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Effect of drip fertigation scheduling on yield and economics of cauliflower (*Brassica oleracea* var.botrytis) and chilli (*Capsicum annuum* L.)

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ABSTRACT

Field experiments were conducted at Horticulture Farm, Rajasthan College of Agriculture, Udaipur, during rabi and summer season in 2013-14 and 2014-15 to the study the effect of drip fertigation scheduling on yield and economic of cauliflower (Brassica oleracea var. botrytis) and chilli (Capsicum annuum L.) The experiments were laid out in split plot design with fifteen treatments (three irrigation levels 80, 60 and 40 % of pan evaporation (PE) along with five fertigation levels, viz. 100% RDF, 75% RDF, 50% RDF, 75% RDF + 2 foliar spray of 1% urea phosphate, and 50% RDF + 2 foliar spray of 1% urea phosphate through drip irrigation) and replicated thrice. Results indicated that the average curd weight (814 g), curd yield (237 q ha^{-1}) of cauliflower and fruit weight per fruit (3.7 g) and fruit yield (161 q ha^{-1}), respectively of chilli and economics were obtained with drip irrigation at 80% PE as compared to lower levels of drip irrigation. Similarly, maximum average curd weight (851 g), curd yield (244 q ha^{-1}) of cauliflower and fruit weight per fruit (3.7 g) and fruit yield (159 q ha^{-1}), respectively of chilli and economics were registered with at 75% RDF through fertigation + 2 foliar spray 1% urea phosphate over 50 % RDF through fertigation. Combined effect of drip irrigation and fertigation significantly increased yield of cauliflower and chilli. Combination of 80% PE drip irrigation along with 75% RDF through fertigation + 2 foliar spray of 1% urea phosphate (I_1F_4) significantly increased yield (280 and 170 q ha^{-1}) of cauliflower and chilli as compared to combination of 40% PE at drip irrigation along with 50% RDF (I_3F_3). In post harvest soil status of available nitrogen, phosphorus and potassium increased by 10.7, 14.8 and 5.0% in cauliflower and 9.9, 10.9 and 5.7% in chilli with the 100% RDF over 50% RDF through drip fertigation.

Keywords: Fertigation, yield, economics, cauliflower, chilli

INTRODUCTION

Water and nutrients are the basic need of commercial crop production. Cauliflower and chilli, most important vegetable crops, require the ample quantity of water and fertilizer than other crops. In intensive agriculture, both fertilizer and irrigation management have contributed immensely in increasing the yield and quality of crops. Nevertheless water scarcity and high input cost of fertilizer are the major constraints in increasing the area, production and productivity of cauliflower and chilli crops. In order to get rid of these constraints irrigation with fertigation through drip is the most suitable option, which can save water and fertilizer in addition to increase in the area along with increasing productivity. Combination of micro irrigation techniques with application of fertilizer through the irrigation system is a common practice in modern agriculture. The advantages of drip fertigation are the supply of nutrients can be more carefully regulated and monitored. Water and nutrients acquisition by plants, and the formation of a depleted zone in the immediate vicinity of the roots are the driving forces for solute movement towards the roots (Silber *et al.*, 2003) Fertigation scheduling is a critical management input to ensure optimum soil nutients status for proper plant growth and development as well as for optimum yield and economic benefits. Therefore, it is essential to develop fertigation scheduling strategies under local climatic conditions to utilize scarce water resources efficiently and effectively. Appropriate fertigation scheduling is to increase fertilizer efficiencies by applying the balance amount of fertilizer needed to replenish the soil nutrients to desire level, saves nutrients resources and energy. Therefore, it is important to develop fertigation scheduling techniques under prevailing climatic conditions in order to utilize scare nutrients resources effectively for crop production (Paramasivam *et al.* 2001 and Neilsen *et al.* 2004).

