

Effect of Different Concentrations of Sulphur on the Economic Yield of Three Chickpea (*Cicer Arietinum*) Varieties

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Abstract

Chickpea is a major pulse crop in Pakistan, where it is grown from high-yield seeds in soil with plenty of water and all the necessary nutrients. Sulphur is the fourth major nutrient essential for biosynthesis, metabolism, and chlorophyll production. The high levels of sulphur create ideal conditions for growing crops, boosting their vitality, growth rate, and yields. The experiment was conducted at the field of University of Agriculture, Faisalabad Pakistan, to examine the effect of different concentrations of sulphur on the economic yield of three chickpea varieties (*Cicer arietinum*). Seeds of three chickpea (*Cicer arietinum*) varieties, Noor-19, Bittal-21, and Bittal-16 were collected from the Ayub Agricultural Research Institute in Faisalabad, Pakistan. The design of the experiment was a completely randomized design (CRD) with factorial arrangements having two factors: chickpea varieties (Noor-19, Bittal-21, and Bittal-16) and different levels of sulphur (120 mg and 240 mg) that were applied at the flowering stage. The data regarding PH (cm), RL (cm), 100 SWT (g), SL (cm), RFW (g), SDW (g), RDW (g), SFW (g), BY (%), EY (%), HI (%) and chlorophyll a, b, and c (%) were recorded during the growth period and at the time of harvest. The data was analyzed through Tukey's test for statistical analysis to see the variation among treatments.

INTRODUCTION

Chickpea, technically known as *Cicer arietinum*, is a member of the Fabaceae family, sometimes known as the legume, pea, or bean family. The *Fabaceae* family, which includes peas, beans, lentils, soybeans, peanuts, and clover, is one of the largest and most commercially significant plant groups (Singh et al., 2022). Chickpeas are annual leguminous plants grown for their edible seeds, which are also known as chickpeas or garbanzo beans. Legumes are significant food crops (Jimenez-Lopez et al., 2020). It is a widespread family cultivated on over 130 million hectares globally. Legumes possess significant amounts of fiber, energy, and protein, contributing to roughly 1/3rd of the dietary protein and processed vegetable oil consumption in humans (S. Kumar et al., 2022). Beans, lentils, and chickpeas are just a few examples of the necessary proteins and amino acids found in legumes. They also include trace elements and minerals like potassium, calcium, phosphorus, and vitamins D, B₁, B₂, A, C, and PP (Roorkiwal et al., 2021). These nutrients are essential for maintaining healthy bones, working muscles, and controlling fluids. Legumes benefit a healthy, balanced diet since they promote overall well-being (TRIPATHI, 2024). *Cicer arietinum* is known by various names in many countries, including chana (Hindi) and gramme or Bengal gramme (English). It is also known as 'nakhut' or 'nohut' in several places worldwide (Turkey, Romania, Bulgaria, and Afghanistan). Chickpeas are cultivated in around fifty-seven countries worldwide under varying environmental conditions (Koul et al., 2022). With 80% of the regional contribution, South and Southeast Asia lead in chickpea production. Although affluent nations contribute little to chickpea production, yields in several Eastern European countries are notably high. China likewise had a high production level of 4,537 kg ha⁻¹ from 2013 to 2017 (Fikre et al., 2020). Chickpeas are abundant in iron, zinc, magnesium, and calcium. A 100 g serving of chickpeas can fulfill the daily iron and zinc requirements, while a 200 g serving can fulfill the daily magnesium requirement. There are two types of

chickpeas cultivated globally: desi and Kabuli chickpeas (Zhang et al., 2024). Kabuli chickpeas are characterized by large, cream-colored seeds with thin seed coats, while Desi has smaller brown seeds with thick seed coats. Chickpea varieties include Desi and Kabuli. In South Asia, chickpeas are commonly used in dal, although it is popular in many areas worldwide (Yegrem, 2021).

Kabuli varieties are characterized by their tall stature, large cream or beige-colored seeds, and white flowers. Desi varieties exhibit reduced height and smaller leaflets, pods, and seeds (Eker et al., 2022). The blooms primarily exhibit a pink coloration. Desi types exhibit more significant variability in the color of their seed, pod, flower, and vegetative components, as well as in the shape and surface characteristics of their seeds, compared to Kabuli types. The Kabuli chickpea is believed to have originated from desi varieties (Kenea & Mohammed, 2023).

Chlorosis is a severe condition that affects plants, causing yellowing, passing away, and disappearance (Hossain et al., 2021). It is a significant barrier to sustainable agricultural production in Asia due to high-yielding crop types, sulphur-free fertilizers, irrigation water misuse, low atmospheric sulphur deposition, winter rainfall, and acid soils (Gerson & Hinckley, 2023). Sulphur is essential for plant growth, photosynthesis, respiration, and nitrogen fixation. Insufficient sulphur availability can hinder plant growth, seed maturation, and productivity. Optimal sulphur levels during vegetative growth and canopy formation can increase photosynthetic surface area, enabling the synthesis of carbohydrates and allocation to seed development (Mustafa et al., 2022).

Optimal sulphur levels can also impact plant reproduction, such as pollen development, pollination, and fertilization (Beltrán et al., 2023). A deficiency in sulphur can lead to decreased pollen viability, hindering pollination and reducing seed output. The harvest index of chickpeas can be increased through the adequate supplementation of sulphur and other essential nutrients (MEKONNEN, 2018). Soil testing and nutrient management techniques are employed to assess sulphur requirements for optimal growth, enabling the application of appropriate fertilizers (Ullah et al., 2020).

MATERIALS AND METHODS

The study examined growth parameters, yield parameters, and economic parameters of plants in which PH (cm), RL (cm), 100 SWT (g), SL (cm), RFW (g), SDW (g), RDW (g), SFW (g), chl a, b, and c (%), and pods were measured. Economic parameters Included Economic Yield, Biological Yield, Harvest Index, and Chlorophyll Contents. The study used ANOVA and Tukey's (HSD) test to compare treatment means at a 5% level of significance. Economic yield was evaluated by calculating the weight of harvested crops and the total biological yield. The harvest index was calculated by weighing the harvested crop and the total biological yield. Chlorophyll contents were measured after leaf growth and compared using spectrophotometers. Statistical analysis used ANOVA and Tukey's (HSD) test to compare treatment means at a 5% level of significance. Overall, the study provides valuable insights into the growth, yield, and economic parameters of plants.

Experimental site

The experiment was conducted at the field of University of Agriculture, Faisalabad Pakistan, during the winter rabi season 2022-2023 to find out the influence of various sulphur fertilizer rates on the development and yield of chickpeas.

