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Effect of integrated nutrient management on growth and yield parameter of cauliflower (*Brassica oleracea* var. *Botrytis*) variety Madhuri

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Abstract
The experiment was carried out at Agriculture Research Farm of Rama University, Mandhana, Kanpur, U.P, India, during *Rabi* season 2022-2023 to assess the plant growth, curd quality and economics of cultivation under various Integrated Nutrient Management (INM). The experiment was laid out in Randomized Block Design with three replications and nine treatments. The results showed that application of T_8 (100% of P + 75% of N & K + *Azotobacter* @ 5 kg/ha + Vermicompost @ 5 t/ha) has resulted in the maximum canopy spread 4.61, 8.44 and 15.27cm at 15, 30 and 45 DAT, maximum number of leaves 5.02, 8.56 and 10.06 at 15, 30 and 45 DAT, minimum time of (days) between transplanting to curd Initiation (29 days), curd length (8.02cm), curd diameter (8.21cm), curd weight (779.35g) and curd yield per hectare (369.35q).

Keywords: Cauliflower var. Madhuri, NPK, vermicompost, *Azotobacter*, plant growth and yield parameter

Introduction
Cauliflower (*Brassica oleracea* var. *botrytis* L.) is one of the most important winter vegetables among the cole crops which belongs to the genus Brassica of the family Cruciferae. Cauliflower is essentially a cold weather hardy crop and thrives best in cool and moist climate. This was originated from Cyprus and the first crop of cauliflower was introduced in India in sixth century A.D. Cauliflower grown over an area 473.0 thousand ha with production of about 9283.0 thousand MT/ha (NHB 2021-2022) [8]. is rich in minerals such as potassium, calcium, iron, phosphorus, magnesium and carbohydrates. The nutritive value per 100g of fresh cauliflower Moisture 90.8g, Riboflavin 0.10mg, Protein 2.6g, Nicotinic acid 1.00mg, Fat 0.4 g, Vitamin C 56mg, Carbohydrate 4.0g, Calcium 33mg, Minerals 1.9g, Phosphorus 57mg, Fibers 1-2g, Iron 1.50mg, Vitamin A 30mg, Potassium 113mg and Magnesium 20mg (Rumeza and Hanit. 2006) [11]. In recent years, an integrated approach for utilization of available resources *viz*., organic, inorganic and microbial inoculants for achieving sustainable economic yield is termed as "Integrated nutrient management" (INM) has emerged as an important technique which has already been receiving wide attention and also contributing substantially towards the acceleration of crop productivity by maintaining physical, chemical and biological balance in soil for plant growth system. Inclusion of organic manures in the nutrient schedule of banana not only supplies micronutrients but also improve physical, chemical and biological properties of the soil. Cauliflower responds positively to large amounts of organic matter. It requires heavier dose of organic manures and also to equalize the inorganic fertilization (Lahav, 1973) [6]. The ample quantity of nitrogen is existing in the atmosphere and the same is being fixing by the root nodules, existing in the legume vegetable crops under normal condition. It is not possible in non-legume vegetable crops. But the use of bio- fertilizers like Azotobacter, Azospirillum, in non-legume vegetable crops helps in fixing atmospheric nitrogen. The beneficial effects of Azospirillum have been related not only to their nitrogen fixation proficiency but also with their abilities to produce antibacterial and antifungal compounds. The uses of bio-fertilizers also improve the texture and structure of the soil (Kalyani *et al.*, 1992) [4]. Application of organic manure such as Vermicompost with or without combination with bio-fertilizers as *Azotobacter* have been reported for replacing 25% of recommended dose of PK for better growth in cauliflower.