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Cauliflower and chilli being a heavy feeder of nitrogen, phosphorus and potassium responds well to the application of manures and fertilizers. Urea is relatively mobile in soils and it is not strongly absorbed by soil colloids. It tends to be more evenly distributed within the wetted profile than dose applied. Fertigated urea and nitrate were more evenly distributed down the soil profile below the emitter and had moved laterally in the profile to 15 cm radius from the emitter. Nitrogen use efficiency was increased by approximately two fold when the fertilizer N was injected into the drip irrigation network. Phosphorus when applied as urea phosphate moved in a calcareous loam soil to a depth of 30 cm. It is used in the fertigation of soil grown crops under neutral and alkaline conditions. Common K sources such as potassium sulphate, potassium chloride and potassium nitrate are readily soluble in water. These fertilizers move freely into the soil and some of the K ions are exchanged on the clay complex and are not readily leached away. Potassium is less mobile than nitrate but distribution in the wetted volume may be more uniform due to interaction with binding sites. Deficiency of N, P and K is a major production constraint in sandy soils. However, drip fertigation optimize the use of water and fertilizer enabling to harness high crop yield, simultaneously ensuring a healthy soil and environment. Hence, scanty research work has been carried out on the water and nutrient management through drip fertigation in relation to cauliflower and chilli.

MATERIALS AND METHODS

The experiment was conducted at Horticulture department Farm, Rajasthan College of Agriculture, Udaipur during *rabi* and *summer* season in 2013-14 and 2014-15. The site is situated at 24^{o}.35' N latitude, 74^{o}.42' E longitude and an altitude of 579.5 m above mean sea level. The region falls under agro-climatic zone IVA (Sub-Humid Southern Plain and Aravalli Hills) of Rajasthan. The soil was Haplustepts, clay loam in texture having pH 8.1, EC 0.67 dS m^{-1}, organic carbon 7.1 g kg^{-1}, available nitrogen 296 kg ha^{-1}, available phosphorus 23 kg ha^{-1} and available potassium 318 kg ha^{-1}. The experiment was laid out in a split plot design with 15 treatment combinations which consisted of 3 levels of drip irrigation (80, 60 and 40% PE) and 5 levels of fertigation (100%, 75%, 50%, 75% RDF + 2 foliar spray of 1% urea phosphate, and 50% RDF + 2 foliar spray of 1% urea phosphate through fertigation) were replicated three times. Cauliflower- (Pusa Snowbal K-1) and chilli- (Pusa Jwala) were grown in *rabi* and *summer* season in 2013-14 and 2014-15 respectively. The fertilizers were applied at fifteen days interval in 6 equal splits starting fifteen days after cauliflower and chilli transplanting through drip irrigation according to fertilizer schedule. The fertilizer schedules were developed on RDF (120-80-60 NPK kg ha^{-1}) for cauliflower and 70-40-50 NPK kg ha-1 for chilli crops. Irrigation water was applied at every alternate day based on pan evaporation data. The curd yield of cauliflower and fruit yield of chilli were recorded at harvest. The economics of treatment was worked out in terms of net returns and the benefit/cost (B: C) ratio on prevailing market price of inputs and output. The net return was calculated by subtracting cost of cultivation for each treatment from gross return arrived at from the economic yield. Soil samples collected after harvest of the crops were analyzed for pH, EC, organic carbon, available N, P and K by adopting standard procedures.

RESULTS AND DISCUSSION

Yield

A perusal of the data (Table 1) indicated that drip irrigation at 80 % PE, irrespective of fertigation levels recorded significantly highest average curd weight and curd yield over drip irrigation at 60 % PE and 40 % PE. Maximum average curd weight plant^{-1}(814 g) and curd yield (237 q ha^{-1}) were recorded with 80 % PE drip irrigation as compared to 40% PE. The differences among all the three drip irrigation levels were statistically significant. This treatment mitigating the water deficit to the level of pan evaporation demand through drip irrigation improved the availability of applied water through the establishment of relatively moist condition in the root zone and also increased the availability of nutrients throughout the crop growth period. Such effect was responsible for significant improvement in growth parameters, yield attributes and yield of cauliflower. Similar type of findings were also reported by Gupta *et al.* (2009) and Gupta and

Chattoo (2014). Application of 75% RDF through fertigation + 2 foliar spray of 1 % urea phosphate registered significant increase in average curd weight (851 g) and curd yield (244 q ha^{-1}) of cauliflower than rest of the treatments (Table 1). Increase in the yield and yield attributes with 75% RDF fertigation + 2 foliar sprays of 1% urea phosphate might be due to the uniform distribution and adequate availability of nutrients and moisture in the root zone of the crop. Similar findings were also reported by Ayyadurai and Manickasundaram (2014), Singla and Singh (2011), Yanglem and Tumbare (2014). Significantly highest yield (280 q ha^{-1}) was obtained by drip irrigation at 80% PE with 75% RDF fertigation + 2 foliar sprays of 1% urea phosphate treatment combination as compared to other treatments (Table 2 and Fig.1). However, other drip irrigation levels i.e. 60% PE and 40% PE increased fruit yield but not reached to the levels of significance. Minimum fruit yield (165 q ha^{-1}) was observed with drip irrigation at 40% PE with 50% RDF fertigation. Significant positive effect of combined drip irrigation and fertigation supply maintain an optimum level of both moisture and nutrients within the root zone (Muralikrishnaswamy *et al.* 2006,) with irrigation water which acts as a vehicle for the nutrients required by the crop (Gupta *et al.* 2009).

