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Effect of NPK and sulphur on yield of cauliflower (*Brassica oleracea* var. *botrytis* L.)

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ABSTRACT

A field experiment was conducted at the Horticulture Farm of the Rajasthan Agricultural Research Institute in Durgapura, Jaipur, during the Rabi season of 2019-20. The study included four levels of NPK (0%, 60%, 100%, and 120% of the recommended dose) and four doses of sulphur (0, 20, 40, and 50 kg/ha), resulting in a total of 16 treatment combinations. These treatments were tested using a randomized block design with three replications. The results indicated that the application of 100% of the recommended dose of NPK, along with sulphur @ 40 kg/ha, was the most effective treatment combination for the cauliflower crop. This combination resulted in an average curd weight of 431.81 g, a total curd yield per plot of 122.68 kg, and a total curd yield of 213.24 q/ha.

Introduction

Cauliflower (*Brassica oleracea* var. *botrytis* L.) is one of the most popular vegetable crops among cole crops and belongs to the Cruciferae family. It is cultivated year-round for its white and tender curds. In India, two main groups of cauliflower are commonly grown: Indian or tropical types, which originated in India, and annual temperate or European types, also known as 'Erfurt' or snowball types. Indian types typically form curds at temperatures between 20 to 26°C, while temperate types require cooler conditions of 10 to 16°C for curd formation. The Indian varieties are notably resistant to waterlogging and heat. Cauliflower is versatile and can be prepared in various ways, including frying, drying, making soups, and pickling. In Rajasthan, cauliflower is extensively cultivated in districts such as Ajmer, Alwar, Tonk, Sikar, Bundi, Bharatpur, Nagaur, Rajsamand, Ganganagar,

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Jaipur, and Jodhpur. The state has approximately 10.2 thousand hectares dedicated to cauliflower cultivation, yielding around 5.17 thousand tons. In India as a whole, it is grown over an area of about 0.43 million hectares, with an annual production of approximately 8.2 million tons and a productivity rate of about 19.25 tons per hectare (Anonymous, 2016).

Nitrogen plays a key role in promoting vigorous vegetative growth and aids in the development of large, compact cauliflower curds. Phosphorus, a vital component of nucleic acids, phytin, and phospholipids, is crucial during the early stages of plant growth, as it helps establish the primordia for reproductive parts in cauliflower. Potassium contributes to increased plant vigor and disease resistance by regulating water movement within plant cells and maintaining the balance between anabolism, respiration, and transpiration. Sulphur plays a critical role in the biosynthesis of amino acids like cysteine, cystine, and methionine, which are key components of proteins. Additionally, sulphur is involved in the synthesis of coenzyme-A, the formation of chlorophyll, and the functioning of the nitrogenase enzyme. It is also present in growth regulators like thiamine and biotin, and in glutathione, which is important for oxidation-reduction reactions (Kanwar, 1976). Sulphur involved in numerous metabolic and enzymatic processes within plants (Goswami, 1988). With the reduction of sulphur dioxide (SO_2) emissions to less than 10 kg per hectare, sulphur deficiency in plants has become more prevalent, as up to 30% of sulphur can be absorbed from SO_2 in the air. The sulphur cycle, similar to nitrogen, involves soil oxidation and reduction within plants, but sulphur from organic compounds can be re-oxidized to sulfate (SO_4-S) in plants (Vanek *et al.*, 2001).

Therefore, considering the crucial role of macronutrients (NPK) and sulphur in the growth and development of cole crops, this study is undertaken to determine the optimum doses of nitrogen, phosphorus, potassium, and sulphur for cauliflower cultivation. The aim is to enhance plant health, improve curd quality, and ensure better nutrient management for optimal yield.

Material and Methods

The field experiment aimed at studying the response of NPK and sulfur on the yield of cauliflower was conducted at the Research Farm of the Rajasthan Agricultural Research Institute in Durgapura, Jaipur, during the Rabi season (October to January) of 2019-20. The experiment was comprised of 16 treatment combinations laid out in Randomized Block Design (RBD) with four levels of NPK (0, 60, 100 and 120 % RD of NPK) and sulphur (0, 20, 40 and 60 kg/ha). The recommended dose of NPK for cauliflower cultivation 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. The 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. Seeds of cauliflower cv. Pusa KT1 obtained from National Seed Corporation and treated with 0.02 per cent Thiram to save the seedlings from damping off disease. A thin layer of powered leaf mould was used to cover the seeds. The crop was provided with optimum irrigation. The seedlings were ready for transplanting in 4-5 weeks. Five weeks old seedlings were transplanted on 5th October, 2019, when average height of seedlings was about 10-12 cm. The distance between row to row and plant to plant was kept at 45 x 45 cm. Thus, 16 plants were accommodated in each plot. The transplanting was done in evening hours followed by light irrigation.