Materials and Methods

The experiment was carried out during the *Rabi* season 2022-23 at the main experiment station. Agriculture Research Farm of Rama University, Mandhana, Kanpur, UP, India. The experiments were laid out in Randomized Block Design with three replications. There were nine treatments and each treatment was allocated randomly in each plot during the period of investigation. For seed sowing fine raised bed of 3 x 1.2 x 0.15m was prepared. Upper 7 cm top layer of bed was applied with well rotten FYM and sieved soil in 1:1 proportion + Trichodarma + 25:25:25 g NPK. The beds were mulched with straw and covered with white transparent plastic sheet during the day and night to warm-up the bed until seed germination. Irrigation should be done with water can with nose at the interval of two days, weeding, intercultural and plant protection measures were undertaken frequently till the seedlings were ready for transplanting. To minimize the damage to the roots of the seedlings, the seedbeds were watered one hour before uprooting the seedlings. The seedlings were transplanted in the evening. To protect the seedlings from the scorching effect of sunlight, an artificial shade was provided by using rice straw until the establishment of the seedlings. Among the total plant population of plots, five plants were selected randomly from a plot for the observations. These plants were tagged for recording the various data on cauliflower. Measuring tape was used to measure Canopy spread (cm), Number of leaves, Time of (Days) between Transplanting to Curd Initiation, Curd length (cm), Curd diameter (cm), Curd weight (g) and Curd Yield (q/ha). Other cultural practices like, gap filling, irrigation and weeding etc.

Table 1: Treatment combinations

Treatments	Treatments details
T1	Control
T2	100% NPK (50:100:50)
T3	75% NPK
T4	50% NPK
T5	Vermicompost @ 5 t/ha
T6	Azotobacter @ 5 kg/ha
T7	100% of N + 75% of P & K + Azotobacter @ 5 kg/ha + Vermicompost @ 5 t/ha
T8	100% of P + 75% of N & K + Azotobacter @ 5 kg/ha + Vermicompost @ 5 t/ha
T9	100% of K + 75% of N & P + Azotobacter 5 @ kg/ha + Vermicompost @ 5 t/ha

Results and Discussion

The result of various parameters such as plant growth and yield parameter effected by different sources of integrated nutrient management on cauliflower (*Brassica oleracea* var. *botrytis* L.) variety "MADHURI" were recorded during 2022-23.

Canopy Spread (cm): The canopy spread of different treatment combination has been presented in Table. 2 and graphically presented in Fig.1. Canopy spread was gradually increased from 30 DAT to 45 DAT. The maximum canopy spread 4.61, 8.44 and 15.27 cm were recorded in T_8 (100% of P + 75% of N & K + *Azotobacter* 5 kg/ha + Vermicompost @ 5 t/ha) at 15, 30 and 45 DAT, whereas the minimum canopy spread 3.01, 5.61 and 11.11 cm were recorded with T_1 (Control). The increase in canopy spread gets the support with the findings of Shree *et al.,* (2014) [12] in cauliflower cv. Poosi and Kumar *et al.,* (2018) [5] in cabbage.

Table 2: Effect of Integrated nutrient management on canopy spread of cauliflower variety "MADHURI" at different DAT.

Treatment	Canopy Spread (cm)		
	15 DAT	30 DAT	45 DAT
T1	3.01	5.61	11.11
T2	3.43	6.78	11.61
T3	3.28	6.39	11.59
T4	3.16	6.02	11.14
T5	3.58	7.16	12.05
T6	3.74	7.56	12.63
T7	3.90	8.02	13.11
T8	4.61	8.44	15.27
T9	4.26	8.24	13.94
S.Em (±)	0.128	0.279	0.429
C.D. (P=0.05)	0.042	0.092	0.142

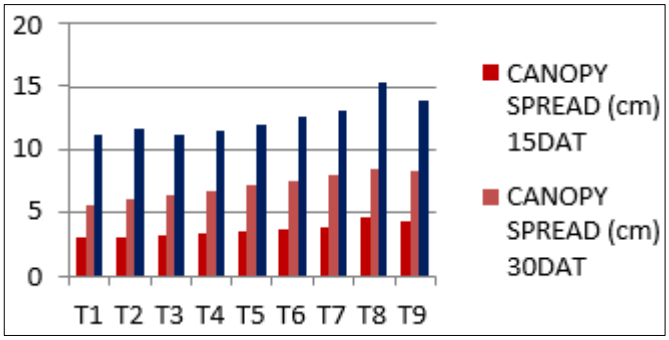

Fig 1: Effect of Integrated nutrient management on canopy spread (cm) of cauliflower variety "MADHURI" at different DAT

Number of leaves: The number of leaves of different treatment combination has been presented in Table. 3 and graphically presented in Fig.2. Number of leaves was gradually increased from 30 DAT to 45 DAT. The maximum number of leaves 5.02, 8.56 and 10.06 were recorded in T_8 (100% of P + 75% of N & K + *Azotobacter* 5 kg/ha + Vermicompost @ 5 t/ha) at 15, 30 and 45 DAT, whereas the minimum number of leaves 3.00, 5.02 and 8.02 were recorded with T_1 (Control). These findings are in close agreement with the results of Salim *et al.,* (2008) [13] in cauliflower and Pawar *et al.,* (2018) [9] in cauliflower. It can be attributed to the fact that the increase in nutrient levels of NPK especially nitrogen enhanced the vegetative growth enhancing the leaf area. This increase in vegetative growth and other parameters might be due to the production of more chlorophyll content with the inoculation of nitrogen fixers. Increased number of leaves might have increased the photosynthetic activity resulting in higher accumulation of carbohydrates.