Table 1: Effect of drip irrigation and fertigation levels on fruit weight, fruit yield and economics of cauliflower and chill (mean of two years)

Treatments	Cauliflower				Chilli			
	Fruit weight (g)	Fruit yield (q ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio	Fruit weight (g)	Fruit yield (q ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio
Irrigation levels								
Drip at 80% PE	814	237	179230	1.67	3.7	161	230291	2.12
Drip at 60 % PE	773	215	147044	1.38	3.5	149	206012	1.94
Drip at 40% PE	741	184	113177	1.09	3.2	142	194386	1.87
SEm ±	14	5	5735	0.06	0.05	3	5223	0.05
CD (P = 0.05)	32	12	13224	0.13	0.13	6	12044	0.11
Fertigation levels								
100% RDF	814	232	158763	1.38	3.6	156	214503	1.91
75% RDF	765	216	146120	1.36	3.5	151	209411	1.95
50% RDF	710	177	117114	1.18	3.2	144	195213	1.92
75% RDF + 2 foliar spray	851	244	178586	1.66	3.7	159	227288	2.11
50% RDF + 2 foliar spray	741	191	131835	1.32	3.3	146	204731	2.00
SEm ±	13	5	5933	0.06	0.05	2	3249	0.03
CD (P = 0.05)	26	9	11928	0.12	0.08	3	6533	0.06

The highest fruit weight per fruit (3.7 g) and fruit yield (161q ha^{-1}), were observed in drip irrigation at 80% PE over 40% PE in (Table 1). The increase in yield might be due to better proportion of air-soil-water which was maintained throughout the life period of crop in drip irrigation (Kadam, 2006). The increase in chilli yield under drip irrigation system may be due to the availability of water all the time when needed around the root zone at very low moisture tension (Gupta and Chattoo 2014). Data further revealed that the highest fruit weight $fruit^{-1}$ (3.7 g) and fruit yield (159 q ha^{-1}), were obtained by application of 75% RDF through fertigation + 2 foliar spray of 1 % urea phosphate which was significant superior to other treatments (Table 1). The better production of yield and yield attributes might be due to better performance under drip fertigation as compared to conventional method of fertilizer application (Vjekoslav *et al.* 2010, Ayyadurai and Manickasundaram 2014). Combined application of irrigation and fertigation had shown significant effect on fruit yield (Table 2 and Fig. 2). The highest fruit yield (171 q ha^{-1}) was obtained by drip irrigation at 80% PE with 75% RDF through fertigation + 2 foliar spray of 1% urea phosphate ha^{-1} as compared to other treatments. Minimum fruit yield (130 q ha^{-1}) was observed by application of drip irrigation at 40% PE with 50% RDF fertigation. The improved yield with conjunctive use of drip irrigation and fertigation might be due to the facts that drip irrigation and fertigation permits better use of water and nutrients, lower leaching losses and more controllable application of nutrients as compared to other nutrient and water supply methods. These results are in line with the findings of Samra (2005).

