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Effect of Drip Fertigation Levels on Soil Fertility and Productivity of Cauliflower cv. Pusa Snowball K-1

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

The field experiment were conducted during 2013-14 and 2014-15 to study the effect of drip fertigation on nutrient availability, plant parameters and yield of cauliflower. The field experiments were laid out in randomized block design with four replications and six fertigation levels (60, 70, 80, 90, 100 and 110 per cent of recommended dose). Recommended doses of N, P and K are 125, 108 and 76kg/ha, respectively for cauliflower in Himachal Pradesh. Fertigation with recommended dose of fertilizer resulted in highest available N (365.3 kg ha^{-1}), P (95.8 kg ha^{-1}) and K (477.8 kg ha^{-1}). Drip fertigation with recommended dose also increased the available Zn, Cu, Fe and Mn content by 8, 29, 21 and 40 per cent, respectively over 60% recommended dose (i.e N- 75, 65 and 46 kg/ha) treatment. The productivity of cauliflower was maximum with the application of 100 percent nutrients through drip irrigation and recorded an increase of 17.9 percent curd yield over 60 percent RD treatment. The study suggests that application of recommended dose of fertilizer through drip irrigation in 10 splits leads to higher and sustainable cauliflower production.

Keywords: Fertigation; drip system; water soluble fertilizer; nutrient availability; cauliflower yield.

1. INTRODUCTION

The continuous improvement in productivity with optimum utilization of water, fertilizer and natural resources is essential for sustainability of any production system. Raina et al. [1]. Furthermore, he revealed that apart from the economic considerations, it is well established that the

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adverse effect of injudicious use of water and fertilizers can also have adverse implications on the environment. Hence, there is a need for technological interventions that will help in minimizing the use of precious resources (nutrient and water) and maximizing crop production without any detrimental effects on the environment. Among the various techniques of water and nutrient application, micro irrigation practices are very efficient and water conserving in nature. The drip or trickle irrigation is gaining much importance now days due to the many unique advantages it provides like conservation of soil moisture, optimum utilization of water resources, lesser wastage of nutrient, proper and sustained water and nutrient availability to the crop. It delivers water and nutrients directly to the root zone of the crop and water is applied in precise amount which synchronizes with the requirement of the crop. Cetin and Akalp, [2]. The major advantages of fertigation are in saving of labour, appropriate timing of application of water and nutrients and their uniform distribution. Apart from other advantages like minimum leaching and voltalization losses, higher fertilizer use efficiency besides higher crop yields. Mintu et al. [3].

Cauliflower is one of the important winter vegetable crop of mid hill region of Himachal Pradesh and is grown on an area of 79.5thousand hectare with production of 1521.1 thousand metric tonnes and productivity of 19.1MT/ha NHB [4]. The major constraints in cauliflower production include the traditional way of fertilizer application and lack of irrigation water. Drip irrigation is the most suitable method for uniform head size and high quality produce. Emphasis on the fertilizer application rate, timing and nutrient balance is critical for achieving good productivity of this crop. The information, on use of water soluble fertilizers, which has recently been introduced in the country especially for fertigation, is scanty. In view of the aforestated facts, the present investigation was undertaken to study the availability of nutrient applied through drip irrigation system and yield of cauliflower.

2. MATERIALS AND METHODS

2.1 Study Area

The experiment was conducted during two crop year (2013-2015) at the experimental farm of Department of Soil Science and Water Management, Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan (HP). The soil (Eutrochrept) was gravelly sandy loam in texture and neutral in reaction. It is located at 30º 51′ N latitude and 76º 11′ E longitude and an elevation of 1175 m above mean sea level having average slope of 7-8 per cent. The study area Nauni falls in sub-temperate, sub-humid agro-climatic zone of Himachal Pradesh (zone-2). The area receives an annual rainfall of 1100 mm and about 75 per cent of it is received during the monsoon period (mid June-mid September). Winter rains are meager and received during the months of January and February. The winter showers during the month of January and February are very common. Maximum temperature during the year 2013-2014 ranged 32.1ºC to 32.6ºC with an average values 25.0ºC and 24.9ºc respectively. Minimum temperature during the year 2013-2014 fell in the range of 1.1ºC to 2.4ºC, average being 11.5ºC and 10.7ºC. Relative humidity on the other hand varied between 82% to 76% with an average value of 62%. Map of study area was shown in Fig. 1.

