Research Article

Effect of NPK and Sulphur on Growth Attributes and Chlorophyll Content of Cauliflower (*Brassica oleracea* var. *botrytis* L.) variety Pusa Synthetic

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Abstract

A field experiment was conducted at Horticulture Farm, S.K.N. College of Agriculture, Jobner (Jaipur) during *Rabi* season 2015-16. The experiment consisting four levels of NPK (0, 75, 100 and 125% RD of NPK) and four doses of sulphur (0, 20, 40 and 60 kg sulphur ha^{-1}) with total 16 treatment combinations were tested in randomized block design with three replications. Results revealed that application of 125 per cent recommended dose of NPK alone or with combination of sulphur doses @ 60 kg ha^{-1} to the cauliflower crop significantly increased the plant height (cm) at 30, 60 DAT and at harvest, number of leaves, leaf area and chlorophyll content (mg/g) as compared to control and 75 per cent recommended dose of NPK with 20 kg sulphur ha^{-1} but statistically at par with 100 per cent recommended dose of NPK and 40 kg sulphur ha^{-1}. Application of sulphur @ 60 kg ha^{-1} was found to be non significant in case of days taken to curd initiation over different sulphur doses.

Keywords: Cauliflower, NPK, sulphur, plant height, number of leaves, leaf area and chlorophyll content

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Introduction

Cauliflower (*Brassica oleracea* var. *botryitis* L.*)* is the most popular vegetable crop among cole crops belong to the family Cruciferae. It is being grown round the year for its white and tender curd. In India, two separate groups of cauliflower are commonly grown *viz.* Indian or tropical types (originated in India) and the annual temperate or European type also known as 'Erfurt' or snowball type. The Indian types form curds at 20 to 25^{0}C and the temperate types require a temperature of 10 to 16^{0}C for curd formation. The Indian types are resistant to water logging and heat. The typical Indian or Tropical cauliflowers have been developed from the inter-crossing of Cornish type (biennial) with European strains. Tropical types have more variability and strong self-incompatibility. Temperate types have less variability and less or no self-incompatibility. Tropical types do not require of vernalization but requires cold treatment at 10 to 13^{0}C for 6 weeks. A temperate type requires vernalization at 7^{0}C for 8-10 weeks. It has small thick stem, bearing whorl of leaves and branched tap root system. The main point develops into shortened shoot system whose apices make up the convex surface of curd. It is used as fried vegetable, dried vegetable, making soup and pickles. In Rajasthan, Cauliflower is grown extensively in the district of Ajmer, Alwar, Tonk, Sikar, Bundi, Bharatpur, Nagaur, Rajsamand, Ganganagar, Jaipur and Jodhpur. Total area of cauliflower in Rajasthan about 9.42 thousand ha with an annual production of about 36.61 thousand tonnes and productivity is about 3.89 MT [1].

Among various essential plant nutrients, nitrogen is an essential for plant growth, development and reproduction. Nitrogen is associated with vigorous vegetative growth. It is helpful in large size compact curd development. The proper use of nitrogen improves the curd size, nutrient value and reduces the chances of buttoning [2]. Phosphorus is a constituent of nucleic acid, phytin and phosphorus. So, an adequate supply of phosphorus in early stage of plant life is an important in laying down the primordia for the reproductive parts of the cauliflower. It is also an essential constituent of majority of enzymes which are of great important in the transformation of energy in carbohydrate and fat metabolism and also in respiration in plants [3]. Potassium imparts increased vigour and disease resistance to plant. It also regulates water conduction within the plant cell and water loss from the plant by maintaining the balance between anabolism, respiration and transpiration. Thus reduces tendency to wilt and help in better utilization of available water which ultimately help in the formation of protein and chlorophyll and quality [4]. Sulphur is an essential plant nutrient and it stands next to primary nutrients in importance. Sulphur plays a vital role in biosynthesis of certain amino acids (cysteine, cystine and methionine) that are essential component of protein and also help in the synthesis of coenzyme-A and formation of chlorophyll and nitrogenase enzyme. Further, sulphur also provides winter

hardiness and drought tolerance, control of insect pests and disease *etc*. Two natural growth regulators, thiamin and biotin contain sulphur. Sulphur occurs in glutathione that is important in oxidation reduction reaction [5]. It is one of the constituents of vitamin B_1, some volatile oils and amino acids like methinine (21% S). It is involved in various metabolic and enzymatic processes in the plant [6]. The substantial decrease in SO_2 emission to less than 10 kg ha^{-1} of S further intensified S deficiency in plants, because as much as 30 per cent of its total amount can be absorbed from SO_2 in the air. The S cycle and its effect on plants are often compared to N (oxidation in soil and reduction in plants). The main difference is that S from organic compounds can be re-oxidised to SO_4–S in plants [7].

