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ENHANCING LENTIL (LENS CULINARIS) YIELD THROUGH SEED RATE ADJUSTMENT UNDER QUETTA'S AGRO-CLIMATIC CONDITIONS

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Article Info

Abstract

Increasing crop yield requires optimizing the seed rate, particularly in regions with unique agroclimatic factors. The yield of lentil (Lens culinaris) cultivars in Quetta, a semi-arid region with fluctuating temperatures and little rainfall, is examined in this study in relation to different seed rates. The optimal planting density for each of the four lentil cultivars was determined by testing them with different seed rates. To take environmental variability into consideration, the experiment was conducted over two growth seasons. The findings demonstrated important variation in yield across seed rates, with both under and overdoing leading to less-than-ideal plant growth and production losses. The importance of adjusting planting density to the unique genetic traits of each lentil variety was highlighted by the fact that different varieties had different ideal seed rates for maximizing yield. The results indicate that lentil productivity can be greatly increased by modifying seed rates in accordance with regional climate and variety types. For lentil farmers in Quetta and other areas with comparable climates, this study offers insightful information and useful suggestions for increasing yields through optimal seed rates. To assess the long-term impacts of different seed rates on soil health and overall agricultural sustainability in semi-arid environments, more research is advised.

Keywords:
Seed Rate Optimization, Agro-Climatic Conditions of Quetta, Lentil Yield.

1. Introduction

The legume family includes approximately 19,300 species across three large subfamilies, of which Papilionoidea stands out with 13,800 species. Lentils were one of the first crops to be domesticated by humans, approximately 11,000 BP. They are diploid legumes that belong to the Papilionoidea subfamily and are of agricultural importance because of their resistance to drought and the fact that they grow in soil with a pH range of 5.5–9; therefore, they are cultivated in various types of soil, and so they have an important role in sustainable food and feed systems in many countries. In addition to their agricultural importance, lentils are a rich source of protein, carbohydrates, fiber, vitamins, and minerals. They are key to human nutrition since they are an alternative to animal proteins, decreasing meat consumption. Another characteristic of legumes, including lentils, is their ability to form nodules, which gives them a growth advantage in nitrogen-deficient soils because they enable the plant to fix atmospheric nitrogen, thus contributing nitrogen to the soil and facilitating the nutrition of other plants during intercropping. Lentils have also been applied for protection against various human diseases, as well as for phytoremediation, and they also have been applied as environmental bioindicators to identify cytotoxicity [1].

Despite being an important source of food and feed, seeds are essentially an important delivery system of genetic information. Seed quality is a crucial determining factor of yield and quality of crop production. Good quality seed is superior to other standard seeds in genetic and physiological purity and is free from seed-borne diseases and disorders. The quality of the seeds is determined by the interaction of several genetic and environmental factors and climatic changes significantly affect seed characteristics. Improving quality seeds effectively and efficiently is a challenge to increasing food demand [2]. Seed quality is a complex trait and novel research approaches to improve seed quality involve a combination of seed technologies, genetics, and molecular biology. Some of the classical methods of seed improvement include coating, pelleting, priming, and production of artificial seed. The development of hybrid seed varieties that adapt to unfavorable climatic conditions and are resistant to a range of pests and diseases is at the forefront of the seed industry in improving crop yield. Hybrid seed varieties of rice, wheat, corn, barley, soybean, and diverse field crops are commonly used in various regions of the world for enhanced crop yield [3]. Modern gene technology methods are being used to modify (GM) crops/seeds genetically to carry one or more beneficial traits such as herbicide and insect resistance, better resistance to drought/waterlogging, and modified nutritional profiles. Research on genetics of seed development and the chemistry of seed reserves is an essential need in developing new technologies for crop improvement [4].