2.2 Soil Sampling

Representative soil samples were collected from 0-15 cm depth before sowing and at the time of curd harvesting during both the years of study. Collected soil samples were air dried in shade and ground with the help of pestle mortar. These ground samples were then passed through 2 mm sieve and stored in polyethylene bags for further analysis of soil.

2.3 Experimental Design and Treatments

The experiment was laid out with six treatments combinations replicated four times in RBD factorial design. The treatments comprised of six levels of nutrients through drip irrigation or fertigation viz. T_1 (100%of Recommended dose), T_2 (90% of Recommended dose), T_3 (80% of Recommended dose), T_4 (70% of Recommended dose), T_5 (60% of Recommended dose), T_6 (110% of Recommended dose). Cauliflower seeds of *Pusa snow Ball* K-1variety were sown in well prepared raised nursery beds and one month old seedling were transplanted in the field at the spacing of 60 cm x 45 cm. Drip system comprised of five emitters in each row, placed at

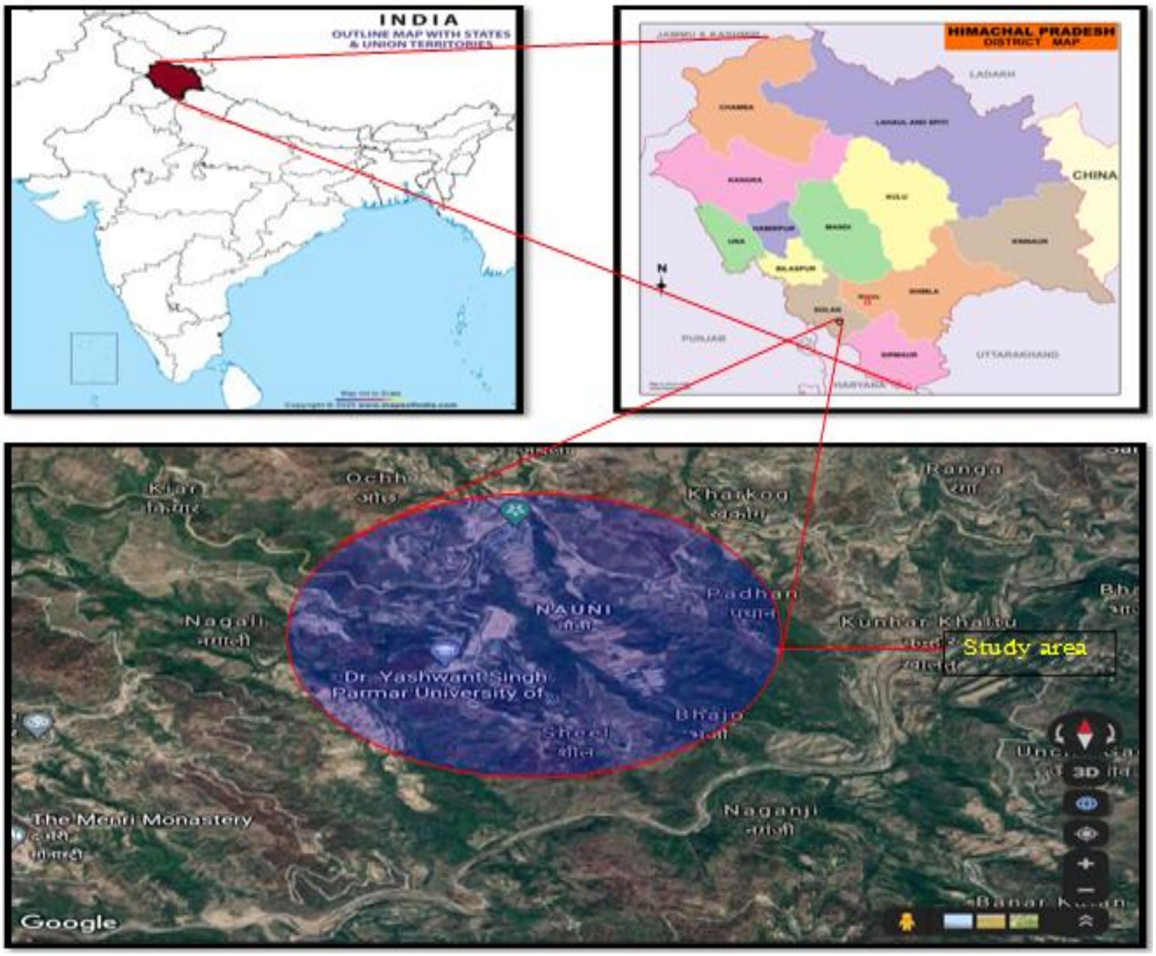

Fig. 1. Location map of the selected study area

an angle of 180^o to each other and at a distance of 23 cm. The trials were conducted during the month of December to March in 2013-14 and 2014-2015 under temperate and dry condition. Twenty four raised plots of dimension 5 m x 1.8 m were made. The whole dose of FYM (i.e. 22.5kg/plot) was applied before start of experiment. Each plot had four rows accommodating 33 plants and total 792 seedlings were transplanted in 24 plots. Recommended doses of N, P and K are 125, 108 and 76kg/ha, respectively for cauliflower in Himachal Pradesh. Fertigation was done through venturi in 10 equal split applications at 10 days interval. The water soluble fertilizer NPK (WSF-19:19:19) was used for fertigation. To meet the NPK requirement of different treatments, WSF was supplemented with urea and muriate of potash (MOP). In the experimental year 2013-2014 and 2014-2015, the quantity of WSF, urea and MOP was computed to be 29.35, 7.73 and 3.81 g/split/ fertigation. After each fertigation, drip system was thoroughly flushed for 5 minutes. Different doses of fertilizers were applied by regulating the supply with the help of closing and opening knobs put at appropriate places. All the cultural operations were done as per package and practices and nutrients were applied as per the treatment details.

2.4 Soil Analysis

The soil samples were analysed for pH, EC,Organic carbon (OC) available N, P, K, Ca, Mg and micronutrient cation i.e Cu, Fe, Mn and Zn were determined by following standard methods. The physico-chemical properties of initial soil used in the present study are presented in (Table 2).

Table 1. Nutrients applied in different treatment

Recommended dose %	Amount of NPK Kg/ha		
	N	P	K
T_1 (100%)	125	108	76
T_2 (90%)	112.5	97.2	68.4
T_3 (80%)	100	86.4	60.8
T_4 (70%)	87.5	75.6	53.2
T_5 (60%)	75.0	64.8	45.6
T_6 (110%)	137.5	118.8	83.6

2.5 Collection of Growth and Yield Data

The observations were recorded on different quantitative characters of cauliflower, viz. stalk length, number of leaves, gross weight, curd weight and curd yield. Four plants were randomly selected and tagged in each treatment to study the plant growth and curd characteristics as given below:

