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Effect of different levels of NPK and manures on growth, yield and quality of cauliflower (*Brassica oleracea* L. var. *botrytis*) under open field conditions

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Abstract
The field experiment entitled "Effect of different levels of NPK and manures on growth, yield and quality of cauliflower (*Brassica oleracea* L. var. *botrytis*) under open field conditions" was carried out at the "Campus for Research and Advanced Studies, GSSDGS Khalsa College, Patiala" during the *Rabi* season of 2021-2022. The experiment was laid out in randomized block design with comprising of thirteen treatment and three replications. The results revealed that different NPK levels and organic manures resulted in significantly superior in growth, yield and quality characters. All the growth parameters plant height (44.79 cm), leaf length (39.45 cm), leaf width (22.64 cm), plant spread (34.91 cm) and no of leaves plant^{-1} (22.86) were significantly maximum in treatment T_2 (100% RDF + 2.5 t ha^{-1} Vermicompost). Yield parameters diameter of curd (17.94 cm), average weight of curd (734.45 g) and curd yield (677.05 g) were maximum in T_2 (100% RDF + 2.5 t ha^{-1} Vermicompost). Maximum TSS (4.95°Brix) and Ascorbic acid content (38.90 mg 100 g^{-1}) were also found in T_2 (100% RDF + 2.5 t ha^{-1} Vermicompost).

Keywords: cauliflower, vermicompost, manures

Introduction
Cauliflower as its botanical name *Brassica oleracea* L. var. *botrytis* is a thermosensitive crop of Cruciferae family most commonly known as "Phul gobhi". Cauliflower was brought to India by Dr. Jemson in the year 1822 from England. Cauliflower has its domestication from Coastal area of Mediterranean Sea. Chromosome number of Cauliflower is 2n=18. Cauliflower is derived from Latin word 'Caulis' meaning stem and 'Floris' meaning flower. India ranks first in cauliflower production. *Brassica cretica* is the ancestor of cauliflower. Indian varieties of cauliflower have been developed from intercrossing between Cornish and European types (Muthukumar and Selvakumar 2017) [5].

The consumable part of cauliflower is "curd" which is closely packed flower buds that are not fully developed. These buds are joined to fleshy stalks that stores most of nutrients for their development. Characterization of Cruciferae includes 6 stamens out of which 2 are small and remaining 4 are long and also includes 4 petals which lies opposite to each other in square cross section. Cauliflower has special kind of pod called siliqua. Cauliflower can thrive well on sandy to heavy soil which is rich in organic matter as it is a heavy feeder crop (Anonymous 2017). Saline soils should be avoided as the crop become susceptible to diseases. The total area under cauliflower in India is 458 thousand hectares with total production of 8840 tonnes. The area under cauliflower in Punjab is 17.09 thousand hectares and total production of cauliflower in Punjab is 279.67 thousand tonnes (NHB 2019) [6].

Human health is significantly improved by vegetable consumption. Cauliflower is freshly processed and florets are used for bagging, soup preparations and for pickling. Vegetables belonging to family Brassicaceae contains a substance indole-3-carbinol that helps to prevent various types of cancers. According to Indian council of medical research on an average 200-300 g of vegetables should be consumed per capita.

Cauliflower is rich source of minerals and vitamins. It provides good quantity of Vitamin C and folate. Cauliflower has moisture content approx. 90%, protein 2.6 g, fat 0.4 g, thiamine 0.04 mg, riboflavin 0.10 mg per 100 g. It has 53 mg Sodium, 57 mg Phosphorus, 138 mg Potassium, 33 mg Calcium, 18 mg Magnesium, 0.4 mg Zinc, 1.23 mg Iron, 231 mg Sulfur,

0.003 mg Chromium, 0.13 mg Copper per 100 g. Vitamins includes 30 mg Carotene, 0.04 mg Thiamine, 0.1 mg Riboflavin, 1 mg Niacin per 100 g. Total carbohydrates are 4 K Cal. (Dhaliwal 2017) [13].