Results and Discussion

Effect of NPKs on growth attributes

The data revealed that different NPK levels had a significant effect on plant height and the number of leaves per plant at various growth stages (Table 1). The mean maximum plant height at 30, 60 days after transplanting (DAT), and at harvest was 30.8 cm, 46.5 cm, and 58.2 cm, respectively. Similarly, the corresponding number of leaves per plant at 30, 60 DAT, and at harvest was 13, 18, and 25, respectively in response to 120 per cent recommended dose of NPK (F_2). This was found to be significantly higher over F_0 (Control) and F_1 (60 per cent RD of NPK) but statistically to at par to F_2 treatment. The data presented in the same table indicated that the days taken for curd initiation were not significantly affected by the different fertility levels. Leaf area and chlorophyll content of cauliflower were significantly influenced by different fertility levels. The mean maximum leaf area and chlorophyll content were 868.3 cm^2 and 1.40 mg/g recorded under F_3 (120 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. These results are closely aligned with the findings of Baghel and Singh (1995), Patil *et al.* (2003), and Abd el-All and El-Shabrawy (2013), who have reported similar outcomes in their studies.

Effect of NPKs on yield attributes

The mean maximum average weight of curd (371.65 g) and volume of curd (264.66 CC) was observed in F_3 *i.e.* 120 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 *i.e.* 100 per cent recommended dose of NPK (Table 2). Whereas, minimum volume of curd (150.76 CC) was recorded under F_0 treatment. In case of yield data reveals that total yield of curd per plot and per ha was significantly influenced by various fertility levels. The maximum yield of curd per plot (5.95 kg) and total curd yield/ ha (183.5 q/ha) was recorded under 120 per cent recommended dose of NPK (F_3) followed F_2 and F_1. While minimum curd yield /plot (3.42 kg) and yield/ (105.60 q) was recorded under control. The maximum yield of curd/ plot and yield/ ha under the treatment F_3 was found significantly more over to F_0 and F_1 but it was statistically at par with F_2 treatment.

The application of 100 per cent recommended dose of NPK significantly increased the average weight of curd (g), curd yield per plot (kg), curd yield per ha and volume of curd (CC). However, 100 per cent recommended dose of NPK (F_2) was statistically at par to 120 per cent recommended dose of NPK (F_3) in all the above characters. This might be due to the fact that increased NPK levels, helped in the expansion of leaf area and chlorophyll content which together might have accelerated the photosynthetic rates and in turn increased the supply of carbohydrates to plants. The application of 100 per cent recommended dose of NPK favoured the metabolic and auxin activities in plant and ultimately resulted in increasing curds weight, volume of curd finally the total yield. However, potassium does not increase the yield of plant but indirectly supported to yield. These results are also in close conformity with the finding of Batel *et al.* (1997), Everaarst and Boou (2000), Yaldas *et al.* (2008) and Abd el-All and EL-Shabrawy (2013).

Effect of sulphur on growth attributes

The application of sulphur @ 40 kg/ha have significantly increased the plant height and number of leaves per plant as compared to 20 kg sulphur per ha and control (Table 1). The maximum plant height of 30.8, 46.1 and 57.5 cm at 30, 60 DAT and at harvest and number of leaves per plant of 12, 18 and 25 cm at 30, 60 DAT and at harvest, respectively were recorded with 60 kg S /ha. However, 60 kg/ha 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. Application of different sulphur doses had significant effect on leaf area and chlorophyll content of leaves. The maximum leaf area (871.00 cm^2) and maximum value of chlorophyll (1.46 mg/g) content was recorded with 60 kg S/ ha which was statistically at par with 40 kg S/ha. 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. The increase in vegetative growth of cauliflower due to sulphur fertilization is consistent with the findings of Yadav and Paliwal (1990), Biswas *et al.* (1995), Dhar *et al.* (1999), Bhagavatagoudra and Rokhade (2001), Meena (2004), and Mahmud *et al.* (2005).

Effect of sulphur on yield attributes

Data presented in Table 2 revealed that the application of 40 kg S/ha significantly increased average weight of curd (g), total curd yield per plot (kg), total curd yield per ha (q) and volume of curd (CC) as compared to control and 20 kg sulphur but remained statistically at par with 60 kg sulphur per ha. The highest average weight of curd (372.08 g) and volume of curd (266.3 CC) was recorded with 60 kg/ha which was statistically at par with 40 kg/ha whereas minimum was recorded under control. The maximum curd yield per plot (5.95 kg) and per ha (105.77 q/ha) was recorded with 60 kg S/ha, which was statistically at par with 40 kg S/ha. These finding corroborates with the research of Hossan and Olsen (1966), Hara *et al.* (1981), Bijania and Dixit (1996), Dhar *et al.* (1999), Bhagavatagoudra and Rokhade (2001), Jamre *et al.* (2010) and Talukder *et al.* (2013).

