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EFFECT OF NPK AND SULPHUR ON GROWTH, YIELD AND CHLOROPHYLL CONTENTS OF CAULIFLOWER (*BRASSICA OLERACEA* L).

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ABSTRACT

Cauliflower is cultivated all around the world for its high nutritional value. In Pakistan, there is dire need to optimize the nutritional supplementation of cauliflower. Therefore, a field experiment was carried out to see the impact of NPK and sulphur on growth, yield and chlorophyll contents of cauliflower. The experiment was laid out according to Randomized Complete Block Design having ten treatments replicated thrice. The experiment was consisted of five levels of NPK (13:17:17, 15:18:18, 16:18:18, 16:19:19 and 20:20:20) in combination with two sulphur levels (20g, 40g) and a control treatment (NPK 0:0:0) without sulphur having three replications. The results revealed that highest values of observed attributes *i.e* plant height (54.06 cm), numbers of leaves per plant (19.93), leaf area (10.93 cm^2), foliage fresh weight (36.4 g), foliage dry weight (18.48 g), curd size (10.93 cm) and curd weight (839.84 g) were observed in (16:19:19) NPK in combination with 40 $gplant^{-1}$ sulphur. While, minimum values were noted in control treatment. However, minimum days to curd formation (51.53) was observed in NPK (16:19:19) in combination with the sulphur (40 $gplant^{-1}$). Chlorophyll contents (1.98 CCi), total soluble solids (13.13 ^oBrix) and vitamin C (56.81 mg100 g^{-1}) were maximum in the treatment (16:19:19) NPK along with 40 $gplant^{-1}$ sulphur. From this study, it is concluded that treatment (NPK 16:19:19 + Sulphur 40 g/plant) is the best optimal dose for the higher growth and production of cauliflower.

Keywords: cauliflower, growth, NPK, quality, sulphur, yield

INTRODUCTION

Cauliflower (*Brassica oleracea* var. botrytis L.) is a vegetable which belongs to the Brassicaceae family (Khan *et al.,* 2018) with origin from Northeast Mediterranean (Arias *et al.,* 2014). The top producing countries for cauliflower production are China, United State, India, Italy, Mexico and Spain (Francisco *et al.,* 2017). It is an annual crop that reproduces through the seed (Hoque *et al.,* 2021) and only a head (white curd) is usually consumed (Gocher *et al.,* 2017). A white inflorescence meristem makes up the cauliflower head (Khan *et al.,* 2018). Cauliflower consumption has been associated to a lower probability of aggressive prostate cancer (Krish *et al.,* 2017).

Pakistan's economy is heavily based on agricultural production, with high yield and resistance becoming a pressing requirement in recent years (Rehman *et al.,* 2015). In Pakistan, total area under the cultivation of cauliflower was 10242 ha during 2019-20 which recorded 185493 tones total yield (GoP, 2020). Pakistan is among the top ten cauliflower producing countries in the world (Aftab *et al.,* 2017).

Among different practices, optimized balance supply of primary nutrients including nitrogen (N), phosphorus (P) and potassium (K) is involved in metabolic processes and enzyme activity (Hasanuzzaman *et al.,* 2018a). Cauliflower needs large amount of macro-nutrients as they play a vital role in development of curd (Singh *et al.,* 2017). Farmers use a lot of urea as a nitrogen fertilizer in cauliflower to promote vegetative growth, fruit set, and fruit size. Nitrogen may enhance cauliflower yield, but it degrades curd quality (KC *et al.,* 2021). Cauliflower is perishable and storing it in the refrigerator causes tissue degradation (Amit *et al.,* 2017). The high nitrogen concentration of cauliflower, along with vitamin shortages, can reduce its storage life (Belbase and Bc, 2020). So, optimization of nitrogen concentration is necessary for maximum yield and higher quality of cauliflower. Phosphorus is second macronutrient which plays a vital role in root

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development (Han *et al.,* 2014). It is an essential part of macrobiotic molecule eg. DNA, RNA and ATP (Kolodiazhnyi, 2021). A sufficient supply of phosphorus during the early stages of plant life is critical for laying down the primordial for plants reproductive sections (Sharma *et al.,* 2013). Potassium is third macronutrient that plays significant role in plant growth and metabolism (Hasanuzzaman *et al.,* 2018a). It also plays a vital role in maintaining cell turgor pressure, activities of enzymes as well as decreasing the absorption of Na+ (Shabala and Pottosin, 2014).