Stalk length: length of stalk was measured in centimeters from the point of uppermost secondary root to the point of first lower leaf.

Number of leaves: number of leaves is the total number of leaves including inner and outer leaves.

Gross weight: gross weight (g $plant^{-1}$) is the total weight of the plants including the stalk, leaves and curd was recorded in grams.

Curd weight: Curd weight (g $plant^{-1}$) including the stalk at marketable maturity was recorded in grams.

Curd yield: Curd yield (qha^{-1}) was calculated from the weight of curds obtained per plot (kg).

2.6 Data Analysis

The data recorded for various parameters under field experiments were subjected to statistical analysis using randomized block design (RBD) and treatment means were separated by critical difference at 5% level of significance. Gomez [5]. The pooled data of chemical properties, nutrient status and plant parameters for two crop year have been presented.

3. RESULTS AND DISCUSSION

3.1 Chemical Properties and Nutrient Status of Soil

Irrespective of treatments, the mean pH, EC and organic carbon was not significant at 0.05 level of significance furthermore, it is not influenced by various treatments in both the years presented in (Table 3). However, different fertigation treatments significantly influenced the availability of nutrients. In general, the decreasing level of nutrients significantly decreased the content of available nutrients. The highest build up of available nitrogen was recorded under 100% RD (365.3 kg ha^{-1}) which was statistically at par with T_6 (354.4 kg ha^{-1}) and T_2 (352.0 kg ha^{-1}). However, these treatments registered significantly higher available nitrogen content over the application of nutrients to the tune of 80, 70 and 60 percent of recommended dose. Treatment comprising fertigation with 100% RD increased the soil available nitrogen status by 20 per cent over the initial value recorded before execution of trial. Such an increase under fertigation with 90 and 110 per cent of RD were recorded to be 15.7 and 4.3 respectively. Quantum of N being added in balance application have helped higher available nitrogen status with 100% RD level. These results are in consonance with those of Janagarathinam [6], Fanish and Muthukrishnan [7] and Behera et al*.* [8]. Similarly, available P contents were relatively greater (95.84kg ha^{-1}) under 100 percent fertigation treatment. However, differences in available P among 100, 110 and 90 percent of RD were not significant. Significantly higher available P under 100% RD treatment may be due to the complete solubility of phosphorus source and frequent and small application rates through drip system. The findings corroborates with the results reported by Harjinder et al. [9] and Mahendran et al*.* [10]. It is also observed that effect of different levels of fertigation treatments on available K, closely followed available N and P in soil. The high availability of potassium may be due to majority of applied K was held in the surface soil and the downward movement was slow resulting in very small movement to deeper layer. The results are in agreement with the findings of Mmolawa and Or [11], Zeng et al. [12], Mishra et al. [13] and Suganya [14] and Fanish and Muthukrishnan [7].