Quetta Subbasin is situated in the upper highlands climatical zone with semi-arid 24 climatic features [5]. The mild to hot summers and harsh winters are classified as "sub-tropical continental highland" climates. Winter spans from October to March, having a mean temperature of 3-5ºC. Spring is from April-May having a 15ºC temperature. May-September is Summer having temperatures from 24-27ºC, and September-November is autumn having 12ºC (Climate and geography of Quetta, 2010). From 1980-2020, the cumulative yearly average temperature of Quetta increased from 24.2-25.8oC. Arid to semi-arid climatic characteristics of Quetta have an extreme difference between summer and winter temperatures that made it inhospitable, as shown in Figure 1. As per rainfall, November is the wet month and 80% of precipitation falls in the wet season. The yearly average rainfall of 213 mm and snowfall is 15% of it. Quetta received 950 mm of record precipitation during 1982-1983, (Pakistan Meteorological Department, 2021a). Quetta Valley was devastated by drought from 1997-2004, the yearly precipitation was 40-70% below average. In 2009 and 2011 there was the heaviest annual rainfall of 317 and 437 mm (Pakistan Meteorological Department, 2021b). Rainfall of 55 mm decreased in the last 35 years from 1975- 2009, [6].

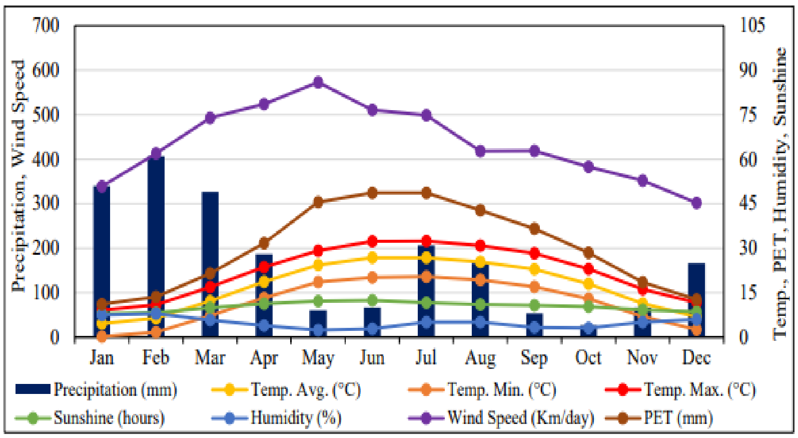

Figure 1.1: Average monthly graphs of precipitation, temperatures, sunshine hours, wind speed, humidity, and PET [7].

The soil in Quetta is generally low in moisture retention capacity due to its arid conditions. This leads to challenges in sustaining crop growth, particularly for water-sensitive crops like lentils. Soil moisture conservation techniques are essential for improving yields in such environments [8].Lentil is sown as a cool-season crop, and is highly susceptible to rising temperatures. It needs low temperatures at the time of vegetative growth, while maturity requires warm temperatures; the best temperature for its optimum growth has been found to be 18–30°C [9]. Lentil is also grown in relatively warmer regions in central and southern parts of India, where the crop is exposed to supra-optimal temperatures that reduce its yield potential [10]. Moreover, it has been observed that the chilling periods are becoming shorter and the heat periods are becoming longer, further resulting in exposure of cool-season crops to heat stress, particularly in the reproductive stage [11]. Heat stress can affect the growth, development, metabolism and productivity of plants [11].Heat stress causes various physiological changes in plants such as leaf and stem scorching, leaf abscission and senescence, shoot and root growth inhibition, reduction in the number of flowers, inhibited pollen tube growth, pollen infertility, and fruit damage, leading to catastrophic losses in crop yields [12], [13]; [14]. Above-normal temperatures also affect membrane stability, water relations, photosynthesis, respiration and modulate the concentration of hormones, and primary and secondary metabolites [14].The research specifically targets the optimal seed rate for various lentil varieties in the agro-climatic conditions of Quetta. The objective of the research is to evaluate how different seed rates affect the yield performance of various lentil varieties under Quetta's agro-climatic conditions. Evaluate how different seed rates affect the yield performance of various lentil varieties under Quetta's agro-climatic conditions. For the sowing of lentils in rows in Ethiopia, a spacing of 20–25 cm between rows and 2.5–5.0 cm between plants has been recommended. On the other hand, the seed rate for the broadcast method appeared to vary depending on seed size and growth habits. Accordingly, a larger seed size requires higher seed rates than a smaller seed size. Thus, a seed rate of 50–65 kg/ha for small-seeded, 65–80 kg/ha for medium-seeded, and up to 80–120 kg/ha for large-seeded lentil cultivars has been recommended on a blanket basis [13]. However, farmers in the study area are using higher seed rates (>100 kg/ha for all varieties) than the blanket recommendations. This is probably related to the absence of recommendations for broadcast planting of lentils on a broad bed and furrow production system where more field loss is expected.