Material and Methods

The study of the "Effect of different levels of NPK and manures on growth, yield and quality of cauliflower (*Brassica oleracea* L var. *botrytis*)" is taken in the experimental field of GSSDGS Khalsa College Patiala during Rabi season (2021-22). The experiment was laid out in Randomised block design with 3 replications. The total number of treatments were 13 and each treatment was randomly allocated during the period of investigation. Germination of seeds takes place within a week after sowing. Seedlings are ready for transplanting when they attain height of 10-15 cm at 3 to 4 leaf stage. Manures like leaf manure, farmyard manure and fertilizers (N, P_2O_5 and K_2O) are used as soil application in rows according to the treatments. Manures improve soil texture and slowly release plant nutrients. They also retain moisture in the soil. Fertilizers provides plant nutrients in available form. The recommended dose of NPK is 50: 25: 25 kg acre $^{-1}$. Healthy seedlings of uniform size are manually transplanted in each plot at spacing of 45×45 cm accommodating 30 seedling in each plot. Seedlings are uprooted from plug trays carefully to avoid any damage. For tagging five plants are randomly selected from each plot after they attained a reasonable height Cauliflower is a shallow rooted crop because of which roots system lies within 45-60 cm of the topsoil. Minor weeds are removed by hands. To avoid root damage deep hoeing is avoided. The field was irrigated immediately after transplanting of the seedlings to avoid shock. Since the crop was planted in winter season and the texture of soil was clayey the number of irrigations required were less. Incidence of insect and disease was not much seen. However 2 to 3 plots were infested by pest. Leaves which were infested by the pest were thrown away.

For tagging five plants are randomly selected from each plot after they attained a reasonable height. The plants that were tagged for recording the various data were used to measure plant height, no of leaves plant^{-1}, leaf length, leaf width, plant spread as well as diameter and weight of the curd. Number of leaves were counted visually whereas plant height, leaf length, leaf width, plant spread and diameter was measured with the help of wooden scale. Electronic weighing machine was used to weigh the curds.

Details of layout

Experimental design	Randomised block Design
No of replications	3
No of treatments	13
Total number of plots	39
Seed rate	500 g ha^{-1}
Spacing	45 × 45 cm
Gross plot size	3.15 × 3.6 m^2
Net plot size	2.7 × 3.15 m^2
Variety	Pusa Katki

Treatment Details

T_1	Control
T_2	100% RDF+ 2.5 t ha^{-1} Vermicompost
T_3	100% RDF+ 3 t ha^{-1} Poultry manure
T_4	100% RDF + 8 t ha^{-1} Leaf manure
T_5	100% RDF+ 10 t ha^{-1} FYM
T_6	75 % RDF + 2.5 t ha^{-1} Vermicompost
T_7	75 % RDF + 3 t ha^{-1} Poultry manure
T_8	75 % RDF + 8 t ha^{-1} Leaf manure
T_9	75 % RDF + 10 t ha^{-1} FYM
T_{10}	50 % RDF + 2.5 t ha^{-1} Vermicompost
T_{11}	50% RDF + 3 t ha^{-1} Poultry manure
T_{12}	50% RDF + 8 t ha Leaf manure
T_{13}	50% RDF + 10 t ha FYM

Result and Discussions

Effect of different level of NPK and manures on growth parameters of cauliflower

Plant height tremendously increased as crop grows. It was seen application of T_2-100% RDF+ 2.5 t ha^{-1} Vermicompost resulted in 15.80 cm plant height at 30 DAT which considerably increased to 38.59 cm at 60 DAT and 44.79 cm at harvest. The data recorded was found at par with T_3-100% RDF + 3 t ha^{-1} Poultry manure which were 15.09 cm at 30 DAT and 37.16 cm at 60 DAT and 42.91 cm at harvest. The lowest plant height was seen in control at various stages of crop growth. Similar observations were elaborated by Gocher *et al.* 2017 [3]. The treatment T_2-100% RDF + 2.5 t ha^{-1} Vermicompost resulted in maximum leaves plant^{-1} at 30, 60 DAT and at harvest (10.69, 21.70 and 22.86). Similar effects were elaborated by Meena *et al*. 2017 [4]. They stated that vermicompost also enhances soil properties including pH, bulk density, porosity, and water-holding capacity of soil. Maximum leaf length were recorded with treatment T_2-100% RDF + 2.5 t ha^{-1} Vermicompost at 30, 60 DAT and at harvest (17.59, 37.60 and 39.45 cm) respectively which were at par with treatment T_3-100% RDF + 3 t ha^{-1} Poultry manure (17.48, 37.12 and 38.91 cm) at 30, 60 DAT and at harvest respectively. Similar research findings have also been reported by Kumar *et al*. 2012. Maximum leaf width was found with treatment T_2-100% RDF + 2.5 t ha^{-1} of vermicompost i.e. 8.89, 20.48 and 22.64 cm at 30 DAT, 60 DAT and at harvest.

Maximum plant spread was found in treatment T_2-100% RDF+ 2.5 t ha^{-1} vermicompost (15.79, 32.78 and 34.91cm) at 30 DAT, 60 DAT and at harvest. The results are in accordance with research findings of Raghuvanshi.2014 and Singh. 2008 on cauliflower.