The data presented in (Table 4) indicated that imposition of different treatment did not influenced the availability of calcium, magnesium and micronutrient content of soil. However, higher content of available Ca (5.99 [cmol (p^+) kg^{-1}]), Mg(2.01 [cmol $(p^+)kg^{-1}$]), Zn (2.95 mg kg^{-1}), Cu (3.99mg kg^{-1}), Fe (26.69 mg kg^{-1}) and Mn (10.52kg ha^{-1}) were recorded under 100% RD (T_1) fertigation treatment.

Table 2. Some important physico- chemical properties of the experimental soil

Characteristics	Value	Methods/ References
pH (soil: water 1:2)	6.56	1:2 Soil : water suspension, measured with digital pH meter [15]
EC (soil : water 1: 2)dSm^{-1}	0.18	1:2 Soil : water suspension, measured with digital EC meter [15]
Textural class	Gravelly sandy loam	Hydrometer method [16]
Organic carbon (%)	1.00	Walkley and Black wet digestion method [17]
Available N (kg ha^{-1})	264.5	Alkaline potassium permanganate method [18]
Available P (kg ha^{-1})	42.5	Olsen's method [19]
Available K (kg ha^{-1})	377.3	Ammonium acetate method [20]
Available Ca (cmol (p^+) kg^{-1})	4.31	Ammonium acetate method [20]
Available Mg (cmol (p^+) kg^{-1})	1.41	Ammonium acetate method [20]
DTPA Zn (mg kg^{-1})	2.58	DTPA extractant [21]
DTPA Cu (mg kg^{-1})	1.60	DTPA extractant [21]
DTPA Fe (mg kg^{-1})	20.76	DTPA extractant [21]
DTPA Mn (mg kg^{-1})	1.96	DTPA extractant [21]

Table 3. Effect of drip fertigation on chemical properties of soil

Treatments	pH	EC (dS/ cm)	OC (%)	Macro nutrient ($kgha^{-1}$)		
				N	P	K
T_1	6.69	0.60	1.39	365.3	95.8	477.8
T_2	6.60	0.48	1.27	352.0	83.2	438.8
T_3	6.55	0.45	1.23	337.1	75.9	428.3
T_4	6.53	0.41	1.17	308.1	69.2	412.6
T_5	6.49	0.38	1.14	303.4	65.0	396.9
T_6	6.62	0.51	1.29	354.4	91.8	463.4
Critical Difference (0.05)	**NS**	**NS**	**NS**	**22.9**	**12.8**	**9.9**

Table 4. Effect of drip fertigation on the availability of secondary and micronutrients of soil

Treatments	Calcium $(cmol(p^+)kg^{-1}$	Magnesium $(cmol(p^+)kg^{-1}$	Zinc (mg kg^{-1})	Copper (mg kg^{-1})	Iron (mg kg^{-1})	Manganese (mg kg^{-1})
T_1	5.99	2.01	2.95	3.99	26.69	10.52
T_2	5.84	2.00	2.85	3.72	26.39	9.27
T_3	5.77	1.98	2.83	3.65	25.99	8.76
T_4	5.62	1.98	2.77	3.38	25.21	8.31
T_5	5.42	1.98	2.63	3.32	24.68	8.27
T_6	5.92	1.99	2.88	3.93	26.61	9.61
Critical Difference (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