Experimental Treatments

The experiment was conducted in mud pots of 16 cm diameter that were filled with 8kg of soil. Seed of chickpea (*Cicer arietinum*) varieties Bittal-2021, Noor-2019, and Bittal-2016 obtained from Ayub Agriculture Research Institute Faisalabad, Pakistan. Six seeds of each variety of chickpeas are sowed in each pot with equal depth and distance. After germination, the seedling was thinned to five of equal size. After two months of germination, flowering occurred, and two levels of sulphur fertilizer were applied. To decrease error, the conducted experiment was completely randomized design (CRD), and the experimental treatments were replicated three times. Sulphur rates of 120 and 240 were randomized, as were three chickpea varieties, Bittal-2021, Noor-2019, and Bittal-2016 as presented in layout.

TREATMENT LAYOUT

RESULTS AND DISCUSSION

Fresh, dry weights of roots and shoots (g)

Three chickpea varieties (Bittal-2021, Noor-2019, and Bittal-2016) investigated regarding fresh shoot weight (g) under sulphur treatments of 120mg and 240mg. The sulphur treatments had no significant effect on the results, but the maximum fresh shoot weight was found in a 120mg sulphur application, which was (19.0g), and the minimum was (17.9g) that was present at 240mg. Varieties showed a significant effect; the maximum fresh shoot weight was present in Bittle-2021 (19.9g), and the minimum was Noor-2019 (16.3g). The sulphur treatments had no significant effect on the results, but the maximum root fresh weight was found in a 120mg sulphur application, which was (2.82g), and the minimum was (1.38g) that was present at 240mg. Varieties showed a significant effect; the maximum root fresh weight was present in Noor-2019 (2.07g), and the minimum was Bittle-2016 (1.27g) as mentioned in table no 1. The sulphur treatments had no significant effect on the results, but the maximum shoot dry weight was found in a 240mg sulphur application, which was (4.04g), and the minimum was (4.02g) that was present at 120mg. Varieties didn't show a significant effect; the maximum shoot dry weight was present in Bittal-2021 (4.48g), and the minimum was in Bittal-2016 (3.7g). The treatments had no significant effect on the results. Still, the maximum root dry weight was found in 120mg, which was (0.27g), and the minimum was present at 240mg, which was (0.26g), and those varieties also showed no significant effect. The maximum root dry weight was present in Bittal-2021 (0.42g), and the minimum was in Bittal-2016 (0.16g) as shown in fig no 1.

Table no 1: Parameters of Shoot Fresh weight (g), Root fresh weight (g), Shoot dry weight (g), and Root dry weight (g).

Shoot Fresh weight (g)				
Treatments	Bittle-2021	Noor-2019	Bittle-2016	Means
120mg	20.5 A	17.3 A	19.4 A	19.0 A
240mg	19.3 A	15.4 A	19.1 A	17.9 A
Means	19.9	16.3	19.2	
Root fresh weight (g)				
Treatments	Bittle-2021	Noor-2019	Bittle-2016	Means
120mg	1.61 A	1.42 AB	1.21 B	2.82 AB
240mg	1.49 AB	1.31 AB	1.34 AB	1.38 AB
Means	1.55	2.07 AB	1.27 B	
Shoot dry weight (g)				
Treatments	Bittal-2021	Noor-2019	Bittal-2016	Means
120mg	3.9 AB	4.27 AB	3.9 AB	4.02 AB
240mg	5.07 A	3.57 B	3.5 B	4.04 B
Means	4.48	3.92 B	3.7 B	
Root dry weight (g)				
Treatments	Bittal-2021	Noor-2019	Bittal-2016	Means
120mg	0.44 A	0.27 A	0.12 A	0.27 A
240mg	0.39 A	0.193 A	0.21 A	0.26 A
Means	0.42	0.231	0.16	

Growth Attributes

The height of chickpea plants varies based on cultivar, growing environment, and management techniques. Mature plants can reach 20-60 cm (8-24 inches), while early growth has a compact, bushy appearance. Plant height affects crop management practices like trimming (Yadav et al., 2022). Three chickpea varieties examined under sulphur treatments, finding no significant effect on height. Noor-2019 had the highest plant height at 48.35 cm. The Branches per Plant statistic measures the branching structure of chickpea plants, allowing researchers and farmers to determine optimal plant growth. Three

chickpea varieties (Bittal-2021, Noor-2019, and Bittal-2016) showed no significant effect of sulphur treatments on branch count. However, Noor-2019 had the highest branch count, while Bittal-2016 had the lowest as shown in fig no 2. The interaction between varieties and treatment also lacked a significant effect. Shoot length is crucial for chickpea plant growth and development, affecting biomass accumulation, nutrient intake, and photosynthetic capability (Benali et al., 2023). Root length is an essential indicator of plant growth and development, impacting nutrition, water intake, anchoring, and health. It is crucial for agriculture, ecology, horticulture, and plant physiology (R. Kumar et al., 2022). The three chickpea varieties under sulphur treatments, finding significant effects on root length. The maximum root length was found to be 240mg, while the maximum was in Bittal-2021. The interaction between varieties and treatment had no significant effect. Shoot lengths under 120 mg and 240 mg treatments found no significant impact on results as mentioned in table no 2. Three chickpea varieties (Bittal-2021, Noor-2019, and Bittal-2016) showed no significant effect on shoot length, and the interaction between varieties and treatment had no significant impact.

Table no 2: Parameters of Plant height (cm), No. Of Branches Per Plant, Shoot length (cm), and Root length (cm)

Plant height (cm)				
Treatments	Bittal-2021	Noor-2019	Bittal-2016	Means
120mg	42.87 ABC	47.67 AB	40.17 BC	43.57 A
240mg	43.3 ABC	49.03 A	38.7 C	43.67 A
Means	43.08 B	48.35	39.43 B	
No. of Branches Per Plant				
Treatments	Bittal-2021	Noor-2019	Bittal-2016	Means
120mg	6 A	6 A	4 A	5 A
240mg	5 A	7 A	4 A	5 A
Means	6	6	4	
Shoot length (cm)				
Treatments	Bittal-2021	Noor-2019	Bittal-2016	Means
120mg	35.0 A	35.8 A	33.13 A	34.6 A
240mg	37.06 A	36.8 A	33.4 A	35.7 A
Means	36.03	36.3	33.2	
Root length (cm)				
Treatments	Bittal-2021	Noor-2019	Bittal-2016	Means
120mg	16.76 AB	15.8 AB	13.7 B	15.42 AB
240mg	19.9 A	18.1 AB	15.37 AB	17.79 AB
Means	18.33	16.9 AB	14.53 B	

Nodulation

The study examined how three chickpea varieties (Bittal-2021, Noor-2019, and Bittal-2016) performed regarding nodules per plant under sulphur treatments of 120 and 240mg as mentioned in table no 3. The sulphur treatments had a significant effect on the results; the maximum number of nodules per plant was found to be 240mg, which was (16), and the minimum was present in 120 mg, which was (11). The varieties showed a significant effect on no nodules per plant, as the maximum value was present in Noor-2019 (15), and the minimum was Bittal-2016 (10) as shown in fig no 3.