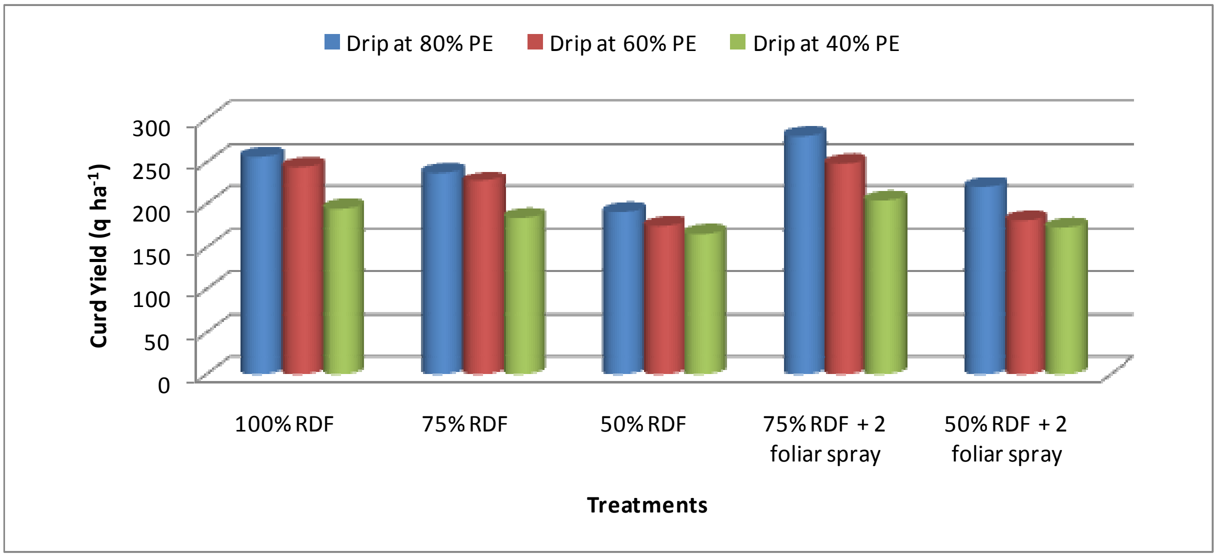

Fig: 1 Effect of drip irrigation and fertigation on curd yield of cauliflower

Economics

The net returns and benefit cost ratio of cauliflower significantly increased with drip irrigation at 80% PE (Table 1). The highest net returns (` 179230) and benefit cost ratio (1.67) of cauliflower was recorded with application of drip irrigation at 80% PE. The higher values of benefit cost ratio and net returns under drip fertigation can be attributed to favourable nutrient-water interaction in the root zone, which in turn resulted in quantum increase in yield of cauliflower there by higher benefit cost ratio and net returns (Muralikrishnasamy *et al.* 2006). The highest net returns (` 178586) and benefit cost ratio (1.66) of cauliflower and were obtained by 75% RDF through fertigation + 2 foliar spray of 1% urea phosphate which could be ascribed to better and timely availability of plant nutrients matching with the demand of crop resulting an additive effect on yield of cauliflower without any additional input cost. Similar findings were also reported by Gupta *et al.* (2009). The highest net returns (` 230291) and benefit cost ratio (2.12) of chilli was recorded with application of drip irrigation at 80% PE. The highest net returns (` 227288) and benefit cost ratio (2.11) of chilli and were obtained by 75% RDF through fertigation + 2 foliar spray of 1% urea phosphate. This might be due to the fact that under these treatments the cost of treatments was low as compared to output added, therefore, higher fruit yields resulted in higher net returns and benefit cost ratio. These findings are in agreement with those reported by Shashidhara, (2006) for chilli.

Table: 2 Interactive effects on curd yield of cauliflower and fruit yield of chilli (mean of two years)

Irrigation/ fertigation	Cauliflower			Chilli		
	Curd Yield (q ha^{-1})			Fruit Yield (q ha^{-1})		
	Drip at 80% PE	Drip at 60% PE	Drip at 40% PE	Drip at 80% PE	Drip at 60% PE	Drip at 40% PE
100 % RDF	256	244	194	170	152	146
75 % RDF	237	227	184	161	148	143
50 % RDF	191	174	165	152	142	130
75 % RDF + 2 foliar spray	280	248	204	171	156	153
50 % RDF + 2 foliar spray	219	181	173	154	145	139
Drip irrigation at same level of fertigation	SEm±	7.9	CD (P=0.05) 16.0	SEm±	2.6	CD (P = 0.05) 5.3

Fertigation at same or different level of irrigation	SEm± 7.9	CD (P = 0.05) 16.0	SEm± 3.1	CD (P = 0.05) 6.3