3.2 Plant Parameter and Yield

The plant parameters of cauliflower i.e. number of leaves, gross weight, curd weight and yield was significantly influenced by different levels of fertigation (Table 5). The number of leaves among nutrient levels was significantly higher under T_1 (19) which was at par with T_2, T_3 and T_6. The higher number of leaves with 100 percent RD treatment may be attributed to balanced nutrition, better water and nutrients utilization which results into more vegetative growth and higher photosynthetic rate. Similar findings on cauliflower crop have also been reported by Yanglem and Tumbare [22]. These results are also in consonance with those of Olesen and Grevsen [23] and Kage et al. [24] and Aladakatti et al. [25]. The increase in gross weight was noted to be 18.5, 6.4, 3.9, 3.1 and 11.9 per cent higher under 100, 90, 80, 70 and 110% RD compared to 60% RD. This could be due to high yield and vegetative growth because of balanced fertilization in fractionated supplies have met the nutrient requirement of cauliflower at different growth stages. The curd weight is an important parameter that determines the commercial viability and acceptability of a variety and is one of the most important traits attaining highest consideration in research programs. Application of recommended level of nutrients (T_1) produced maximum (873.8 g plant^{-1}) curd weight which was at par with T_6 (844.4 g plant^{-1}). A comparision of data among different fertigation level reveals that T_1, T_2, T_3, T_4, T_5 and T_6 registered curd yield in the tune of 291.0, 274.5, 266.5, 254.3, 246.9 and 281.2q ha^{-1}, respectively. The increase in curd yield was noted to be 18 per cent higher under 100% RD treatment over to 60% RD treatment. These results suggested that increasing level of fertigation significantly improved the curd yield. Significantly higher yield under 100% RD treatment may be attributed to much better water and nutrient utilization as nutrients were applied in ten equal splits. These fractionated supplies in optimum nutrient concentration might have met the nutrient requirement of cauliflower at various growth stages thus leading to higher curd weight and yield. Sathya et al. [26], Brahma et al. [27] and Kapoor et al. [28] observed significantly higher yield of tomato on fertigation. Similar observations were also made by Patel and Rajput [29] in broccoli. Yanglem and Tumbare [22] have also made the similar findings and attributed to such effect at higher fertigation level, crop meet out its nutritional requirement at respective growth stage which lead to luxurious growth and there by enhancement of yield in cauliflower.

Table 5. Effect of drip fertigation on plant growth and yield of cauliflower

Treatments	Stalk length (cm)	No. of leaves	Gross weight (g)	Curd weight (g plant^{-1})	Yield (q ha^{-1})
T_1	5.0	19	1281.0	873.8	291.0
T_2	4.7	18	1149.6	825.5	274.5
T_3	4.6	18	1123.1	800.3	266.5
T_4	4.3	17	1114.5	763.8	254.3
T_5	4.2	16	1080.8	741.4	246.9
T_6	4.8	18	1209.1	844.4	281.2
Critical Difference(0.05)	**NS**	**1.08**	**65.16**	**41.64**	**13.92**

Analysis of Variance Table (ANOVA)
Analysis of variance table for pH, EC and Organic carbon

Source of variation	Degree of freedom	Mean sum of squares		
		pH	EC	OC
Replication	3	0.04894	0.006878	0.00949
Treatment	5	0.021452	0.024816	0.031724
Error	15	0.007428	0.011435	0.011486

Analysis of variance table for available N, P, K, Ca and Mg

Source of variation	Degree of freedom	Mean sum of squares				
		N*	P*	K*	Ca	Mg
Replication	3	5940.354	1387.773	1647.616	0.719254	0.000198
Treatment	5	2634.395	608.8732	3714.824	0.173314	0.000466
Error	15	127.2805	38.15634	40.69194	0.050573	0.000183

Analysis of variance table for available Zn, Cu, Fe and Mn

Source of variation	Degree of freedom	Mean sum of squares			
		Zn	Cu	Fe	Mn
Replication	3	0.567834	1.029584	24.43853	1.976226
Treatment	5	0.046481	0.302082	2.654056	2.983689
Error	15	0.038231	0.148127	1.966706	1.064675

Analysis of variance table for stalk length, number of leaves, gross weight, curd weight and curd yield

Source of variation	Degree of freedom	Mean sum of squares				
		Stalk length (cm)	Number* of leaves	Gross weight* (g plant^{-1})	Curd weight* (g plant^{-1})	Curd* yield (q/ha)
Replication	3	0.157189	14.38628	27340.9	19978.09	2235.354
Treatment	5	0.376954	3.233854	21497.52	9923.313	1097.149
Error	15	0.195906	0.365451	1048.308	551.7628	63.01973

**Significant at 5% level*

4. CONCLUSION

The results revealed that application of 100% RD of nutrients in ten splits through drip irrigation was found better in soil fertility status, plant parameter and curd yield over rest of the fertigation treatments. Compared with other treatments, use of 100% RD through fertigation resulted in significantly greater availability of nutrients that contributed to higher yield of cauliflower. Therefore it may be concluded that better soil health, higher and sustainable cauliflower production could be realized by applying 100% of recommended NPK in splits through drip irrigation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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