Table no 3: Parameters of no nodules per plant

No. of Nodules Per Plant				
Treatments	Bittal-2021	Noor-2019	Bittal-2016	Means
120mg	13 AB	13 AB	9 B	11 B
240mg	18 A	17 A	12B	16 A
Means	15	15 B	10 B	

Yield Attributes

The number of pods per chickpea plant is crucial for its productivity and output potential. This depends on factors like planting density, nutrient availability, water availability, pest and disease management, and genetic potential (Maya & Maphosa, 2020). Farmers can evaluate the performance of different chickpea varieties by observing and recording pods throughout the growing season and harvest (Jha et al., 2020). Three chickpea varieties examined (Bittal-2021, Noor-2019, and Bittal-2016) under sulphur treatments of 120mg and 240mg. The sulphur treatments had a significant effect on the results, with the maximum pods per plant found at 240mg and the minimum at 120mg. The productivity and output potential of chickpea plants are determined by the number of seeds per plant, which is influenced by factors like variety, environmental conditions, cultural practices, and management strategies. A higher seed count indicates better plant health, efficient pollination, and effective seed germination, increasing grain output and crop productivity. The chickpea varieties (Bittal-2021, Noor-2019, and Bittal-2016) under sulphur treatments, finding that the maximum seed number per plant was 15 at 240mg and 12 at 120mg. Three varieties of sulphur-treated chickpeas (Bittal-2021, Noor-2019, and Bittal-2016) significantly affected seed weight, with the maximum weight found at 240mg and the minimum at 120mg as written in table no 4.

Table no 4: Parameters of no pods Per Plant, No. of seeds Per Plant, and 100 seed weight (g).

No of Pods Per Plant				
Treatments	Bittal-2021	Noor-2019	Bittal-2016	Means
120mg	12 ABC	12 ABC	10 BC	11 B
240mg	15 AB	16 A	7 C	13 A
Means	13	14	8 B	
No. of seeds Per Plant				
Treatments	Bittal-2021	Noor-2019	Bittal-2016	Means
120mg	14 ABC	12 ABC	12 C	12 AB
240mg	16 A	16 A	12 BC	15 A
Means	15	14	12B	
100 seed weight (g)				
Treatments	Bittal-2021	Noor-2019	Bittal-2016	Means
120mg	2.92 AB	2.91 AB	2.61 B	2.81 AB
240mg	3.60 A	3.67 A	2.89 AB	3.39 A
Means	3.26	3.29	2.71 B	

Economic Yield (%), Biological Yield (%), and Harvest Index (%)

The sulphur treatments had the highest significant effect on the results; the maximum economic yield was found in 240mg, which was (28.17), and the minimum was present in 120 mg, which was (24.52). The varieties also showed a significant effect on economic yield; the maximum value was present in Noor-2019 (30.05), and the minimum was Bittal-2016 (16.03). The sulphur treatments had the highest significant effect on the results; the maximum harvest index % was found in 240mg, which was (2,242.55), and the minimum was present in 120 mg, which was (1,564.21) as shown in fig no 4. The varieties also showed a significant effect on harvest index %; the maximum value was present in Noor-2019 (2076.075), and the minimum was Bittal-2016 (1570.71) as mentioned in table no 5. The biological yield, the total biomass produced by a crop or plant population, is influenced by genetics, environment, production methods, and management strategies (Bailey-Serres et al., 2019). Three varieties of sulphur-treated chickpeas were analyzed, with the highest biological yield at 240mg (32.76) and the lowest at 120mg (28.7). The interaction between varieties and treatments had no significant effect.

Table no 5: Parameters of Economic Yield, Biological yield, and Harvest Index.

Economic Yield				
Treatment	Bittal-2021	Noor-2019	Bittal-2016	Means
120mg	17.34 B	27.49 A	14.37 B	24.52 B
240mg	34.22 A	32.60 A	17.70 B	28.17 A
Means	25.78	30.05	16.03 B	
Biological yield				
Treatments	Bittal-2021	Noor-2019	Bittal-2016	Means
120mg	31	31.70 B	23.34 C	28.7 B
240mg	31 B	36.53 A	30.67 B	32.76 A
Means	31 B	34.11	26.99 B	
Harvest Index				
Treatments	Bittal-2021	Noor-2019	Bittal-2016	Means
120mg	1634.26 B	1592.95 B	1465.87 B	1,564.21 B
240mg	2492.92 A	2559.20 A	1675.55 B	2,242.55 A
Means	1254.63	2076.075	1570.71 B	

Chlorophyll a, b, and c

The advantages of chlorophyll on chickpea productivity can be influenced by elements such as genetic features, environmental circumstances, nutrient availability, and crop management techniques. Sulphur and its levels were significantly affected by chlorophyll a (Maphosa et al., 2020). Three chickpea varieties were examined (Bittal-2021, Noor-2019, and Bittal-2016) performed regarding chlorophyll under sulphur treatments of 120mg and 240mg. The sulphur treatments had a highly significant effect on the results; the maximum chlorophyll a found in 240mg, which was (0.23), and the minimum was present in 120 mg, which was (0.18). The varieties also showed a significant effect on chlorophyll a, as the maximum value was present in Bittal-2021 (0.30), and the minimum was in Bittal-2016 (0.13). Chickpea varieties (Bittal-2021, Noor-2019, and Bittal-2016) performed in terms of chlorophyll b under sulphur treatments of 120mg and 240mg. The sulphur treatments had a highly significant effect on the results; the maximum chlorophyll b was found in 240mg, which was (0.28), and the minimum was present in 120 mg, which was (0.23) as mentioned in table no 6. The varieties also showed a significant effect on chlorophyll b; the maximum value was present in Bittal-2021 (0.32), and the minimum was in Bittal-2016 (0.19) as mentioned in fig no 5. Chickpea varieties (Bittal-2021, Noor-2019, and Bittal-2016) performed in terms of carotenoids under sulphur treatments of 120mg and 240mg. The sulphur treatments had a highly significant effect on the results; the maximum carotenoids found in 240mg was (0.31), and the minimum

was 120 mg, which was (0.27). The varieties also showed a significant effect on carotenoids; the maximum value was present in Bittal-2021 (0.35), and the minimum was in Bittal-2016 (0.24).

