation absorption, it appears that the optimal increase in plant density increased dry matter accumulation per unit area.

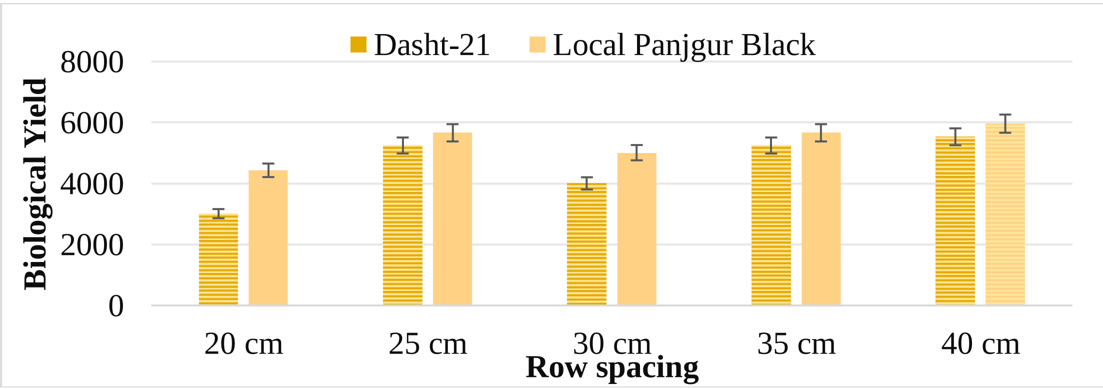

Figure: 14. Effect of row spacing on biological yield of two lentil varieties

CONCLUSION

The study compared the growth characteristics of two lentil types, Local Panjgur Black and Dasht-21, with varying row spacing. Local Panjgur Black consistently outperformed Dasht-21 in a variety of metrics, including the highest number of leaves (10.86 leaves per plant at 60 days and 20.80 leaves at 75 days), branches (1.46 branches per plant), plant height (34.00 cm), and pod dimensions (20.133 cm length and 11.33 cm width). The most leaves and branches were found at a spacing of 40 cm, which also resulted in the tallest plants (38.00 cm) and the most pods (57.60 per plant). Local Panjgur Black variety outperformed Dasht-21 in terms of pod production, seed yield, biological yield, moisture content, and carbohydrate content. Local Panjgur Black had the highest number of pods per plant, with an average of 57.60 pods, while Dasht-21 had the lowest, with an average of 38.00 pods. The optimal row spacing for maximum pod production and seed yield was found to be 40 cm, which resulted in an average of 44.33 pods per plant and a seed yield of 1616.5 kg ha^{-1}. In contrast, the 20 cm row spacing yielded the lowest results for both varieties.

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