Sulphur is a vital plant nutrient that ranked second after primary nutrients i.e. nitrogen, phosphorus and potassium (Zenda *et al.,* 2021). Sulphur is necessary for the biosynthesis of some amino acids (cysteine, cystine, and methionine), which are important components of proteins (Mukwevho *et al.,* 2014). Sulphur also aids in winter hardiness and drought tolerance, as well as the prevention of insect pests and disease (Hasanuzzaman *et al.,* 2018b; Gesraha and Ebeid, 2019). To keep the importance of macronutrients and sulphur on cauliflower, this study was conducted to optimize the best suitable dose of NPK and sulphur for the maximum growth, yield and quality of cauliflower.

MATERIALS AND METHODS

This experiment was carried out at Vegetable Research Area, Institute of Horticultural Sciences, University of Agriculture, Faisalabad, during the year 2020-2021. Cauliflower cv. Bianca seeds were provided by Ayub Agricultural Research Institute Faisalabad. Seeds were sown at Vegetable Research Area. Seedlings were transplanted after 30 day on one side of the ridge (75 cm) at 30 cm plant to plant distance. Various levels of NPK and sulphur i.e. T_0; (Control), T_1: (13:17:17 NPK+20g/plant sulphur), T_2: (15:18:18 NPK + 20g/plant sulphur) T_3: (16:18:18 NPK+20g/plant sulphur), T_4: (16:19:19 NPK+20g/plant sulphur), T_5: (20:20:20 NPK+20g/plant sulphur)), T_6: (13:17:17 NPK+ 40g/plant sulphur), T_7: (15:18:18 NPK+ 40g/ plant sulphur) T_8: (16:18:18 NPK+ 40g/plant sulphur), T_9: (16:19:19 NPK+ 40g/plant sulphur), T_{10}: (20:20:20 NPK+40g/plant sulphur) were applied at 30 and 45 days intervals. The experiment was laid out according to the Randomized Complete Block Design (RCBD) with three replications.

Different parameters such as plant height (cm), number of leaves per plant, leaf area (cm^2), number of days taken from sowing to curd formation, foliage fresh and dry weight (g), curd weight (g), curd diameter (cm), curd size (cm) and chlorophyll contents (CCi) were measured by using chlorophyll meter as described by Dong *et al.* (2019). Whereas, total soluble salts were recorded by using digital refractometer and vitamin C was measured by adopting the methodology of Ali *et al.* (2019). The Least Significant Difference (LSD) test was used to compare mean values of various treatments at 5% probability level (Steel *et al.,* 1997).