2. Materials and Methods

2.1. Research area

A field experiment on the Evaluation of the response of seed rate to the yield of lentil (lens culinaris l.) varieties under the Agro-climatic conditions of Quetta was conducted on 20 of December 2024 at the Agriculture Research Institute (ARI) Quetta.

2.2. Varieties

1. V1= Local Panjgur black
2. V2= Dasht-21

2.3. Seed rates

1. S1= 7 kg acre^{-1}
2. S2= 10kg acre^{-1}
3. S3= 13kg acre^{-1}
4. S4= 16kg acre^{-1}

2.4.Layout

Randomized Complete Block Design (RCBD) was used with two varieties namely Local Panjgur black and Dasht-21 and four seed rates of 7kg acre^{-1}, 10kg acre^{-1}, 13kg acre^{-1} and 16kg acre^{-1} with three replications. Composite Soil sample was taken and tested at Department of Soil and Water Testing ARI. Soil was sandy clay loam with pH 7.93, EC 0.98 dS/m and organic matter 0.68%. Plot size was kept at 4 x 4m^2. Crop was cultivated maintaining the recommended row to row distance of 30cm. NPK was applied at recommended dose of 20:50:30 kg ha^{-1} and weeding was performed. Field was irrigated according to the need throughout the experiment.

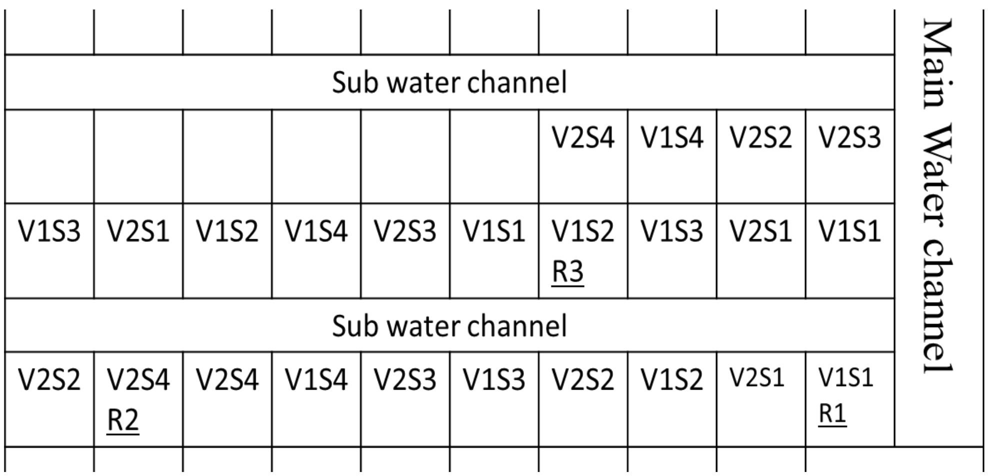

Figure 2.1: Layout of experiment

2.5. Agronomic Observations

Five plants from each plot were randomly chosen and labeled to record observations on various agronomic characteristics. When observations on growth metrics were recorded and the crop attained full physiological maturity, the crop was harvested. The marked plants were manually picked, and bundled in short bundles. Manual threshing was used. Following agronomic parameters were recorded. To calculate the germination time, the period was noted from sowing to germination of plants and the time, the period was noted from sowing to 50% flowering of plants.