Effect of different levels of NPK and manures on growth parameters

Treatments	Plant height (cm)	Leaves plant^{-1}	Leaf length (cm)	Leaf width (cm)	Plant Spread (cm)
T_1	24.74	14.29	30.18	13.71	19.64
T_2	44.79	22.86	39.45	22.64	34.91
T_3	42.91	21.99	38.91	21.75	33.69
T_4	39.10	20.45	37.08	20.38	32.19
T_5	41.08	21.38	38.04	21.16	33.24
T_6	39.61	21.01	37.56	20.72	32.82
T_7	38.76	20.04	36.60	19.59	30.99
T_8	35.69	18.74	34.38	18.75	29.78
T_9	38.18	19.55	35.49	19.31	31.70
T_{10}	36.15	19.17	34.94	19.01	30.29
T_{11}	34.98	18.04	33.79	18.18	28.18
T_{12}	33.45	16.79	32.50	17.41	26.38
T_{13}	34.31	17.32	33.18	17.86	27.15
SE (d)±	1.12	0.42	0.34	0.46	0.64
CD (5%)	2.24	0.96	0.77	0.98	1.49

Effect of different level of NPK and manures on yield and quality parameters cauliflower

The largest diameter of curd (17.94 cm) was resulted from treatment T_2-100% RDF+ 2.5 t ha^{-1} vermicompost, followed by treatment T_3-100% RDF+3 t ha^{-1} poultry manure (17.38 cm). In control, the smallest diameter (13.19 cm) was observed. Similar results were observed by Naveen. 2008 [7] in cauliflower. The highest diameter was due to adequate absorption of various nutrients from soil, better root development and transportation of nutrients. Application of both fertilizers and manures leads to availability of macronutrients as well as micronutrients that produced curd with greater diameter. The largest average weight of curd (734.45 g) was resulted from treatment T_2-100% RDF+ 2.5 t ha^{-1} vermicompost, followed by treatment T_3-100% RDF+ 3 t ha^{-1} poultry manure (727.28 g). Similar results were observed by Patel *et al.* 2011 and Pawar and Barkule.2017 in cauliflower. The maximum weight was achieved with T_2-100% RDF+2.5 t ha^{-1} vermicompost (228.53 q ha^{-1}). Minimum curd yield was obtained in control 118.62 (q ha^{-1}). The TSS (°Brix) of cauliflower is significantly influenced by various treatments. The results showed that treatment T_2-100% RDF + 2.5 t ha^{-1} vermicompost resulted in maximum TSS (5.16° Brix). Similar result was found by Rana *et al.* 2020 [14]. The results showed that treatment T_2-100% RDF+ 2.5 t ha^{-1} Vermicompost (38.90 mg 100 g^{-1}), which was followed by treatment T_3-100 percent RDF + 3 t ha^{-1} poultry manure (38.55 mg 100 g^{-1}). Combine application of manures and fertilizer resulted in increase in all yield and quality parameters of the cauliflower.

Effect of different levels of NPK and manures on yield and quality parameters

Treatments	Diameter(cm)	Average weight (g)	Curd yield (q ha^{-1})	TSS (°Brix)	Ascorbic acid (mg 100 g $^{-1}$)
T_1	13.19	378.30	118.62	4.06	37.15
T_2	17.94	734.45	228.53	5.16	38.90
T_3	17.38	727.28	218.02	5.02	38.55
T_4	16.03	629.23	189.43	4.78	38.09
T_5	16.71	668.35	202.19	4.91	38.01
T_6	16.34	654.45	201.09	4.87	38.28
T_7	15.79	601.40	183.15	4.71	37.94
T_8	14.78	551.63	170.32	4.52	37.40
T_9	15.45	590.28	177.75	4.65	37.81
T_{10}	15.12	576.55	172.06	4.59	37.64
T_{11}	14.54	540.18	166.40	4.47	37.18
T_{12}	14.06	497.38	163.69	4.32	37.70
T_{13}	14.29	540.18	166.40	4.41	37.94
SE (d)±	0.48	1.46	1.16	0.11	0.22
CD (5%)	1.12	3.18	2.54	0.24	0.49

Conclusion

From the above research trial, it can be concluded that 100% RDF + 2.5 t ha^{-1} Vermicompost resulted in higher production of cauliflower. Vermicompost acted as natural fertilizers which does not cause any type of side effects to soil as well as crop and also gave better yield and quality of cauliflower. It acted as natural conditioner and helped the plants to develop stronger root system. It does not cause any environment pollution. Application of fertilizers enhances the plant traits but also help in maintaining soil fertility, nourishes young seedlings with nutrients in available form. Fertilizer addition not only lead to vigorous growth in plant but also improves their disease resistance.

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