Material and methods

The field experiment was conducted at Horticulture farm, S.K.N. College of Agriculture, Jobner, Jaipur during *Rabi* season 2015-16 during October to January. The climate of Jobner is typically semi-arid characterized by extremes of temperature both in summer and winter, low rainfall and moderate relative humidity. Maximum temperature in summer ranges between 30 to 48^0C whereas, in winter, temperature falls down to as low as -1^0C. The average rainfall varies between 300 to 400 mm; most of which is received in rainy season from July to September but the amount has declined over the recent years. The soil was loamy sand in texture, slightly alkaline in reaction, poor in organic carbon with low available nitrogen, phosphorus and medium in potassium content. The experiment was comprised of 16 treatment combinations carried out in Randomized Block Design (RBD) with four levels of NPK (0, 75, 100 and 125 % RD of NPK) denoted by F_0, F_1, F_2 and F_3 and Sulphur (0, 20, 40 and 60 kg ha^{-1}) denoted by S_0, S_1, S_2 and S_3. The recommended dose of NPK for cauliflower is 120 kg, 80 kg and 80 kg per ha respectively. Full dose of P_2O_5, K_2O and half dose of N in various treatments were applied manually as the basal dose at the time of transplanting. Remaining dose of nitrogen was given as top dressing in two split doses at 30 and 45 days after transplanting. Sulphur was applied as per treatment through agriculture grade elemental sulphur and was broadcasted uniformly before transplanting and incorporated in the soil. The transplanting was done in evening hours followed by light irrigation.

Total chlorophyll content in leaves (mg/g)

Total chlorophyll content was determined at 40 DAT by using the method of [8]. 50 mg fresh leaf material was used for chlorophyll estimation. The materials were homogenized with 5 ml of 80 per cent acetone in a mortar with pestle. Then this aliquot was taken and centrifuged for 10 minutes at 2000 rpm and made the final volume to 10 ml and clear supernatant solution was taken. Absorbance of clear supernatant was measured at 663 nm and 645 nm on Spectronic-20 (spectrophotometer).

$$\text{Total chlorophyll (mg/g)} = \frac{20.5\,(A645 + 8.02\,(A663)}{1000 \text{ X } W} \text{ X } V$$

Where, A= Absorbance specific wave lengths, V= Final volume of chlorophyll extract in 80% acetone solution, W= Fresh weight of bits of leaves extracted

Results and discussion

Effect of NPKs on growth attributes and chlorophyll content

The effect of NPK on plant height and number of leaves per plant of cauliflower at different stages of growth presented in **Table 1** shows different NPK levels significantly influenced the plant height and number of leaves per plant (**Figure 1**) at different stages of growth. The mean maximum plant height at 30, 60 DAT and at harvest was (30.83, 46.57 and 58.25 cm, respectively) and number of leaves per plant at 30, 60 DAT and at harvest (13.00, 18.22 and 24.96, respectively) was recorded under F_3 *i.e.* 125 per cent recommended dose of NPK, which was found to be significantly higher over F_0 and F_1 but statistically to at par to F_2 treatment. The data reported in same table revealed that days taken to curd initiation varied non-significantly due to different fertility levels. Leaf area and chlorophyll content (Table 1 and **Figure 2**) of cauliflower also significantly influenced by different fertility levels. The mean maximum leaf area was (868.30 cm^2) and chlorophyll content (1.42 mg g^{-1}) recorded under F_3 (125 per cent recommended dose of NPK), which was found to be significantly higher over F_0 and F_1 but it was statistically at par with F_2. The mean minimum leaf area (695.98 cm^2) was recorded in F_0 (control).

It might be due to that fluctuation in the day and night temperature during curd initiation. The maximum temperature in 3rd week was recorded 23° C however, it was 27° C in 1st week of January. Significantly increased the

plant height, leaf area and number of leaves per plant might be due to the better nutritional environment in the root zone for growth and development of the plant by the application of NPK.