To calculate the days to maturity days, the period (in days) was noted from sowing to 90% chlorosis of the plant. Plant height was calculated with the help of measuring tap when the plant reached maturity. Three plants from each plot were randomly picked, and the numbers of pods were counted. Three plants from each plot were randomly picked, and the numbers of grains were counted. To measure weight, 100 seeds were taken and weight was calculated with digital balance. After harvesting the crop from each plot, the total grain production was recorded and converted to Kg acre^{-1}.

The following quality parameters were determined.

- The AOAC method was used to evaluate the protein contents (Anon., 1990).
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The collected data was subjected to statistical analysis using Statistic 8.1. The LSD test was applied to compare treatments' superiority, where necessary.

3. Results and Discussions

3.1. AGRONOMIC PARAMETERS

3.1.1. Day to germination

The results of the analysis of variance showed that the tested varieties had significantly different germination days. The different seed rates had a significant impact on germination days. Moreover, the interaction between seed rates and varieties was also significant as shown in Table 3.1.1(a). The local Panjgur black variety took fewer days (5.33 days) to germinate as compared to the Dasht-21 variety (7.33 days) as shown in table 3.1.1 (b). The lentil plants took fewer days (5.83 days) to germinate in blocks in which seeds were applied at a rate of 13 kg/ acre followed by 16 kg/acre (5.50 days), 10 kg/ acre (7.00) and 7 kg/acre (7.00 days) as represented in table 3.1.1 (c). Mean comparison of days to germination of different lentil varieties under different seed rates showed that the Panjgur black plants took a few days to germinate at a seed rate of 13 kg/acre whereas maximum days were taken by Dasht-21 plants when sown at a seed rate of 7 kg/acre (table 3.1.1 d).

The local Panjgur variety germinates early as compared to Dasht-21 this might be due to genetic variability. Similar results were reported by Shah et al. (2013) who noted that the different varieties of lentils take different times to germinate due to genetic variability [15]. Mandi et al. (2015) also reported the difference in germination time of different lentil varieties. Among tested seed rates, the best results in terms of germination were noted at a seed rate of 13 kg/acre. This might be due to optimum plant density as a high seed rate results in a high plant population which increases competition among plants for resources [16].

Table 3.1 (a): Analysis of variance of days to germination of two lentil varieties under different seed rates

Source	DF	SS	MS	F	P
Blocks	2	0.583	0.291		
Lentil Varieties	1	24.00	24.00	82.29	0.000**
Seed Rates	3	11.00	3.67	12.57	0.000**
Lentil Varieties × Seed Rates	3	3.67	1.22	4.19	0.026*
Error	14	4.08	0.2917		
Total	23	43.33			

* = Significant at 5% **= Highly Significant at 1% Non-Significant= ^{NS}

Table: 3.1(b): Mean comparison of days to germination of lentil varieties

Sr no	Varieties	Mean
1	Local Panjgur black	5.33 b
2	Dasht-21	7.33 a

Values with the same letters are not significantly different from each other

Table 3.1 (c): Mean comparison of impact of seed rates on days to germination of lentil

Sr no	Seed rates	Mean days to germination
1	16 kg acre^{-1}	5.83 b
2	13 acre^{-1}	5.50 b
3	10 kg acre^{-1}	7.00 a
4	7 kg acre^{-1}	7.00 a

Values with the same letters are not significantly different from each other

Table 3.1(d): Mean comparison of days to germination of different lentil varieties under different seed rates

Sr no	Varieties	Seed rates	Mean day to germination
1	Local Panjgur black	16 kg acre^{-1}	5.00 d
2	Local Panjgur black	13 kg acre^{-1}	4.67 d
3	Local Panjgur black	10 kg acre^{-1}	5.33 d
4	Local Panjgur black	7 kg acre^{-1}	7.67 b
5	Dasht-21	16 kg acre^{-1}	6.67 c
6	Dasht-21	13 kg acre^{-1}	6.33 c
7	Dasht-21	10 kg acre^{-1}	6.33 c
8	Dasht-21	7 kg acre^{-1}	8.67 a