RESULTS AND DISCUSSION

Vegetative parameters

Among the various treatments of NPK and sulphur, NPK (16:19:19) in combination with 40 $gplant^{-1}$ sulphur was the best treatment for the vegetative parameters. Highest plant height (54.06cm), number of leaves per plant (19.93) and leaf area (10.93cm^2) were noted in NPK (16:19:19) with 40 g/$plant^{-1}$ sulphur as shown in Figure 1, 2 and 3 respectively. Moreover, Maximum, Maximum foliage fresh weight (36.4g) and foliage dry weight (18.48g) were recorded in NPK (16:19:19) in combination with 40g/ $plant^{-1}$ sulphur as shown in Figure 4 and 5 respectively. However, plant height (39.33cm), number of leaves per plant (15.53), leaf area (6.53cm^2), foliage fresh weight (19.45g) and foliage dry weight (9.44g) were obtained in control treatment (NPK 0:0:0) without sulphur. NPK are the essential elements for plant growth development and production which increased the auxin activity and metabolism like photosynthesis and production of hormones, proteins, carbohydrates, vitamins, nucleic acids, and chlorophyll molecules in plants (Sharma, 2016; Metwaly, 2017). Our results are supported by the findings of El-Saady and Omar (2018) that NPK significantly enhanced plant height, number of leaves, leaves fresh and dry weight percentage of cauliflower. Many studies reported that Sulphur application reduced the pH of soil which increased the availability of many nutrients by activation of several enzymes which help in transformation of energy, formation of chlorophyll and in metabolism of carbohydrates too (Gocher *et al.,* 2017) might be responsible for better vegetative growth of cauliflower. Similar effect of sulphur are reported in cauliflower by Khan *et al.* (2018), Ali *et al*. (2019) and Kisko *et al.* (2021).

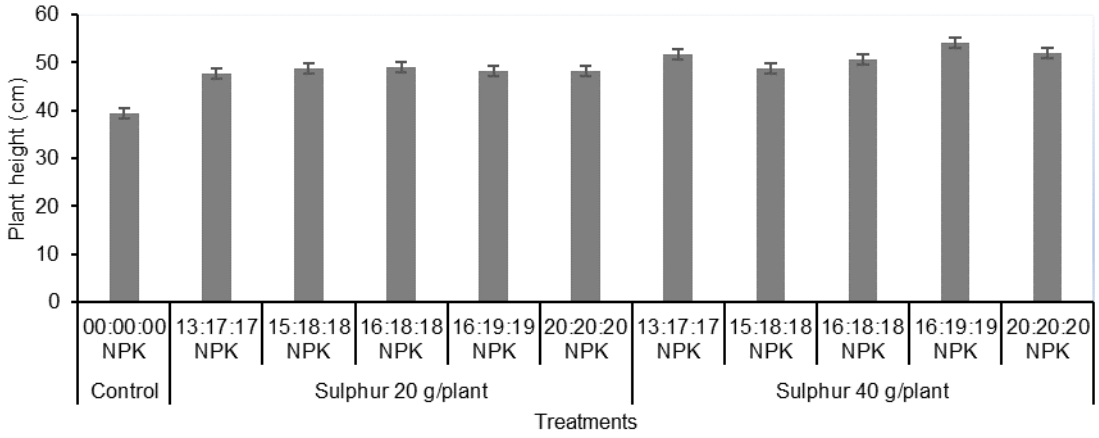

Figure 1. Effect of various levels of NPK and sulphur on plant height (cm) of cauliflower (*Brassica oleracea*)

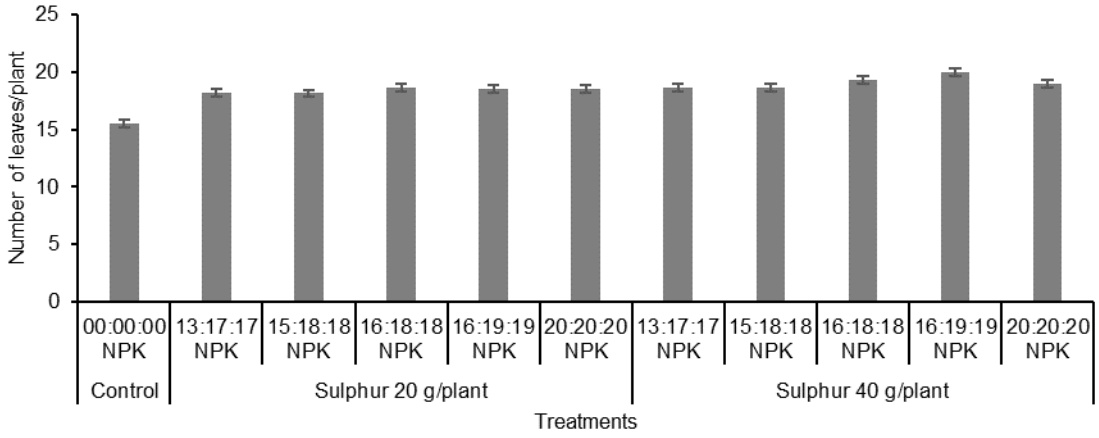

Figure 2. Effect of various levels of NPK and sulphur on number of leaves/plant of cauliflower (*Brassica oleracea*)

