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Effect of different fertigation levels on plant growth and fruit yield of sweet pepper grown under greenhouse conditions

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ABSTRACT

The present experiment was carried out with six different combination of fertigation treatments viz., T_2 (75% RDF); T_3 (100% RDF); T_4 (125% RDF); T_5 (75% RDF + 75% recommended dose of micronutrients (RDM i.e. 0.5% (5 ml/l) of micronutrient mixture.); T_6 (100% RDF + 100% RDM); T_7 (125% RDF + 125% RDM) and a control treatment T_1 (Soil application of NPK i.e., 100% recommended dose of fertilizers). A micronutrient mixture, Agromin consisting of Zn, Cu, Mn, B, Mo was applied at recommended dose i.e. 0.5% (5 mg/l). Maximum crop yield of 75.51 t ha^{-1} in cv. Nishat-1 and 85.34 tha^{-1} in Shalimar Capsicum Hybrid-2 (SCH-2) was obtained with fertigation treatment T_5 which resulted in 42.28% and 46.63% increased yield in cultivar and hybrid, respectively as compared to control treatment T_1. Maximum number of harvested fruits per plant were obtained in T_5 viz., 21.46 and 23.20 in cultivar and hybrid, respectively. The treatment T_6 recorded maximum fruit weight of 59.36g and 63.07 g in cv. Nishat-1 and SCH-2, respectively. Leaf area (cm^2) and leaf chlorophyll content (mg/100g) were higher under higher levels of fertigation treatments.

Key words: *Capsicum annuum*, NPK, micronutrients, drip fertigation, polygreenhouse

INTRODUCTION

Water and nutrients are the major inputs vital for agricultural production but their availability is now getting affected and overexploited. Although India has the largest irrigation network in the world but its irrigation efficiency is less than 40 percent (Agrawal *et al.,* 3; Nagre *et al.,* 10). Conventional irrigation generally results in increased downward soil water flux leading to higher water and nutrient loss below the root zone (Wang and Xing, 14). Similarly, faulty application of nutrients results in greater nutrient losses through leaching polluting both soil and water bodies besides adding to production costs. The amount of fertilizer lost through leaching can be as high as 50 per cent in traditional system while it is only 10 percent in fertigation. Drip irrigation has several advantages over other irrigation methods as it does not wet the foliage and because of its high water application frequency, the concentration of salts in the rooting zone remains manageable (Kumar *et al.,* 9). Applying timely doses of small amounts of nutrients to the plants throughout the growing season has significant advantages over conventional fertilizer practices (Wang and Xing, 14). Non-uniformity of water and nutrients application leads to reduction in crop yield, inferior quality of produce, ground water contamination and soil degradation. Properly designed fertigation system therefore can reduce leaching of salts and make available optimal quantity of nutrients to the plants during different crop growth stages resulting in higher crop yield and better quality of produce.

Sweet pepper is an important commercial crop of India grown over an area of 30 thousand hectares with a production of 1.72 lakh metric tons while in Jammu and Kashmir, it occupies only about 1.05 thousand hectares with a production of 23.16 thousand metric tons (Roma and Arun, 12) which has a high water and nutrient requirement particularly during the establishment period and fruit setting. Co-application of optimum plant nutrients and water via fertigation avoids excessive leaching of nutrients from the soil where roots are actively taking up nutrients and thus minimizes losses and groundwater contamination while on the other hand excessive nutrient application not only reduces fertilizer efficiency, but also increases soil nutrient loss and results in environmental pollution (Chen *et al.*, 4). Therefore, fertigation approach is a promising way to simultaneous increase the productivity as well as fertilizer and water use efficiencies (Fanish *et al.*, 5). Although, very little work has been conducted on sweet pepper with drip irrigation, however, no work is reported on fertigation under green house in temperate Kashmir valley of India. In view of this, present fertigation study under protected greenhouse was conducted to investigate the effect of different fertigation levels and ascertain the best

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optimum nutrient dose for growth and yield of sweet pepper.