3.1.2 Days to 50% flowering

The analysis of variance revealed significant differences in the time to 50% flowering among lentil varieties and seed rates, though their interaction was not significant. The local Panjgur black variety flowered earlier (141 days) than Dasht-21 (151.33 days). Among seed rates, 13 kg acre^{-1} led to the earliest flowering (141 days), followed by 16, 10, and 7 kg acre^{-1}. The combination of Panjgur black at 13 kg acre^{-1} resulted in the fastest flowering (135.33 days), while Dasht-21 at 7 kg acre^{-1} was the slowest (155.67 days). Early flowering in the Panjgur variety is attributed to genetic and environmental factors. Prior studies support these findings, emphasizing that both variety and optimal seed rate significantly influence flowering time. Higher or lower than optimal seed rates can delay flowering due to increased competition or poor establishment.

Table 3.2 (a): Analysis of variance of days to 90% maturity of two lentil varieties under different seed rates

Source	DF	SS	MS	F	P
Blocks	2	20.33	10.17		
Lentil Varieties	1	1107.04	1107.04	877.28	0.000**
Seed Rates	3	348.46	116.15	92.05	0.000**
Lentil Varieties × Seed Rates	3	30.46	10.15	8.05	0.002**
Error	14	17.67	1.26		
Total	23	1523.96			

* = Significant at 5% **= Highly Significant at 1% Non-Significant= NS

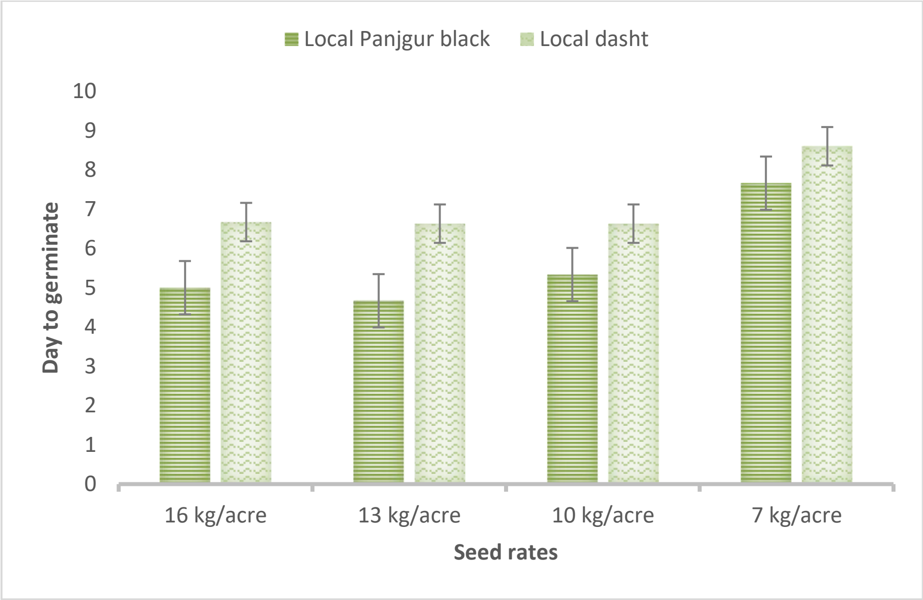

Figure: 3.1: Days to germinate taken by different lentil varieties under different seed rates

3.1.3 Plant Height (cm)

The analysis of variance showed significant differences in plant height among lentil varieties and seed rates, but their interaction was not significant. The Local Panjgur black variety had the tallest plants (34.75 cm), while Dasht-21 had the shortest (26.50 cm). The tallest plants were observed at a seed rate of 13 kg/acre, followed by 16, 10, and 7 kg/acre. The superior height of Local Panjgur is attributed to its genetic makeup and adaptability to Baluchistan's agro-climatic conditions. Previous studies support that plant height varies with genetic differences. Reduced plant height at lower seed rates may be due to fewer branches and reduced competition, while very high seed rates may increase competition for light, affecting stem thickness and height. Optimal seed rate promotes better plant height by balancing intra-plant competition and light penetration.