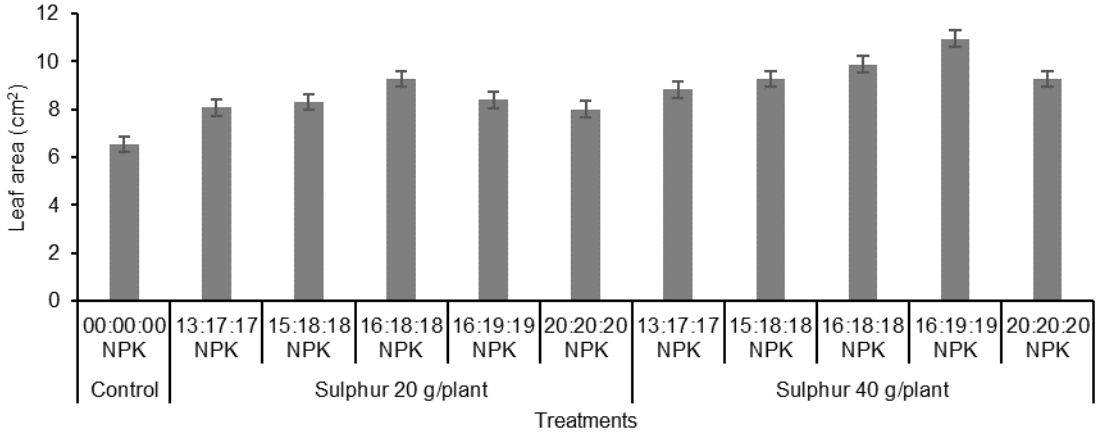

Figure 3. Effect of various levels of NPK and sulphur on leaf area (cm^2) of cauliflower (*Brassica oleracea*)

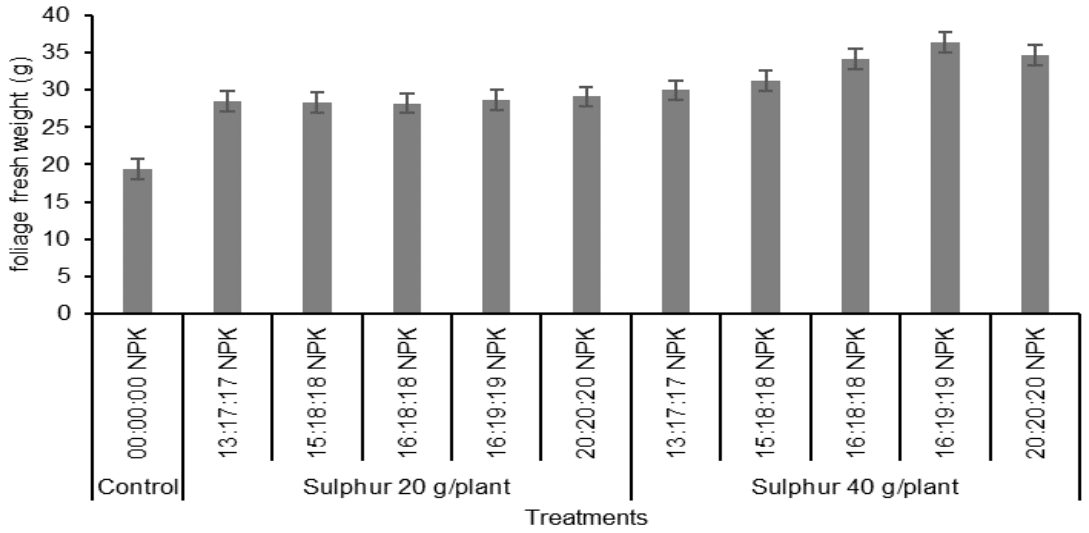

Figure 4. Effect of various levels of NPK and sulphur on foliage fresh weight (g) of cauliflower (*Brassica oleracea*)