Table 3: Effect of Integrated nutrient management on number of leaves of cauliflower variety "MADHURI" at different DAT.

Treatment	Number of leaves		
	15 DAT	30 DAT	45 DAT
T1	3.00	5.02	8.02
T2	3.58	6.21	8.62
T3	3.39	5.83	8.40
T4	3.21	5.41	8.23
T5	3.78	6.45	8.94
T6	3.96	6.85	9.17
T7	4.14	7.19	9.36
T8	5.02	8.56	10.06
T9	4.65	7.94	9.77
S.Em (±)	0.134	0.356	0.385
C.D. (P=0.05)	0.044	0.118	0.127

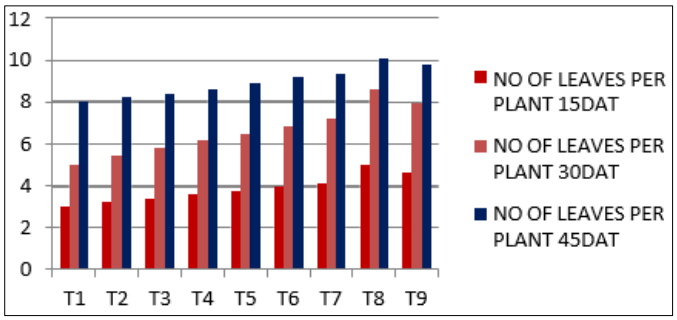

Fig 2: Effect of Integrated nutrient management on number of leaves of cauliflower variety "MADHURI" at different DAT

Time of (Days) between Transplanting to Curd Initiation

The time of (days) between transplanting to curd Initiation of different treatment combination has been presented in Table. 4 and graphically presented in Fig.3. The minimum time of (days) between transplanting to curd Initiation 29.00 days were recorded in T_8 (100% of P + 75% of N & K + *Azotobacter* 5 kg/ha + Vermicompost @ 5 t/ha), whereas the maximum time of (days) between transplanting and curd Initiation 40.00 days were recorded with T_1 (Control). These findings are in agreement with the reports of Yadav *et al.*, (2012) [15] in cabbage cv. Pride of India and Mohanta *et al.*, (2018) [7] in Sprouting Broccoli cv. Shayali.

Table 4: Effect of Integrated nutrient management on Time of (Days) between Transplanting to Curd Initiation of cauliflower variety "MADHURI"

Treatment	Time of (Days) between Transplanting and Curd Initiation
T1	40.00
T2	36.00
T3	37.00
T4	39.00
T5	35.00
T6	33.00
T7	32.00
T8	29.00
T9	31.00
S.Em(±)	1.562
C.D. (P=0.05)	0.517

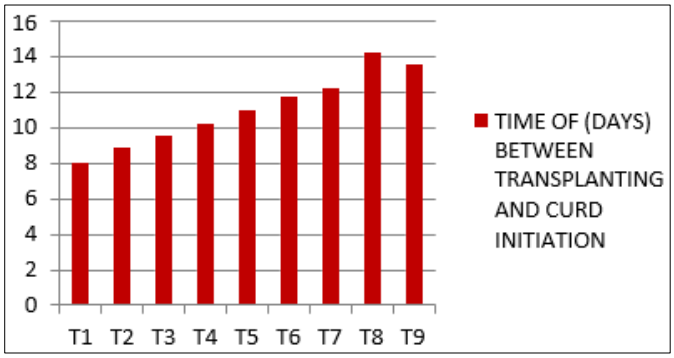

Fig 3: Effect of Integrated nutrient management on Time of (Days) between Transplanting to Curd Initiation of cauliflower variety "MADHURI"

Curd length (cm)

The curd length (cm) different treatment combination has been presented in Table.5 and graphically presented in Fig.4. The maximum curd length 14.29cm were recorded in T_8 (100% of P + 75% of N & K + *Azotobacter* 5 kg/ha + Vermicompost @ 5 t/ha), whereas the minimum curd length 8.02cm were recorded with T_1 (Control). These results get support of the findings of Yadav *et al.*, (2012) [15] in cabbage cv. Pride of India and Rana *et al.*, (2020) [10] in cabbage.