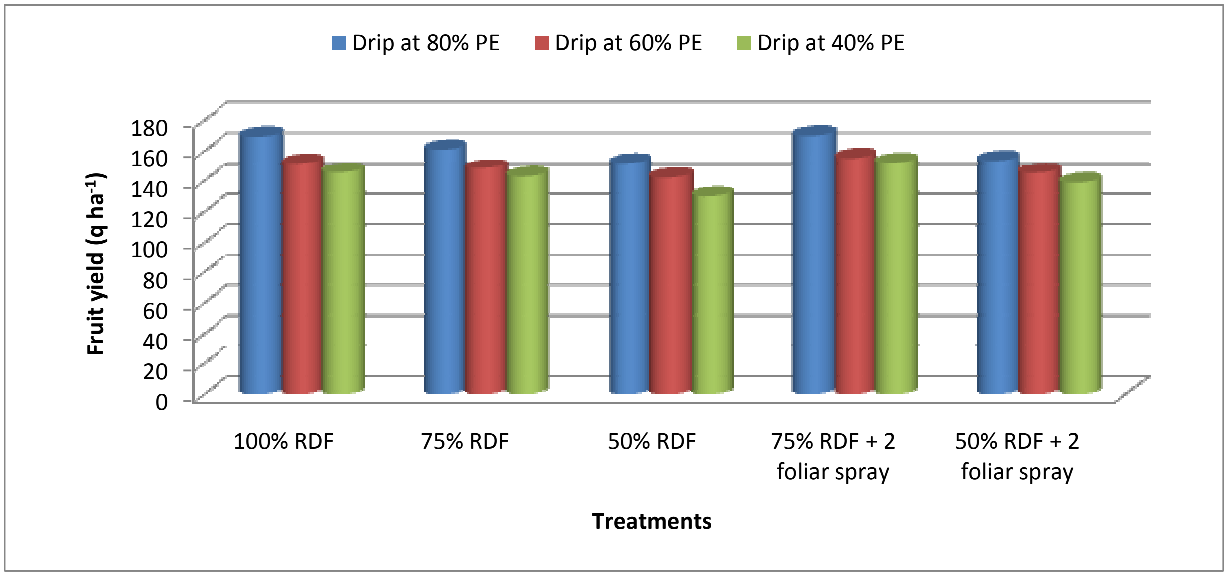

Fig. 2 Effect of drip irrigation and fertigation on fruit yield of chilli

Soil fertility

The status of organic carbon, available N, P and K was not affected significantly with drip irrigation (Table 3) but they were affected significantly with fertigation. Maximum values of available N (329 kg ha^{-1}) in cauliflower and (333 kg ha^{-1}) in chilli were recorded with 100% RDF fertigation and minimum (297 kg ha^{-1} and 303 kg ha^{-1}) with 50% RDF fertigation (F_3). Significant increase in soil P was observed and P content in soils varied from 24.3 kg ha^{-1} in cauliflower and 25.6 kg ha^{-1} in chilli under 50% RDF fertigation (F_3) and 27.9 kg ha^{-1} and 28.4 kg ha^{-1} under 100% RDF fertigation. Available phosphorus was found to be more in higher dose of fertilizer as compared to 50% RDF. Soil potassium content in post harvest soils varied from 319 kg ha^{-1} in cauliflower and 329 kg ha^{-1} in chilli @ 50% RDF fertigation to 335 kg ha^{-1} in cauliflower and 348 kg ha^{-1} in chilli under 100% RDF fertigation, which could be attributed to favorable nutrient –water interaction in the root zone which in turn resulted increased nutrient use efficiency thereby improving nutrient status of the soil after harvest of crop. These results are in agreement with the findings of Salim *et al.* (2010), Singh *et al.,* (2014) and Lalhruaizeli *et al.* (2017).

Table: 3 Effect of drip irrigation and fertigation on soil fertility of post harvest soil (mean of two years)

Treatments	OC (g kg^{-1})	Avail. N (Kgha^{-1})	Avail. P_2O_5 (Kg ha^{-1})	Avail. K_2O (Kg ha^{-1})	OC (g kg^{-1})	Avail. N (Kg ha^{-1})	Avail. P_2O_5 (Kg ha^{-1})	Avail. K_2O (Kg ha^{-1})
Irrigation levels	**Cauliflower**				**Chilli**			
Drip at 80% PE	7.7	313	25.8	328	7.9	319	26.9	349
Drip at 60 % PE	7.5	312	25.6	326	7.7	318	27.0	337
Drip at 40% PE	7.3	309	25.5	325	7.6	310	26.7	336
SEm ±	0.01	3.1	0.26	2.9	0.01	2.7	0.29	2.1
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Fertigation levels								
100% RDF	7.8	329	27.9	335	8.0	333	28.4	348
75% RDF	7.6	313	25.2	327	7.8	321	26.7	339
50% RDF	7.1	297	24.3	319	7.5	303	25.6	329
75% RDF + 2 foliar spray	7.7	317	26.0	330	7.9	323	27.4	343
50% RDF + 2 foliar spray	7.3	302	24.9	321	7.5	307	26.2	333