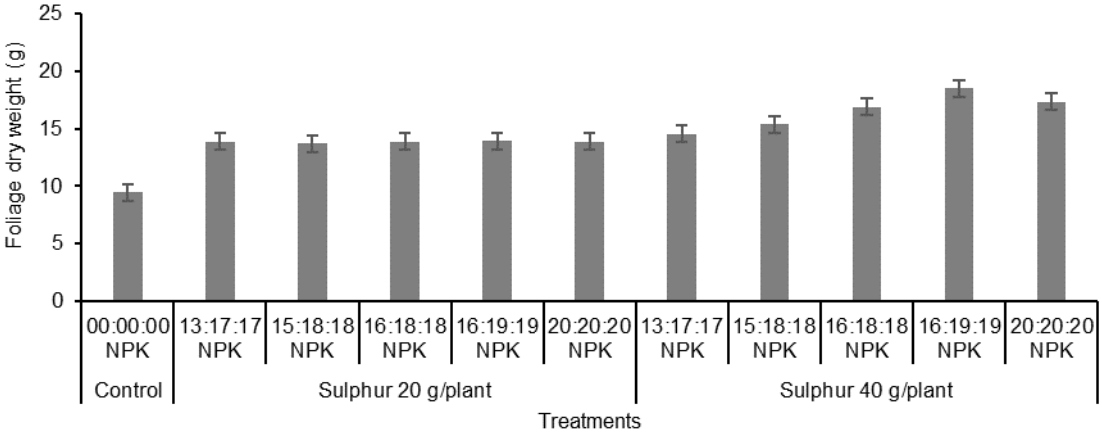

Figure 5. Effect of various levels of NPK and sulphur on foliage dry weight (g) of cauliflower (*Brassica oleracea*)

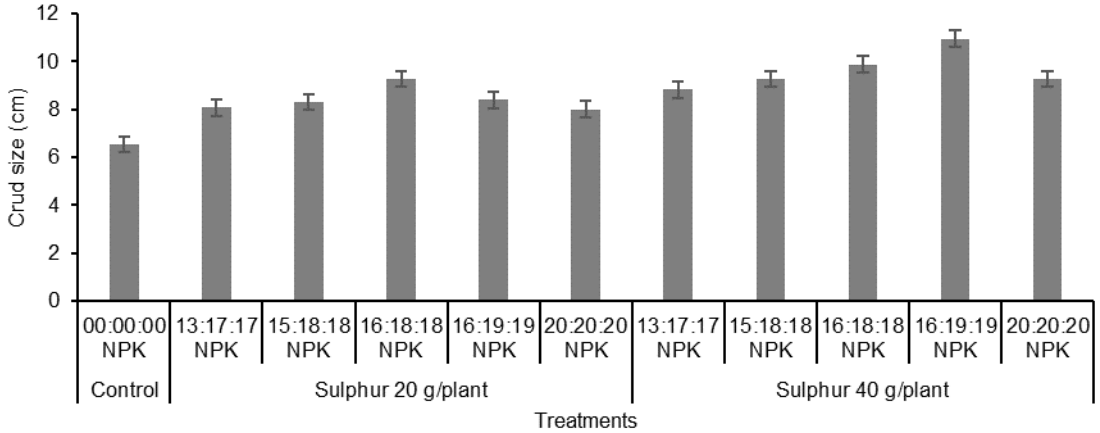

Figure 6. Effect of various levels of NPK and sulphur on curd size (cm) of cauliflower (*Brassica oleracea*)