Table 5: Effect of Integrated nutrient management on curd length (cm) of cauliflower variety "MADHURI"

Treatment	Curd length (cm)
T1	8.02
T2	10.25
T3	9.59
T4	8.88
T5	11.02
T6	11.76
T7	12.26
T8	14.29
T9	13.59
S.Em (±)	0.611
C.D. (P=0.05)	0.202

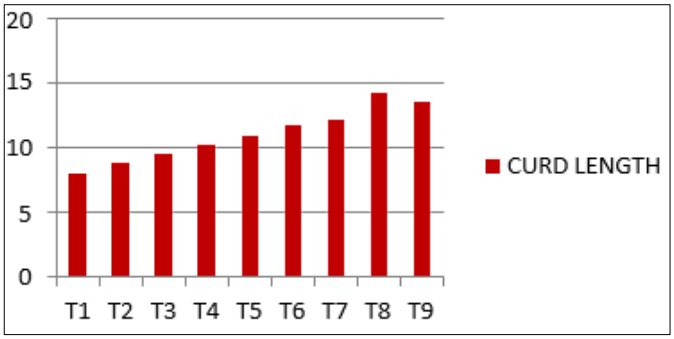

Fig 4: Effect of Integrated nutrient management on curd length (cm) of cauliflower variety "MADHURI"

Curd diameter (cm): The curd diameter (cm) different treatment combination has been presented in Table.6 and graphically presented in Fig.5. The maximum curd diameter 16.59cm were recorded in T_8 (100% of P + 75% of N & K + *Azotobacter* 5 kg/ha + Vermicompost @ 5 t/ha), whereas the minimum curd diameter 8.21cm were recorded with T_1 (Control). The obtained result was consistent with the findings of Devi *et al.*, (2018) [2] in cauliflower. This may be due to an increase in the photosynthetic activity of the plant with overall growth and an increase in chlorophyll content. Increased chlorophyll content produced more photosynthesis that was diverted for curd growth and resulted in better curd nutrition, leading to an increase in curd diameter.

Table 6: Effect of Integrated nutrient management on curd diameter (cm) of cauliflower variety "MADHURI"

Treatment	Curd diameter (cm)
T1	8.21
T2	11.30
T3	10.21
T4	9.13
T5	12.11
T6	13.25
T7	14.02
T8	16.59
T9	15.38
S.Em (±)	0.625
C.D. (P=0.05)	0.207

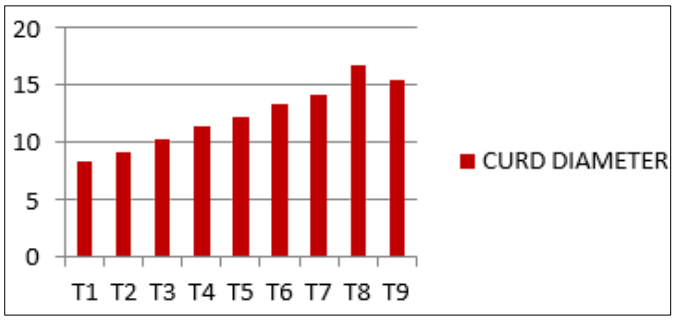

Fig 5: Effect of Integrated nutrient management on curd diameter (cm) of cauliflower variety "MADHURI"

Curd weight (g): The curd weight (g) different treatment combination has been presented in Table.7 and graphically presented in Fig.6. The maximum curd weight (779.35g) were recorded in T_8 (100% of P + 75% of N & K + *Azotobacter* 5 kg/ha + Vermicompost @ 5 t/ha), whereas the minimum curd weight (589.33g) were recorded with T_1 (Control). The increase in curd weight (g) can be attributed to the increase in canopy spread, number of leaves, curd length and diameter which may have increased the photosynthetic surface area and led to greater synthesis and translocation of photosynthetase towards curd formation. These findings are in line with the findings of Upadhyay *et al.*, (2012) [14] and Rana *et al.*, (2020) [10] in cabbage.