Table 3.3 (a): Mean comparison of plant height of different lentil varieties under different seed rates

Sr no	**Varieties**	**Seed rates**	**Mean plant height**
1	Local Panjgur black	16 kg acre^{-1}	34.67 b
2	Local Panjgur black	13 kg acre^{-1}	39.33 a
3	Local Panjgur black	10 kg acre^{-1}	32.44 bc
4	Local Panjgur black	7 kg acre^{-1}	26.33 de
5	Dasht-21	16 kg acre^{-1}	32.67 bc
6	Dasht-21	13 kg acre^{-1}	29.33 cd
7	Dasht-21	10 kg acre^{-1}	26.67 de
8	Dasht-21	7 kg acre^{-1}	23.67 e

Values with the same letters are not significantly different from each other

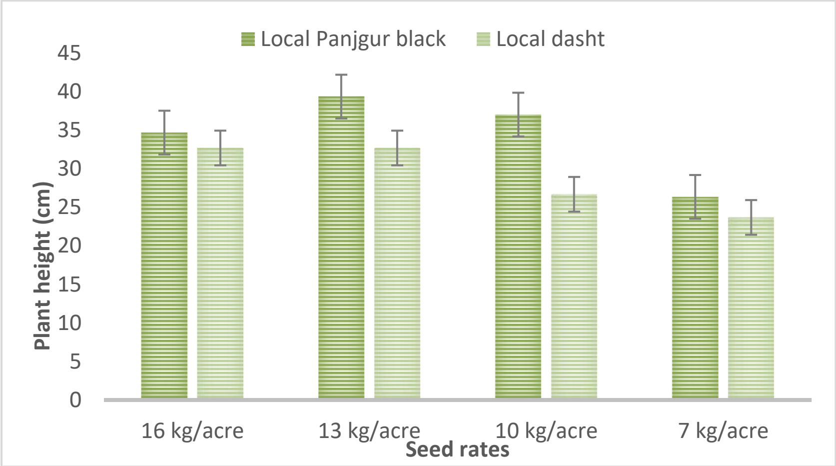

Figure 3.2: Plant height of different lentil varieties under different seed rates

3.2 Qualitative parameters

3.2.1 Protein contents (mg/100 g)

The analysis of variance displayed a significant variation in protein contents among the examined varieties and seed rates. However, the combined effect of seed rate and varieties had non-significant impact on the protein contents, as depicted in table 4.2.1 (a). In the present study, the Local Panjgur black variety showed the highest protein contents (26.89 mg/100g), while the Dasht-21 variety exhibited the lowest protein contents (25.36 mg/100g). Upon assessing the different seed rates, it was apparent that the maximum protein contents were recorded at a seed rate of 13 kg/acre (26.42 mg/100g), whereas the minimum contents were observed at the 7 kg/acre seed rate (25.82 m/100g). Agronomic techniques, environmental variables, and genetic composition might all have an impact on this variation in protein content between the two varieties of lentils. The Local Panjgur variety genetic makeup might have certain characteristics or alleles that support increased protein synthesis or accumulation in the seeds. Similar results were reported by Zia-Ul-Haq et al. (2011) who noted the variation in protein contents of different lentil varieties. Among tested seed rates, 13 kg/acre results in high protein contents. Similar results were reported by Bekele et al. (2020) who reported the high protein contents at optimum seed rate. Similar, results were reported by Ayub et al. (2003) who noted that the optimum seed rate results in high protein contents in sorghum.