MATERIALS AND METHODS

A two year field study was conducted under protected poly house (Gothic type of size 20 ×8×4.5 m) of Division of Vegetable Sciences, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir during 2017 and 2018.The crop was raised during May to October each year to study the influence of different fertigation levels on growth and yield of sweet pepper. The soil of experimental site was well drained, deep and loamy comprising of 51.26% sand, 34.94% silt and 13.8% clay. The soil reaction was slightly alkaline with a pH of 7.8 and EC of 0.16dsm^{-1}with a bulk density of 1.33g cm^{-3}.

Two genotypes of sweet pepper namely cultivar Nishat-1 and hybrid Shalimar Capsicum Hybrid 2 (SCH 2) were simultaneously evaluated under Gothic type polyhouse. Four week old seedlings were transplanted on 18th May 2017 at spacing 50×20 cm for both cultivar and hybrid. The experiment was laid out in randomized complete block design (RCBD) with three replications and seven treatments viz., T_1(control) i.e. soil application of NPK (100% recommended dose of fertilizers (RDF i.e. 120:90:30 NPK kgha^{-1} for cv. Nishat 1 and 150:120:60 NPK kgha^{-1}for hybrid SCH-2); T_2 (75 % RDF through fertigation) ; T_3(100 % RDF through fertigation); T_4 (125 % RDF through fertigation);T_5 (75 % RDF + 75% recommended dose of micronutrients (RDM i.e. 0.5% (5ml/l) of micronutrient mixture) through fertigation); T_6 (100 % RDF + 100 % RDM through fertigation); T_7 (125 % RDF + 125 % RDM through fertigation).The experimental area was divided into two blocks, each block consisted of three sub-blocks which was divided into seven equal plots of size 1.75 m^2. A border of 1m width separated the two blocks. Each plot consisted of five rows and three columns. In one block, cv. Nishat 1 was grown and in other Shalimar Capsicum Hybrid 2 was planted. A uniform dose of vermi-compost was mixed to soil prior to planting @ 2kg per plot. Fertigation was carried out using water soluble fertilizers viz., Urea, SSP and MOP and micronutrient mixture (Agromin) as per treatments. First dose was given after one month of transplanting, second dose after fifteen days of first dose and third and other remaining doses at an interval of ten days.

To test the significance of treatments and calculating critical difference (CD), the experimental data was subjected to statistical analysis as per the standard statistical procedure given by Gomez and Gomez (7). Levels of significance used for 'F' and't' tests were p=0.05 as given by Fisher (6).

RESULTS AND DISCUSSION

Important inputs like water and nutrients are now becoming scarce and costly. Their uniform application through drip irrigation system has become important for optimizing their requirement particularly for high value crops like sweet pepper grown under protected conditions for harvesting best quality and higher yields besides improving efficiency. On the contrary, the non-uniform application of water and nutrients may lead to improper distribution within the soil profile along the drip-line resulting in considerable reduction in crop yield and substandard quality of produce. This may also result in ground water contamination and soil degradation through excessive nutrient leaching from the crop root zone. Therefore, estimation of exact requirement of nutrients by the crop with minimum leaching loss in the soils and obtaining greater output per drop of water is of paramount importance. The present study was an attempt in these direction to optimize fertigation requirements to obtain higher yields in polyhouse grown sweet pepper. Among different fertigation treatments which included both N, P, K and micronutrients, the results revealed that the maximum fruit yield of 76.04, 74.98, 75.51 t ha^{-1} and 86.36, 84.31, 85.34 t ha^{-1} was obtained during *kharif* 2017, 2018 and pooled over years in both cultivar (Nishat 1) and hybrid (Shalimar Capsicum Hybrid 2) with application of T_5 i.e., 75% each of recommended dose of fertilizers and micronutrients (Table 1 and 2) saving 25% of costly nutrients with an increase yield advantage of 42.28% and 46.63% respectively over control (T_1) i.e., soil application of recommended dose of fertilizers closely followed by T_6 i.e., 100% of each of recommended dose of fertilizers and micronutrients while T_7 i.e.,125 % each of recommended dose of fertilizers and micronutrients showed significantly lower yield than T_5 recording 64.38, 63.82, 64.16 and 70.32, 69.53, 69.93 tha^{-1}. The lowest fruit yield was, however, recorded in control (T_1) with only 22.32, 21.96, 22.14 and 27.81, 27.42, 27.62 tha^{-1} during both the years and in pooled data in cultivar as well as hybrid, respectively. Similar results were observed by Patil and Das (11) who reported significant differences among fertigation treatments with maximum fruit yield of 87.20 tha^{-1} when fertilizers were given at 75%RDF (recommended dose of fertilizers) through fertigation. Like in fruit yield, the average number of harvested fruits were also found highest in T_5 i.e., 75% of each of recommended dose of fertilizers and micronutrient with 21.46 and 23.20 fruits plant^{-1} in both cultivar as well as hybrid showing 49.74 and 55.03 per cent increase over control treatment T_1 i.e.,