Table 7: Effect of Integrated nutrient management on curd weight (g) of cauliflower variety "MADHURI"

Treatment	Curd weight (g)
T1	589.33
T2	652.38
T3	632.43
T4	610.22
T5	673.26
T6	694.55
T7	715.24
T8	779.35
T9	750.36
S.Em (±)	28.300
C.D. (P=0.05)	9.359

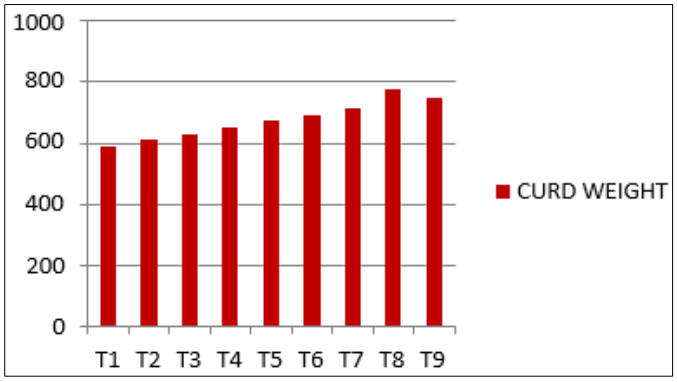

Fig 6: Effect of Integrated nutrient management on curd weight (g) of cauliflower variety "MADHURI"

Curd Yield (q/ha): The curd Yield (q/ha) different treatment combination has been presented in Table.8 and graphically presented in Fig.7. The maximum curd Yield (260.44q/ha) were recorded in T_8 (100% of P + 75% of N & K +*Azotobacter* 5 kg/ha + Vermicompost @ 5 t/ha), whereas the minimum curd Yield (196.03q/ha) were recorded with T_1 (Control). The similar result was conformity with Chaterjee *et al.*, (2012) [1] in cabbage, Upadhyay *et al.*, (2012) [14] in cabbage and Islam *et al.* (2014) in cauliflower.

Table 8: Effect of Integrated nutrient management on curd yield (q/ha) of cauliflower variety "MADHURI"

Treatment	Curd Yield (q/ha)
T1	196.03
T2	217.59
T3	210.35
T4	204.36
T5	224.52
T6	231.68
T7	238.96
T8	260.44
T9	254.64
S.Em (±)	10.658
C.D. (P=0.05)	3.525

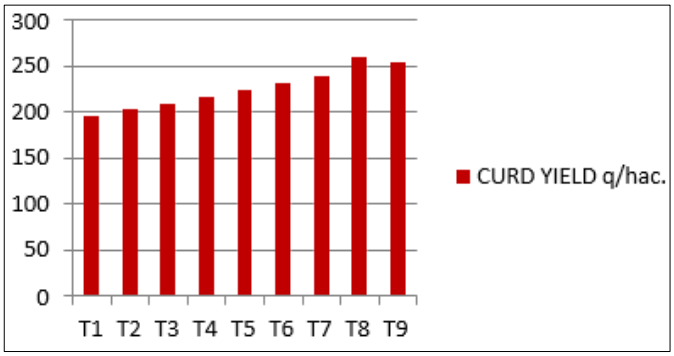

Fig 7: Effect of Integrated nutrient management on curd yield (q/ha) of cauliflower variety "MADHURI"

Conclusion

Based on the results obtained from the present investigation, it is conducted that the highest growth and yield of cauliflower *viz*., maximum canopy spread 4.61, 8.44 and 15.27 cm at 15, 30 and 45 DAT, maximum number of leaves 5.02, 8.56 and 10.06 at 15, 30 and 45 DAT, minimum time of (days) between transplanting to curd Initiation (29 days), curd length (8.02cm), curd diameter (8.21cm), curd weight (779.35g) and curd yield per hectare (369.35q) were observed with the treatment T_8 (100% of P + 75% of N & K + *Azotobacter* 5 kg/ha + Vermicompost @ 5 t/ha). From this study it can be recommend that the application of INM at 100% of P + 75% of N & K + Azotobacter 5 kg/ha + Vermicompost @ 5 t/ha a can be applied to obtain maximum growth and yield of Cauliflower variety "MADHURI".

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