Table 1 Effect of NPKs and sulphur on growth attributes and chlorophyll content of cauliflower

Treatments	Plant height (cm)			No. of leaves per plant			Days taken to curd initiation	Leaf area (cm^2)	Chlorophyll content (mg/g)
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest			
Fertility levels									
Control (F_0)	25.61	39.74	47.88	9.64	15.52	20.50	65.57	695.98	1.09
75 per cent RD of NPK (F_1)	27.72	42.96	53.11	10.91	17.03	21.79	61.05	786.32	1.26
100 per cent RD of NPK (F_2)	30.67	45.15	57.03	12.51	17.94	24.38	56.52	853.98	1.37
125 per cent RD of NPK (F_3)	30.83	46.57	58.25	13.00	18.22	24.96	54.85	868.30	1.42
SEm±	0.85	0.76	1.09	0.29	0.29	0.54	2.40	14.00	0.04
CD at 5%	2.47	2.19	3.14	0.84	0.84	1.57	NS	40.44	0.11
Sulphur levels (kg/ha)									
Control (S_0)	25.14	39.88	48.71	9.95	15.45	19.12	64.01	690.12	1.05
Sulphur 20 kg ha^{-1} (S_1)	28.21	43.11	53.05	11.25	17.05	22.59	60.11	787.18	1.25
Sulphur 40 kg ha^{-1} (S_2)	30.69	45.33	56.95	12.31	18.00	24.81	56.82	856.28	1.38
Sulphur 60 kg ha^{-1} (S_3)	30.79	46.11	57.56	12.55	18.21	25.11	57.05	871.00	1.46
SEm±	0.85	0.76	1.09	0.29	0.29	0.54	2.40	14.00	0.04
CD at 5%	2.47	2.19	3.14	0.84	0.84	1.57	NS	40.44	0.11

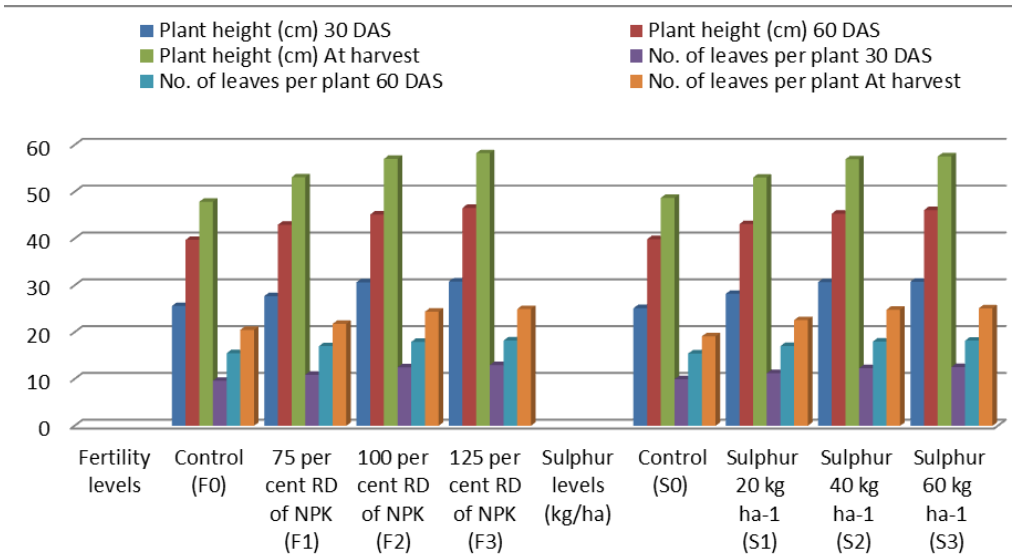

Figure 1 Effect of NPK and Sulphur on plant height and number of leaves

The NPK are considered as one of the major nutrient required for proper growth and development of the plant. Besides this, nitrogen is a main constituent of protoplasm, cell nucleus, amino acids, proteins, chlorophyll and many other metabolic products. Phosphorus is a constituent of nucleic acid, phytin and phospholipids. The beneficial influence of phosphorus in early stages of growth may be explained by early stimulation of root system through efficient translocation to the root of certain growth stimulation compounds formed on account of protoplasmic activity of tops in phosphorus fed plants, when enhanced absorption of nitrogen and other nutrient and their utilization. So an adequate supply of phosphorus in early stage of plant life is an important in laying down the primordial for the reproductive parts of the cauliflower [9]. The response to potassium fertilization in terms of overall

improvement in growth parameters in further supported by the fact that the leaching losses of potassium were more in light textured soils. Therefore, potassium fertilization improved overall crop growth in terms of plant height, number of leaves per plant. Potassium helps in the protein and chlorophyll formation ultimately the NPK are used for better vegetative growth. The results are close conformity with the finding of [10], [11], [12] and [13].