Table no 6: Parameters of Chlorophyll a, Chlorophyll b, and Carotenoids.

Chlorophyll a				
Treatments	Bittal-2021	Noor-2019	Noor-2019	Means
120mg	0.25 B	0.17 CD	0.13 D	0.18 A
240mg	0.35 A	0.20 BC	0.137 D	0.23 B
Means	0.30	0.18B	0.13 C	
Chlorophyll b				
Treatments	Bittal-2021	Noor-2019	Bittal-2016	Means
120mg	0.31 AB	0.23B	0.14 C	0.23 B
240mg	0.34 A	0.27 AB	0.27B	0.28 A
Means	0.32	0.25 B	0.19 C	
Carotenoids				
Treatments	Bittal-2021	Noor-2019	Bittal-2016	Means
120mg	0.34 AB	0.26 D	0.22 D	0.27 A
240mg	0.37 A	0.31 BC	0.26 CD	0.31 B
Means	0.35	0.28 B	0.24 C	

CONCLUSION

Chickpeas, or "chana" or "gram," are a significant crop in Pakistan, providing economic, economic, and cultural value. They are rich in essential elements like folate, iron, magnesium, and potassium and are a low-cost source of nourishment. Sulphur, a crucial component of various industries, is vital for life, agriculture, soil health, insect control, industrial applications, and geological processes. It aids in plant growth and development, enhancing protein synthesis, plant structure, nutrient uptake, stress tolerance, and seed output. Sulphur availability and impact on chickpea productivity vary depending on soil conditions, climate, fertilizer management, and crop variety. Adequate sulphur levels support healthy plant development, boost photosynthesis, and increase agricultural output. sulphur also improves nutrient efficiency, making chickpea plants more stress- and disease-resistant. Sulphur availability significantly impacts chickpea pod development, affecting pod formation, seed setting, nutrient delivery, pod filling, maturation, and quality. Proper nutrient management practices, including soil testing and applying nutrients at recommended rates, are critical for optimizing pod growth in chickpea plants. The

number of pods per chickpea plant is crucial for its productivity and output potential, influenced by factors like planting density, nutrient availability, water availability, pest and disease management, and genetic potential. During the study, three chickpea varieties were subjected to two levels of sulphur treatment (120 mg and 240 mg): Bittal-2021, Noor-2019, and Bittal-2016. According to the study, higher sulphur levels, specifically 240 mg, increased pod production and seed production. As a result of these treatments, economic yield, harvest index percentages, and biological yields also exhibited significant impacts, with 240mg resulting in the best outcomes. A significant interaction between chickpea varieties and sulphur treatments did not occur. The sulphur level also affected chlorophyll content, with higher levels leading to a higher concentration of chlorophyll a and b and a higher concentration of chlorophyll c at 120mg. Different sulphur treatments resulted in differences in the levels of chlorophyll b and carotenoid in chickpea varieties. The results of this research provide valuable insights into optimizing chickpea cultivation to increase yields and manage chlorophyll more effectively.

DISCUSSION

Chickpeas are cultivated in 50 countries globally, with India being the largest producer, accounting for 70% of global output (Sharma & Sharma, 2020). The ideal plant population density is critical for generating maximum yields since it directly influences plant growth and development (Das et al., 2022). However, sulphur shortage is growing more severe, limiting crop output, produce quality, fertilizer usage efficiency, and economic returns. Sulphur contributes significantly to nitrogen fixation, chlorophyll synthesis, and carbohydrate, protein, and fat metabolism (Zenda et al., 2021). The advantages of chlorophyll on chickpea productivity can be influenced by elements such as genetic features, environmental circumstances, nutrient availability, and crop management techniques (Maphosa et al., 2020). Sulphur and its levels were significantly affected by chlorophyll a. The study discovered that sulphur treatments had a substantial influence on economic yield and harvest index % in chickpeas (Anandamai et al., 2021). The findings emphasize the significance of biological yield in assessing crop performance, resource utilization, ecosystem dynamics, and production system efficiency in agricultural and ecological research (Garnaik et al., 2023). Sulphur is an essential component in plant growth and development, influencing physiological processes and abiotic stress tolerance (Samanta et al., 2020). However, agriculture has paid little attention to sulphur nutrition, despite soil sulphur deficits and rising demand for high-quality cereal and vegetable diets (Prasad & Shivay, 2020). Sulphur can increase agricultural output and quality while also helping plants adapt to abiotic challenges (Narayan et al., 2023). To address these issues, future research should concentrate on understanding the molecular processes and dynamics of sulphur availability and utilization in plants and diagnosing nutrient deficiencies, and matching site-specific crop sulphur demands with fertilizer amendments. This will contribute to more sustainable and ecologically friendly food production (Sharma et al., 2024).