Interactive effect (F x S)

The treatment combination F_3S_3 resulted in the maximum average curd weight of 449.84 g, curd yield per plot of 7.20 kg, and curd yield per hectare of 222.14 q/ha, which were significantly superior to both the control and other treatment combinations (Table 3). However, F_3S_3, was statistically comparable to F_2S_2, F_3S_2, and F_2S_3. In contrast, the minimum curd weight of 148.98 g, curd yield per plot of 2.38 kg, and curd yield per hectare of 73.57 q/ha were recorded with the F_0S_0 treatment combination (control). The results are in agreement with the findings of Jamre *et al.* (2010) and Abd el-All and El-Shabrawy (2013).

Conclusion

Based on the findings of the experiment, it can be concluded that the treatment combination F_3S_2, which consists of 100% of the recommended dose of NPK and sulphur at 40 kg/ha, resulted in an average curd weight of 431.81 g, a total curd yield per plot of 122.68 kg, and a total curd yield of 213.24 q/ha.

Table 1. Effect of NPK and sulphur on growth attributes 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)	25.6	39.7	47.8	9	15	20	65	695.9	1.07
60 per cent RD of NPK (F_1)	27.7	42.9	53.1	10	17	21	61	786.3	1.24
100 per cent RD of NPK (F_2)	30.6	45.1	57.0	12	17	24	56	853.9	1.35
120 per cent RD of NPK (F_3)	30.8	46.5	58.2	13	18	25	54	868.3	1.40
SEm±	0.86	0.76	1.09	0.29	0.29	0.54	2.40	14.00	0.04
CD at 5%	2.48	2.19	3.14	0.84	0.84	1.57	NS	40.44	0.11
Sulphur levels (kg/ha)									
Control (S_0)	25.1	39.8	48.7	9	15	19	64	690	1.03
Sulphur 20 kg ha^{-1} (S_1)	28.2	43.1	53.0	11	17	22	60	787	1.23
Sulphur 40 kg ha^{-1} (S_2)	30.7	45.3	56.9	12	17	24	56	856.2	1.36
Sulphur 60 kg ha^{-1} (S_3)	30.8	46.1	57.5	13	18	25	57	871	1.44
SEm±	0.86	0.76	1.09	0.29	0.29	0.54	2.40	14.00	0.04
CD at 5%	2.48	2.19	3.14	0.84	0.84	1.57	NS	40.44	0.10

Table 2. Effect of NPK and sulphur on yield attributes of cauliflower

Treatments	Average weight of curd (g)	Volume of curd (cc)	Curd yield (kg/plot)	Curd yield (q/ha)
Fertility levels				
Control (F_0)	213.80	150.78	3.42	105.60
60 per cent RD of NPK (F_1)	286.62	211.37	4.59	141.56
100 per cent RD of NPK (F_2)	358.70	247.36	5.74	177.15
120 per cent RD of NPK (F_3)	371.65	264.66	5.95	183.55
SEm±	5.62	6.98	0.09	2.74
CD at 5%	16.24	20.16	0.26	7.92
Sulphur levels (kg/ha)				
Control (S_0)	214.15	147.13	3.43	105.77
Sulphur 20 kg ha^{-1} (S_1)	286.25	212.53	4.58	141.37
Sulphur 40 kg ha^{-1} (S_2)	358.36	248.19	5.73	176.98
Sulphur 60 kg ha^{-1} (S_3)	372.02	266.32	5.95	183.73
SEm±	5.61	6.98	0.09	2.74
CD at 5%	16.22	20.16	0.26	7.92

Table 3. Interactive effect of NPK and sulphur on yield attributes of cauliflower

Treatments	Fertility levels											
	Average weight of curd (g)				Curd yield (kg/plot)				Curd yield (q ha^{-1})			
Sulphur levels	F_0	F_1	F_2	F_3	F_0	F_1	F_2	F_3	F_0	F_1	F_2	F_3
Control (S_0)	148.98	199.71	249.07	258.96	2.38	3.20	3.99	4.14	73.57	98.62	123.00	127.88
Sulphur 20 kg ha^{-1} (S_1)	199.13	266.94	332.91	346.13	3.19	4.27	5.33	5.54	98.34	131.82	164.40	170.93
Sulphur 40 kg ha^{-1} (S_2)	248.42	333.02	420.31	431.81	3.97	5.33	6.72	6.91	122.68	164.45	207.56	213.24
Sulphur 60 kg ha^{-1} (S_3)	258.79	346.92	432.65	449.84	4.14	5.55	6.92	7.20	127.80	171.32	213.65	222.14
SEm±	11.25				0.18				5.48			
CD (0.05)	32.49				0.52				15.83			

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