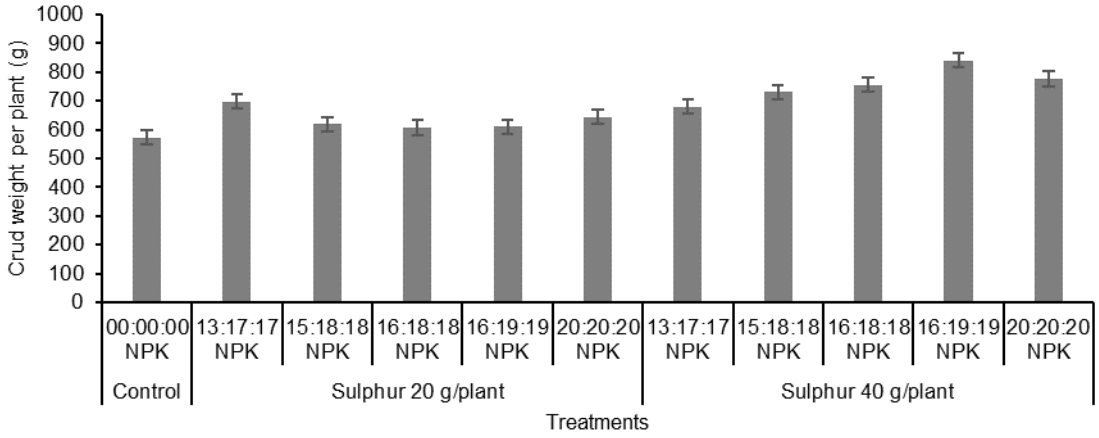

Figure 7. Effect of various levels of NPK and sulphur on curd weight (g) of cauliflower (*Brassica oleracea*)

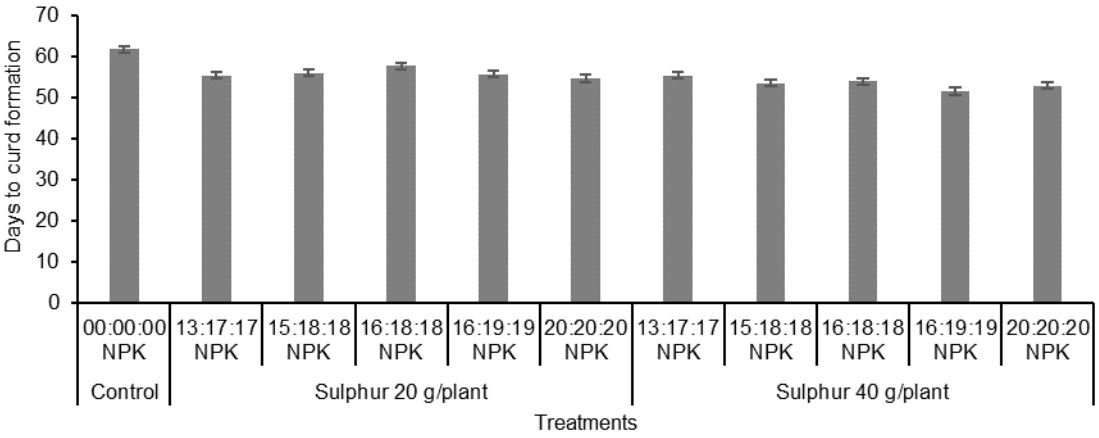

Figure 8. Effect of various levels of NPK and sulphur on days to curd formation of cauliflower (*Brassica oleracea*)