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Figures

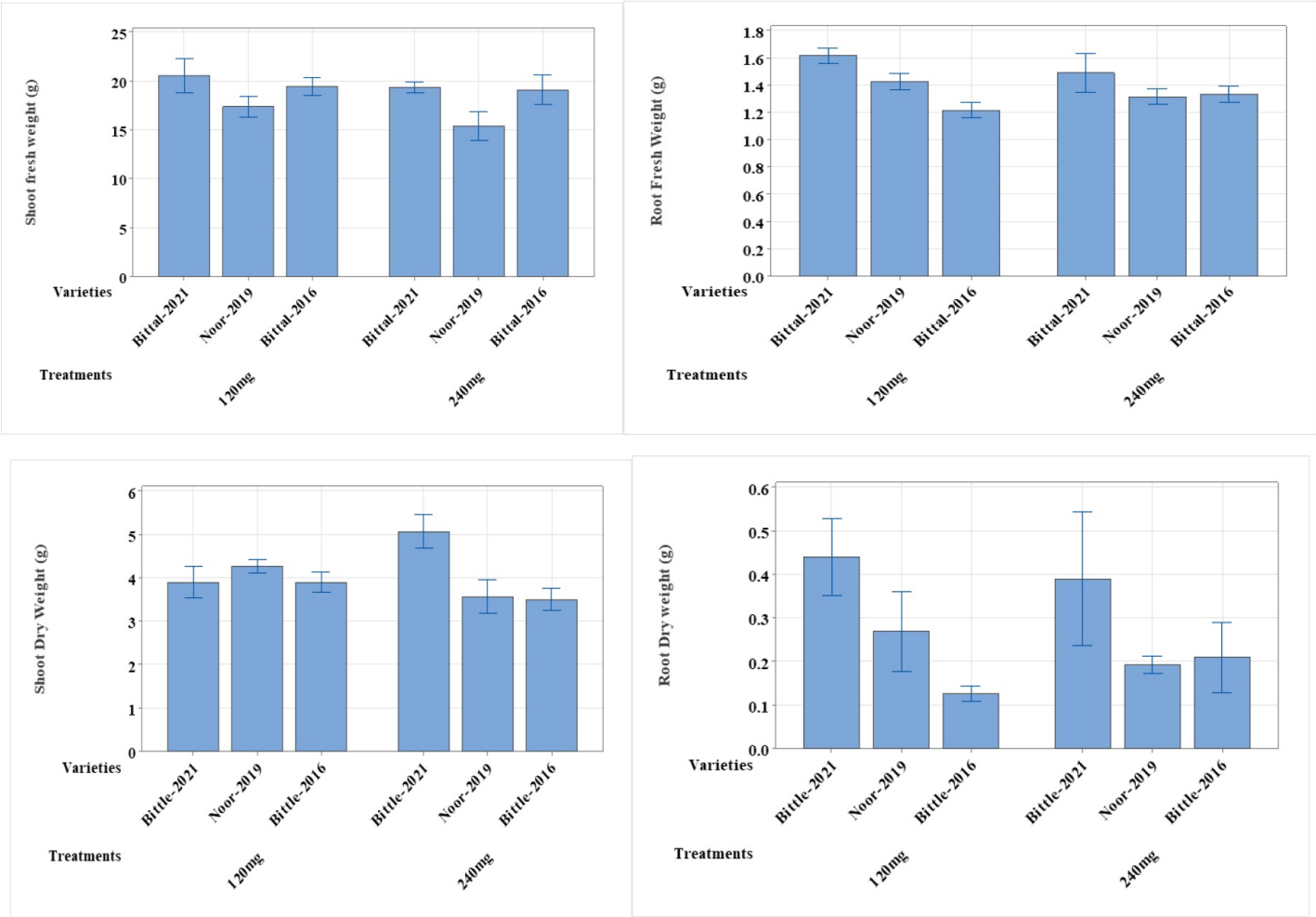


Figure 1

Comparisons of Shoot Fresh weight (g), Root fresh weight (g), Shoot dry weight (g), and Root dry weight (g).

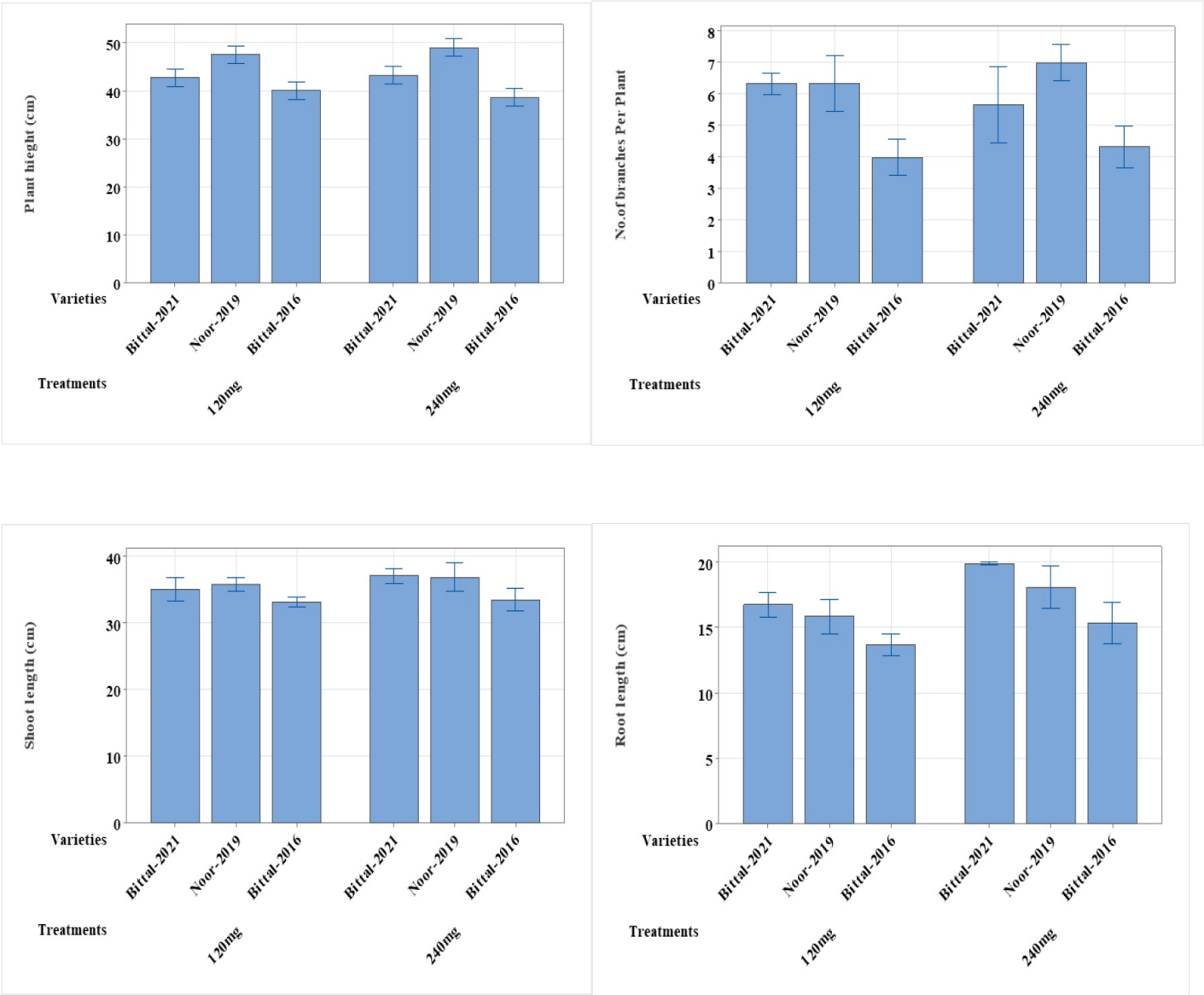


Figure 2

Comparisons of Plant height (cm), No. of Branches Per Plant, Shoot length (cm), and Root length (cm)