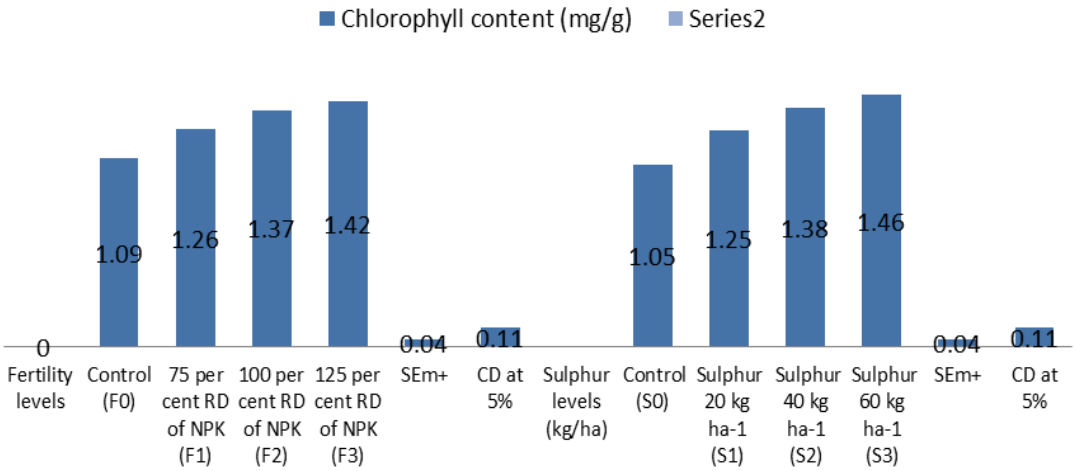

Figure 2 Effect of NPK and sulphur on chlorophyll content of cauliflower

Effect of sulphur on growth attributes and chlorophyll content

The result of present investigation have shown that increasing levels of sulphur significantly increased the plant height and number of leaves per plant (Table 1 and Figure 1), while days taken to curd initiation decreased with higher levels of sulphur. The results revealed that application of sulphur at the rate of 40 kg ha^{-1} have significantly increased the plant height and number of leaves per plant as compared to 20 kg sulphur per ha and control. The maximum plant height of 30.79, 46.11 and 57.56 cm at 30, 60 DAT and at harvest and number of leaves per plant of 12.55, 18.21 and 25.11 cm at 30, 60 DAT and at harvest, respectively were recorded with 60 kg S ha^{-1}. However, 60 kg ha^{-1} was found statistically at par to it. The interaction effect of fertility levels and sulphur dose on plant height, number of leaves per plant and days taken to curd initiation was found to be non-significant. It is obvious, because of the fact that application of sulphur has been reported to improve not only the availability of sulphur but of other nutrient too, which are considered important for growth and development of plant. Increased vegetative growth of cauliflower due to sulphur application in the present investigation is in close conformity with the finding of [14] and [15].

Application of different sulphur doses had significant effect on leaf area and chlorophyll content of leaves (Table 1 and Figure 2). The maximum leaf area (871.00 cm^2) and maximum value of chlorophyll (1.46 mg g^{-1}) content was recorded with 60 kg S ha^{-1} which was statistically at par with 40 kg S ha^{-1}. The mean minimum leaf area and chlorophyll content of leaves was recorded in S_0 (control).The mean increase in leaf area and chlorophyll content of leaves under S_2 treatment was found to be 24.07, 8.78 and 31.43 and 10.40 per cent over S_0 and S_1, respectively. Application of sulphur has been reported to help in lowering soil pH resulting in increased availability of several nutrients or might be due to the activation of a number of enzymes, energy transformation, chlorophyll formation and also in carbohydrate metabolism [16], Due to sulphur fertilization, xylem and collenchymas fiber are also reported to be thickened resulting into more pronounced growth of plant [17]. Increasing vegetative growth of cauliflower due to sulphur fertilization in the present investigation is in close conformity with the findings of [18] and [19]. Sulphur also plays an important role in the production of chlorophyll. It was found that the sulphur increased the chemical and biological activation of iron in the leaves resulting in increased chlorophyll content [20].

Conclusion

The combined application of 100 per cent recommended dose of NPK along with sulphur 40 kg ha^{-1} was found best to harvest a good cauliflower crop with maximum number of leaves per plant, leaf area, reduced days taken to curd initiation and chlorophyll content, respectively because resulting saving of 25 per cent recommended dose of NPK and 20 kg sulphur ha^{-1}. Thus, application of 100 per cent recommended dose of NPK along with sulphur 40 kg ha^{-1} recommended for cauliflower crop.