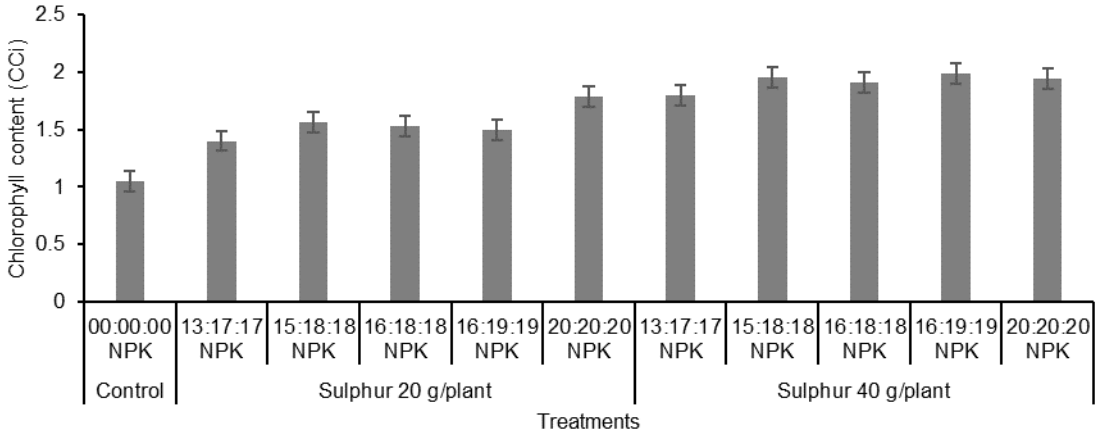

Figure 9. Effect of various levels of NPK and sulphur on chlorophyll content (CCi) of cauliflower (*Brassica oleracea*)

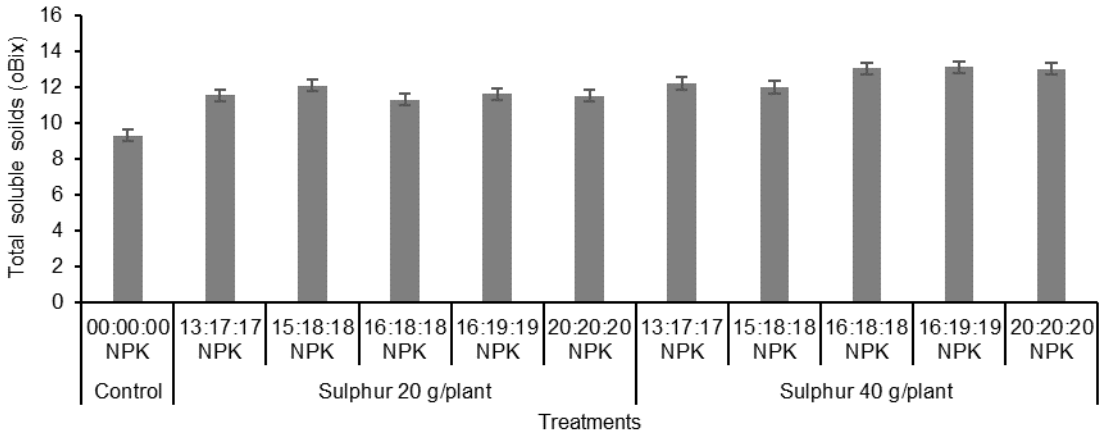

Figure 10. Effect of various levels of NPK and sulphur on total soluble solids (ºBrix) of cauliflower (*Brassica oleracea*)