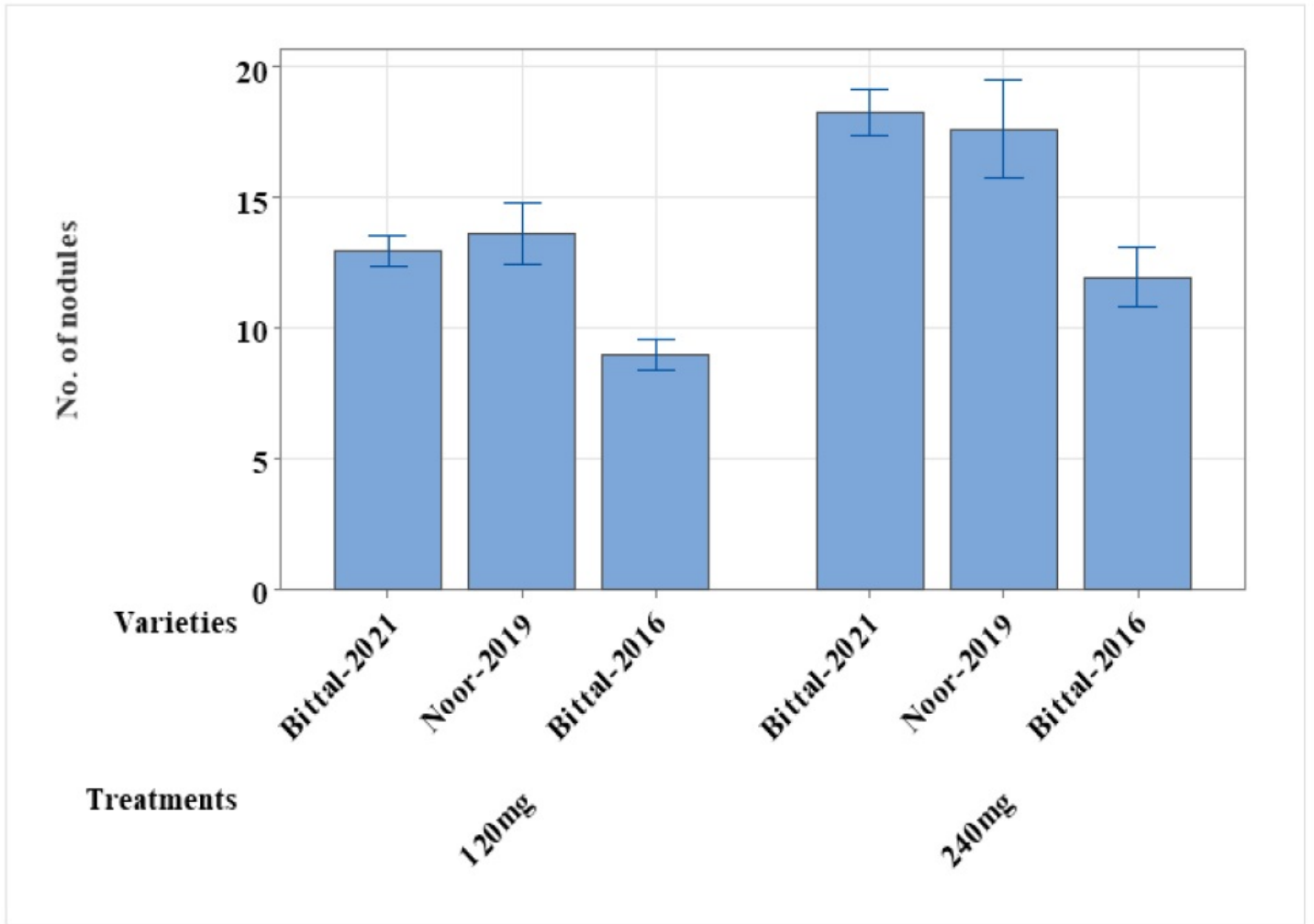


Figure 3

Comparisons of No. of Nodules Per Plant

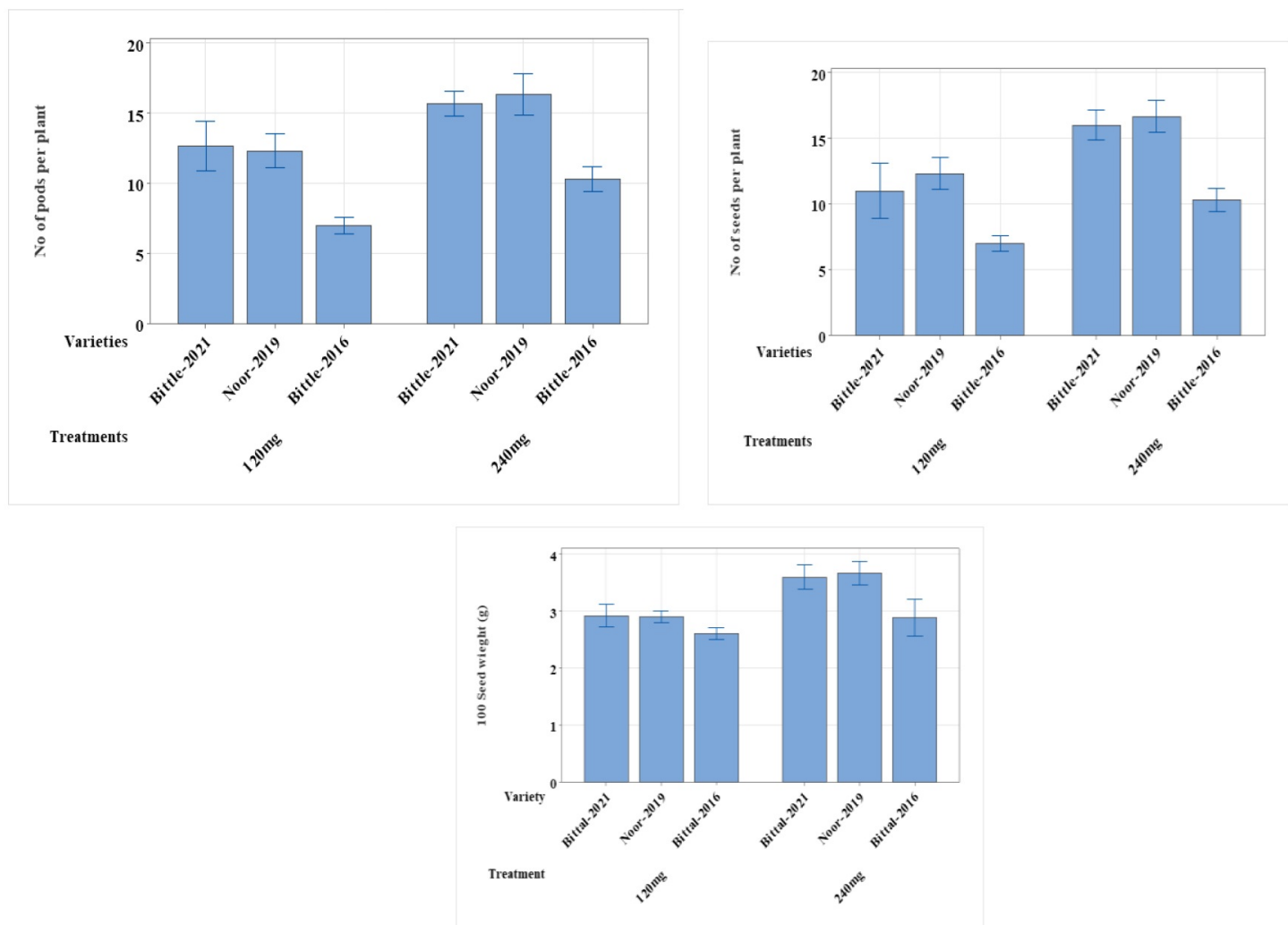


Figure 4

Figure No. 3: Comparisons of no of pods Per