Table 3.4 (a): Analysis of variance of protein contents of two lentil varieties under different seed rates

Source	DF	SS	MS	F	P
Blocks	2	0.0084	0.0042		
Seed rates	3	1.2243	0.4081	27.62	0.0000
Lentil Varieties	1	14.0607	14.0607	951.58	0.0000
Lentil Varieties × Seed Rates	3	0.0841	0.0280	1.90	0.1763^{NS}
Error	14	0.2069	0.0148		
Total	23	15.5845			

* = Significant at 5% **= Highly Significant at 1% Non-Significant= NS

Table 3.4 (b): Mean comparison of protein contents of lentil varieties

Sr no	Varieties	Mean protein contents
1	Local Panjgur black	26.887 a
2	Dasht-21	25.356 b

Values with the same letters are not significantly different from each other

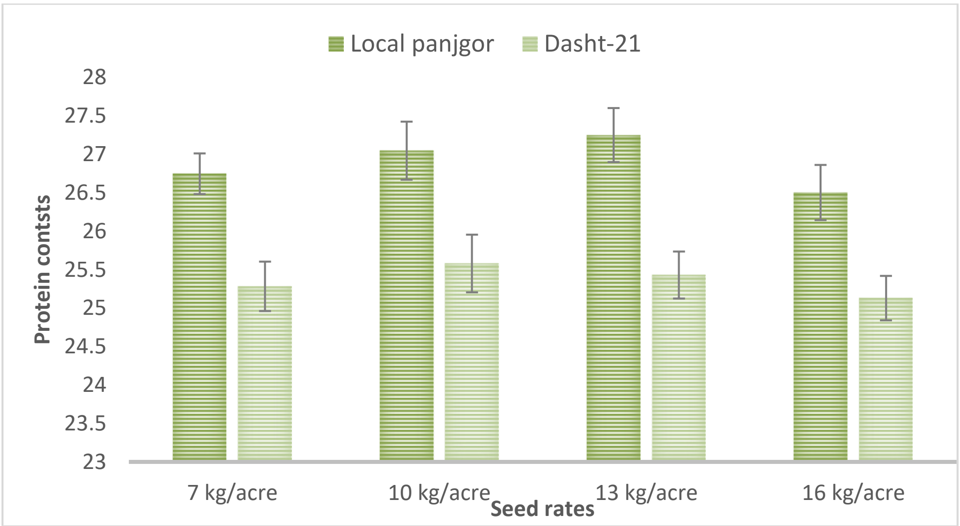

Figure 3.3: Total Protein contents of different lentil varieties under different seed rates

3.2.3 Moisture contents

The results showed a non-significant difference in moisture contents of tested varieties. Similarly, a non-significant impact of seed rate on the moisture content of lentils was observed. Moreover, the interaction between seed rates and lentil varieties on moisture contents was also non-significant as shown in table 3.2.1 (a).

Table 3.5(a): Analysis of variance of moisture contents of two lentil varieties under different seed rates

Source	DF	SS	MS	F	P
Blocks	2	5.0833	2.54167		
Lentil Varieties	1	6.000	6.0000	7.69	0.0149**
Seed Rates	3	0.5000	0.1667	0.21	0.855^{NS}

Lentil Varieties × Seed Rates	3	9.333	3.1111	3.99	0.0302^{NS}
Error	14	109167	0.77976		
Total	23	31.8333			

* = Significant at 5% **= Highly Significant at 1% Non-Significant= NS

Table 3.5(b): Mean comparison of moisture contents of lentil varieties

Sr no	**Varieties**	**Mean moisture contents**
1	Local Panjgur black	12.583 a
2	Dasht-21	11.583 b

Values with the same letters are not significantly different from each other

Table 3.5(c): Mean comparison of impact of seed rates on moisture contents of lentil

Sr no	**Varieties**	**Mean moisture contents**
1	16 kg acre^{-1}	12.167 ^{NS}
2	13 acre^{-1}	12.167
3	10 kg acre^{-1}	12.167
4	7 kg acre^{-1}	11.83

Values with the same letters are not significantly different from each other

Table 3.5 (d): Mean comparison of moisture contents of different lentil varieties under different seed rates

Sr no	**Varieties**	**Seed rates**	**Mean moisture contents**
1	Local Panjgur black	16 kg acre^{-1}	12.67 ab
2	Local Panjgur black	13 kg acre^{-1}	13.33 a