SEm ±	0.01	3.7	0.31	2.4	0.01	3.2	0.32	2.5
CD (P = 0.05)	0.02	7.4	0.63	4.9	0.02	6.4	0.64	5.0

On the basis of the results, it can be concluded that drip irrigation and ferigation resulted in higher yields of cauliflower and chilli. Among the different levels of drip irrigation and fertigation best results were obtained under combined application of 80% PF drip irrigation with 75% RDF through fertigation + 2 foliar spray of 1% urea phosphate as compared to other treatments.

REFERENCES

Ayyadurai, P. and Manickasundaram, P. (2014) Growth, nutrient uptake and seed cotton yield as influenced by foliar nutrition and drip fertigation in cotton hybrid. *International Journal of Agricultural Sciences* **10** (1): 276-279

Gupta, A.J. and Chattoo, M.A. (2014) Response of Knolkhol cv. Early White Vienna to drip irrigation and fertigation in Kashmir Region. *Indian Journal of Ecology* **41(**1): 152-157.

Gupta, A.J., Chattoo, M.A. and Bhat F.N. (2009) Techno-economic evaluation of drip irrigation and fertigation practices in capsicum under kashmir conditions. *Vegetable Science* 36: 309-314.

Kadam, U. S., Deshmukh, M. R.,Takte, R. L. and Daund, V. P. (2006) Fertigation management in cauliflower. *Journal of Maharashtra Agricultural Universities* **31**:252-255.

Lalhruaizeli, Sharma, Y.K. and Sharma, S. K. (2017) Response of tomato (*Lycopersicon esculentum Mill*) to lime and potassium under acidic soil condition. *Annals of Plant and Soil Research* **19** (1): 89-94

Muralikrishnaswamy S. Veerabadran V. Krishnasamy V. Kumar V. and Salthivel S. (2006) Drip irrigation and fertigation in chillies (*Capsicum Annum* L.). In: *7th International micro-irrigation congress, Kaula Lumpur, Malaysia*.

Neilsen, G.H., D. Neilsen, L.C. Herbert and E.J. Hogue, (2004) Response of apple to fertigation of N and K under conditions susceptible to the development of K deficiency. American Society for Horticultural Science 129: 1.

Paramasivam, S., Alva, A.K., Fares, A. and Sajwan, K.S. (2001) Estimation of nitrate leaching in an entisol under optimum citrus production. *Soil Science Society of America Journal* 65: 914-921.

Salim, E.M., El-Neklawy, A.S. and Soad El-Ashry, M. (2010). Beneficial effects of humic substances on soil fertility to fertigated potato grown on sandy soil. *Libyan Agriculture Research Center Journal Internation* **1** (4): 255-262.

Samra, J.S. (2005) Micro-irrigation and fertigation to enhance water use efficiency in India. Souvenir-International Conference on Plastic-culture and Precision Farming 21-29.

Silber, A., G., Levkovitch I., Soriano, S., Bilu, A. and Wallach R. (2003) High fertigation frequency: the effects on uptake of nutrients, water and plant growth. *Plant and Soil*, **253**: 467-477.

Singh, A., Gulati, I.J., Chopra, R., Sharma, D. and Gochar, R. (2014) Effect of drip-fertigation with organic manures on soil properties and tomato (*Lycopersicon esculentum* Mill.) yield under arid condition. *Annals of Biology* **30** (2): 345-349.

Singh, K.G., Mahajan, G. and Siag, M. (2006) Evaluation of drip irrigation system in cauliflower-hybrid chilli sequence. *Haryana Journal of Horticultural Sciences* **35**: 326-328.

Singla, C. and Singh, K. G. (2011) Crop water requirements and fertigation options for early drip irrigated cauliflower (*Brassica oleracea* var. *botrytis* L.) grown in a greenhouse. *Progressive Horticulture* **43**: 99-101.

Vzekoslav, T., Ordan, C., Domor, R. and Gabriyel, O. (2010). The influence of drip fertigation on water use efficiency in tomato crop production. *Agriculture Conspectus Scientiificus*.**76**: 57-63.

Yanglem. S.D. and Tumbare, A.D. (2014) Influence of irrigation regimes and fertigation levelson yield and physiological parameters in cauliflower. *The Biocane* **9** (2): 589-594.