Plant, No. of seeds Per Plant, and 100 seed weight (g).

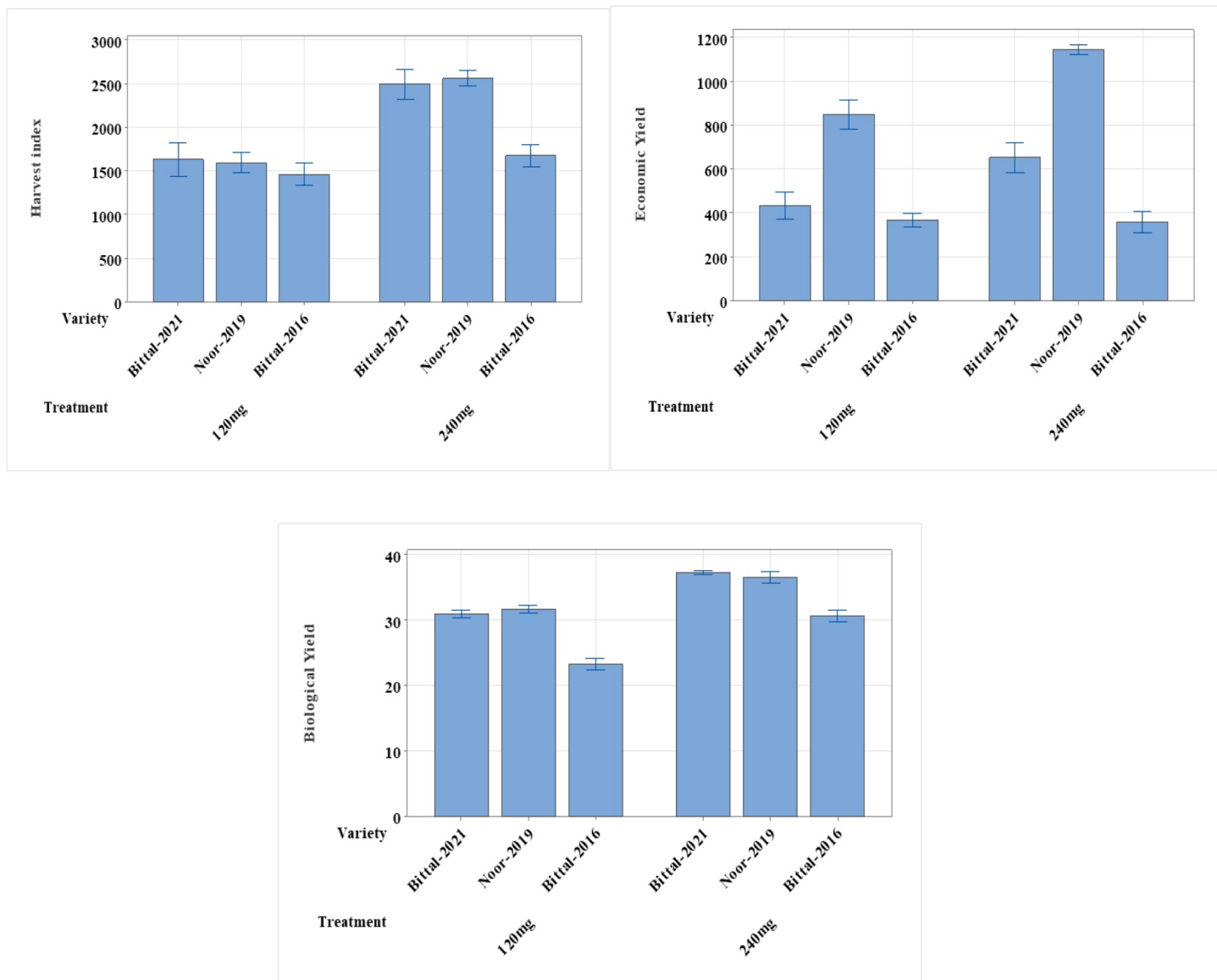


Figure 5

Figure No. 4: Comparisons of Economic Yield, Biological Yield, and Harvest Index.