References

[1] NHB, 2013. Ministry of Food Processing Industries, Government of India, Gurgaon (Haryana).
[2] Markovic, V. and Diurovaka, M. 1990. The effect of mineral nutrition on the yield and quality of cauliflower (Brassica oleracea var. botryitis L.). Acta Horticulture, 267: 101- 109.
[3] Yawalkar, K.S., Agarwal, J.P. and Bokde, S. 1996. Manures and Fertilizers. Agri-Horticulture Publishing House, Nagpur, india.
[4] Rutkauskiene, G. and Poderys, M. 1999. Influence of NPK fertilizers on the yield and quality of white cabbage heads. Sodininkyste ir darzininkyste, 18: 155-162.
[5] Kanwar, J.S. 1976. Soil fertility – Theory and practice. ICAR, New Delhi.
[6] Goswami, N.N. 1988. Sulphur in Indian Agriculture. The Fertilizer Association, New Delhi, India.
[7] Vanek, V.; Kola, L.; Stipek, K. and Jakl, M. 2001. The metabolism of sulphur in plants and the role of S compounds. In: International Conference Reasonable Use of Fertilizers, 7., Praha,. Proceedings Praha, EZU. pp. 27-34.
[8] Arnon, D.I. 1949. Copper enzymes in isolated chloroplast- polyphenol oxidase in Beta- vulgaris. Plant Physiology, 24: 1-15.
[9] Thakur, O.P.; Sharma, P.P. and Singh, K.K. 1991. Effect of nitrogen and phosphorus with and without boron on curd yield and stalk rot incidence in cauliflower. Vegetable Science, 18: 115-121.
[10] Baghel, M.S. and Singh, D.B. 1995. Effect of different level of N, K fertilizer and date of transplanting on cauliflower (Brassica oleracea var. botrytis L.). Recent Horticulture, 2 (2): 84-87.
[11] Patil, B. N.; Ingle, V. G.; Patil, S. S., 2003. Effect of spacings and nitrogen levels on growth and yield of knol-khol (Brassica oleracea var. caulorapa) cv. White Vienna. Annals of Plant Physiology, 17 (2): 110-113.
[12] Kumhar, R. 2004. Effect of NPK and vermicompost on growth, yield and quality of cauliflower (Brassica oleracea var. botrytis Lamk.) cv Pusa Katki. M.Sc. (Ag.) Thesis submitted to Rajasthan Agriculture University, Bikaner, Campus-Jobner.
[13] Abd el-All, H.M. and EL- Shabrawy, R.A. 2013. Effect of some phosphorus sources, nitrogen and sulphur levels on yield, quality, sulforaphane and Vit. C content in broccoli. Research Journal of Agriculture and Biological Sciences, 9 (6): 351-365.
[14] Bhagavatagoudra, K.H. and Rokhade, A.K. 2001. Effect of sources and levels of sulphur nutrition on growth and yield of cabbage. Karnataka Journal of Agricultural Science, 14 (3): 724-726.
[15] Mahmud, Z.U.; Rahman, M.M.; Salam, M.A.; Saha, S.R. and Alam, M.S. (2005). Effect of Sulphur, Boron and Molybdenum on curd yield of cauliflower. Journal Subtropical agric. Research & Development, 3 (1): 82-86.
[16] Tandon, H.L.S. 1986. Fertilizer recommendation for horticultural crops in India. A Guide Book F.D. Co., New Delhi, pp. 112.
[17] Biswas, D.R.; Ali, S.A. and Khera, M.S. 1995. Response of gobhi sarson (Brassica napus L.) to N and S. Journal of the Indian Society of Soil Sciences, 43 (2): 220-223.
[18] Dhar, M.; Jana, J.C. and Maity, T.K. 1999. Response of cabbage to sulphur fertilization, Vegetable Science, 26 (1): 82-84.
[19] Meena P.S. 2004. Effect of nitrogen and sulphur on growth and yield of sprouting broccoli (Brassica oleracea var. italica L.) cv. EU-Green. Udyanika, 10 (3): 7-10.
[20] Chhipa, B.G. 2005. Effect of different levels of sulphur and zinc on growth and yield of cauliflower (Brassica oleracea var. botrytis L.). Thesis M.Sc. (Ag.) submitted to RAU, Bikaner campus, Jobner.

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