3	Local Panjgur black	10 kg acre^{-1}	12.67 ab
4	Local Panjgur black	7 kg acre^{-1}	11.00 c
5	Dasht-21	16 kg acre^{-1}	12.67 ab
6	Dasht-21	13 kg acre^{-1}	11.67 bc
7	Dasht-21	10 kg acre^{-1}	11.67 bc
8	Dasht-21	7 kg acre^{-1}	11.00 c

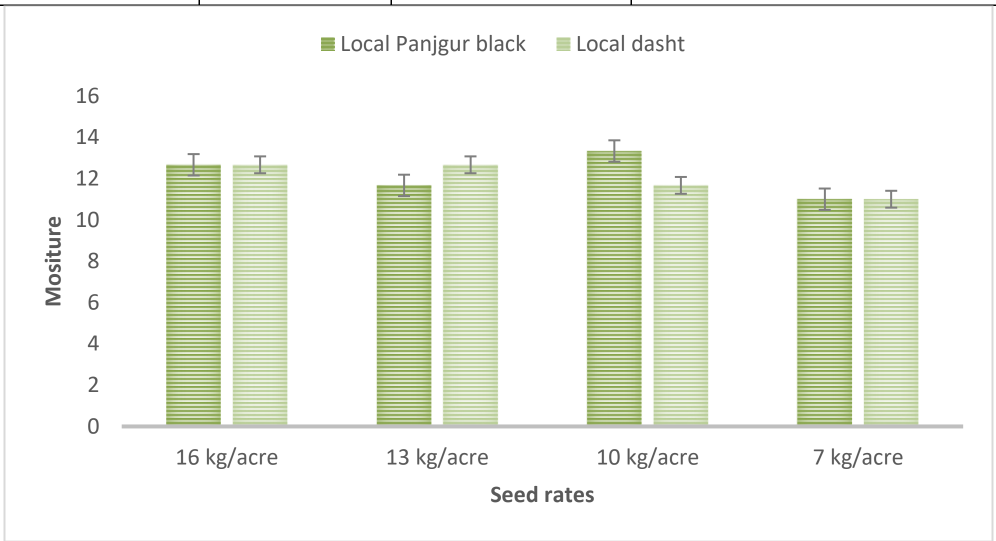

Figure 3.4: Moisture contents of different lentil varieties under different seed rates

Conclusion:

The findings of this study clearly highlight the superior performance of the Local Panjgur black lentil variety over the Dasht-21 variety under the agro-climatic conditions of Balochistan. Local Panjgur black consistently demonstrated earlier germination, quicker flowering, and faster maturity, which are crucial traits for adapting to environments with shorter growing seasons or limited water availability. These advantages are largely attributed to its favorable genetic makeup and better adaptation to local environmental conditions. Among the tested seed rates, 13 kg/acre emerged as the optimal rate for maximizing crop performance. This seed rate consistently produced the best results across multiple parameters including germination time, flowering duration, plant height, pod number, seed count per pod, 100-seed weight, grain yield, and nutritional quality (protein and carbohydrate content). The improved performance at this rate can be linked to a balanced plant population that minimizes inter-plant competition while ensuring sufficient space and resources for optimal growth and development.

In contrast, both lower seed rates (such as 7 kg/acre) and higher ones (like 16 kg/acre) negatively affected plant growth and yield. Lower seed rates likely resulted in poor stand establishment and underutilization of available space, while higher rates intensified intra-plant competition for nutrients, light, and moisture, leading to suppressed plant vigor and reduced productivity. Furthermore, the Local Panjgur black variety not only showed better agronomic performance but also superior nutritional quality, with higher protein and carbohydrate content. These traits make it a promising candidate for both food security and nutritional improvement initiatives.

Overall, the combination of the Local Panjgur black variety with a seed rate of 13 kg/acre is recommended for lentil cultivation in Balochistan, and possibly similar agro-ecological zones. This combination ensures enhanced growth, early maturity, better yield, and improved grain quality, making it a viable option for farmers seeking to optimize production under resource-constrained conditions.

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