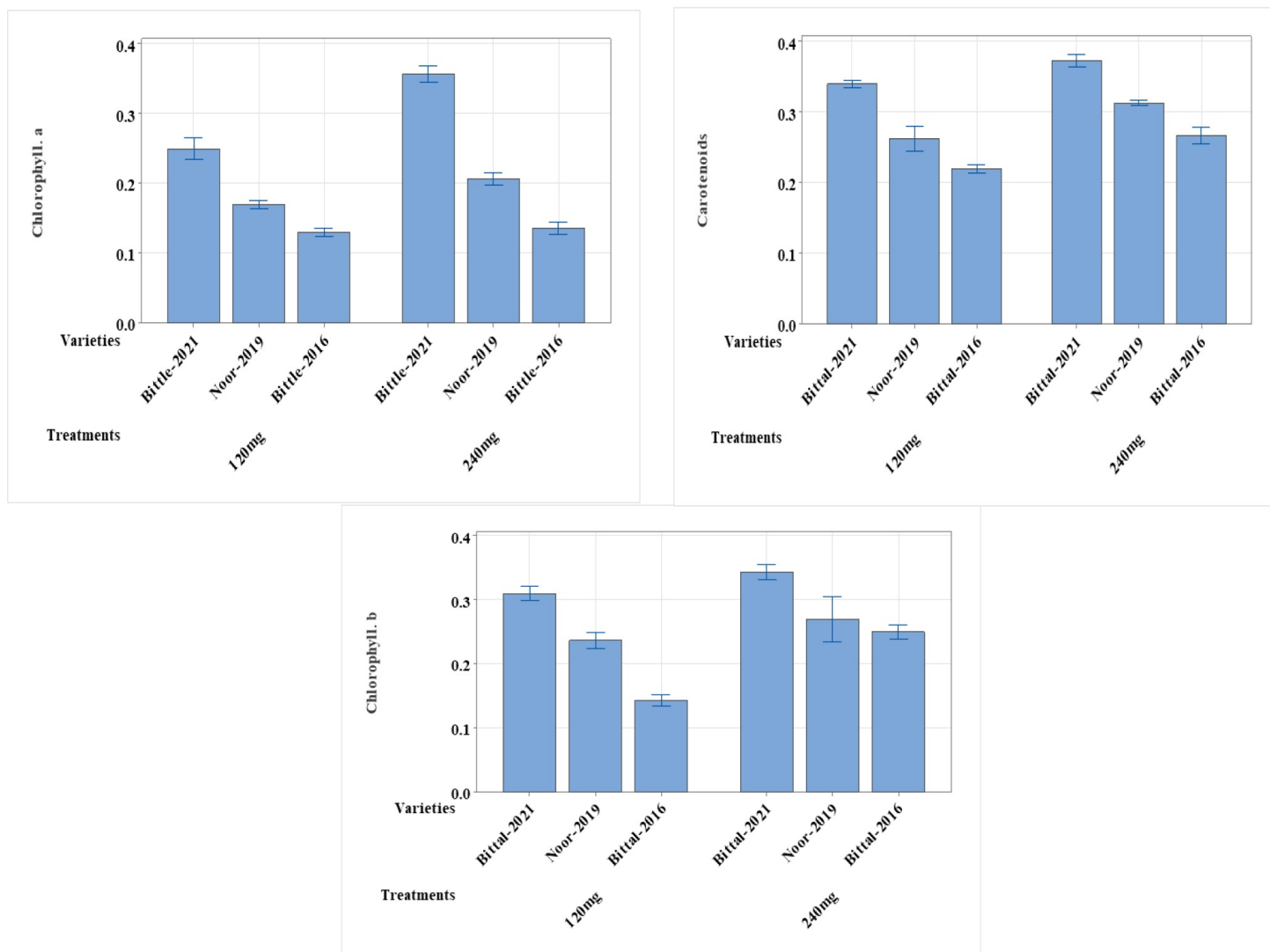


Figure 6

Figure No. 5: Comparisons of Chlorophyll a, b, and c.

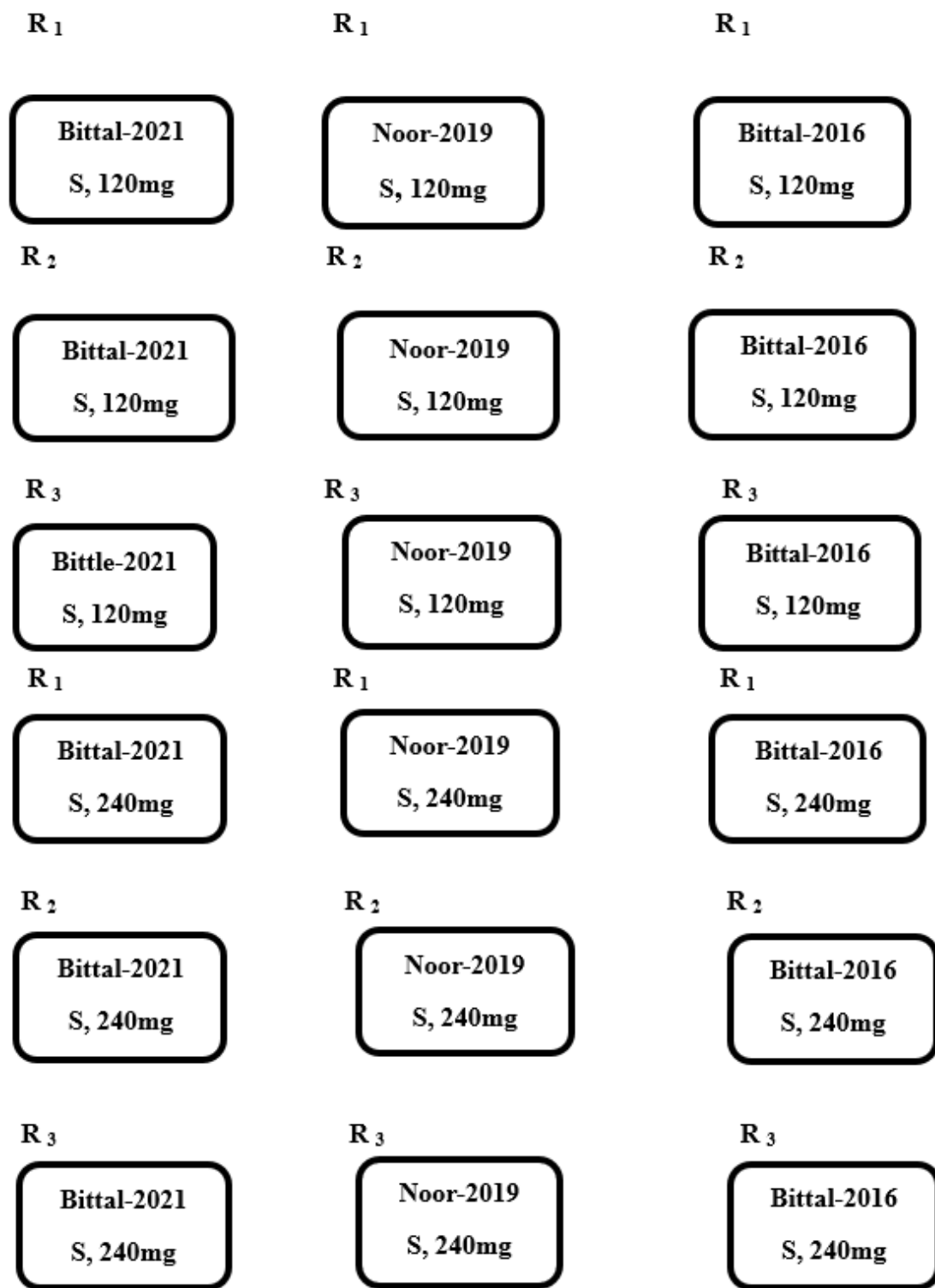


Figure 7

Unnumbered image in the MATERIALS AND METHODS section.