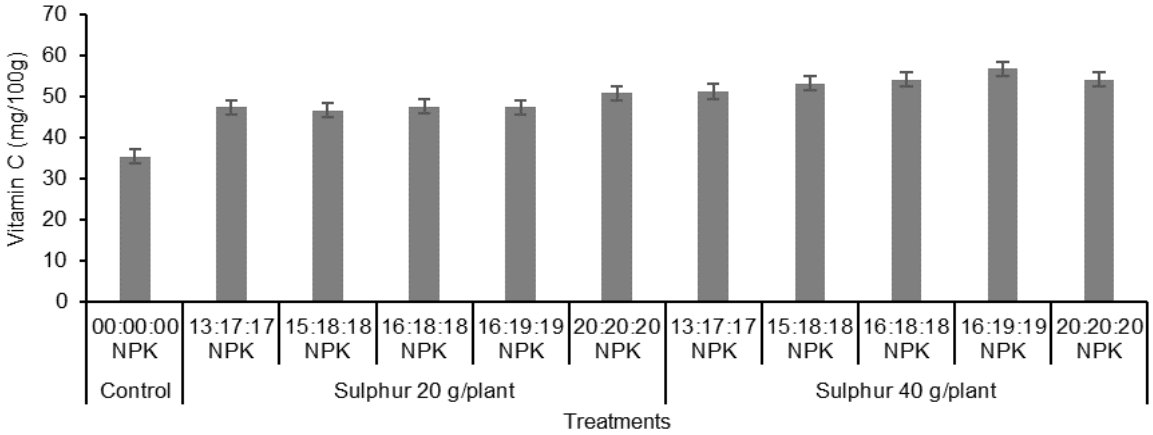

Figure 11. Effect of various levels of NPK and sulphur on vitamin c (mg/100g) of cauliflower (*Brassica oleracea*)

Reproductive parameters

Maximum value for reproductive parameters i.e. curd size (10.93cm) and curd weight (839.84g) were noted in NPK (16:19:19) in combination with 40g plant^{-1} sulphur as shown in Figure 6 and 7 respectively. While, lowest value for curd size (6.53cm) and curd weight (572.35g) were observed in control treatment (NPK 0:0:0) without sulphur. However, minimum days to curd formation (51.53) was noted in NPK (16:19:19) in combination with 40g/plant sulphur as shown in Figure 8. Whereas, maximum days to curd formation (61.8) was recorded in control treatment (NPK 0:0:0) without sulphur. Application of NPK improved the enzymatic activities in plants which ultimately enhanced the curd weight, curd size and yield of plant (Gocher *et al.,* 2017). Potassium did not directly increased the cauliflower yield but indirectly improved the yield (Eimon *et al.,* 2019). Sulphur improved the yield attributes by consequently the enhanced partitioning of photosynthates towards sink (Abd el-All and El-Shabrawy, 2013). These results corroborates with the findings of Ali *et al.* (2019), Eimon *et al.* (2019), Majeed *et al.* (2020) and Kisko *et al.* (2021).

Physiochemical parameters

Maximum chlorophyll contents (1.98 CCi) were noted in plants received NPK (16:19:19) in combination with 40g/plant^{-1} sulphur as shown in Figure 9. While, minimum chlorophyll contents (1.05 CCi) was measured in control treatment (NPK 0:0:0) without sulphur. Total soluble solids and vitamin c were maximum (13.13ºBrix and 56.81mg/100 g respectively) in NPK (16:19:19) in combination with 40 gplant^{-1} sulphur as shown in Figure 10 and 11. Whereas, minimum total soluble solids and vitamin c (9.29ºBrix and 35.35mg/100g respectively) were noted in

control treatment (NPK 0:0:0) without sulphur. Result was parallel to the research in which experiments expressed that NPK foliar spray with the combination of sulphur enhanced the chlorophyll production by increasing the iron activity in the leaves (Škarpa *et al.,* 2021). Total soluble solids did not influence by nitrogen however, phosphorus increased it at certain level. While, potassium significantly increased the total soluble solids in plants (Majeed *et al.,* 2020).

CONCLUSION

NPK and sulphur enhanced the plant biomass, yield, quality and nutrient uptake in cauliflower. It is concluded that foliar application of NPK (16:19:19) in combination with sulphur (40g/ plant) is optimal dose for the improvement of the growth, curd formation, yield and curd quality of cauliflower. From this study, it is recommended to farmers to use (16:19:19) NPK 100kg per acre along with 40g/plant^{-1} sulphur to increase growth and yield of cauliflower cultivars.

AUTHOR'S CONTRIBTION

I. Ashraf: Contribution as execution of research trial

M. Z. Rashid: Contribution as execution of research trial

Amina: Design the research study and conducted the biochemical analysis

M. F. Sarwar: Write up and assistance in the research

B. S. Khan: Removed Plagiarism and statistical work

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