Table 1. Influence of various levels of NPK and micronutrients on sweet pepper cv. Nishat 1 through fertigation under polygreenhouse.

Treatments	Plant height (cm)			Leaf area (cm^2)			Leaf chlorophyll (mg/100g)			Fruit weight (g)			Number of fruits $plant^{-1}$			Fruit yield per hectare ($t\ ha^{-1}$)		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
T_1	73.08	71.06	72.07	10.42	10.22	10.32	62.12	63.19	62.65	35.06	35.73	35.40	9.72	9.57	9.65	22.32	21.96	22.14
T_1	84.69	82.45	83.57	15.92	15.40	15.66	66.14	67.23	66.68	48.53	50.21	49.37	14.57	14.07	14.31	46.12	45.58	45.85
T_1	92.31	89.40	90.86	12.90	12.26	12.57	69.43	70.61	70.02	51.06	51.96	51.50	15.44	15.03	15.23	50.54	50.24	50.39
T_1	98.55	96.69	97.62	17.40	16.84	17.12	74.10	74.26	73.68	43.49	43.68	43.59	14.17	14.05	14.10	38.95	38.83	38.89
T_1	103.6	100.34	102.0	19.76	19.13	19.45	76.34	77.57	76.95	58.07	59.08	58.57	21.72	21.19	21.46	76.04	74.98	75.51
T_1	114.4	111.9	113.2	18.10	17.36	17.73	78.30	79.39	78.84	59.27	59.44	59.36	20.21	18.55	19.38	72.25	66.65	69.45
T_1	120.4	117.09	118.8	22.32	21.31	21.81	81.54	83.19	82.36	55.20	55.57	55.38	17.89	17.76	17.83	64.38	63.82	64.16
C.D. ($p<0.05$)	12.02	11.44	11.71	3.62	3.94	3.55	6.09	6.06	5.98	5.42	7.53	6.17	2.26	2.18	1.73	10.23	8.65	8.36
S.E(d)	6.01	5.72	5.85	1.81	1.74	1.78	3.04	3.03	2.99	2.71	3.77	3.08	1.13	1.09	0.86	5.16	4.32	4.17

Table 2. Influence of various levels of NPK and micronutrients on sweet pepper hybrid Shalimar Capsicum Hybrid 2 through fertigation under polygreenhouse.

Treatments	Plant height (cm)			Leaf area (cm^2)			Leaf chlorophyll (mg/100g)			Fruit weight (g)			Number of fruits $plant^{-1}$			Fruit yield per hectare ($t\ ha^{-1}$)		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
T_1	75.48	74.09	74.78	11.46	10.89	11.17	65.48	66.95	66.21	36.85	37.16	37.01	11.74	11.58	11.66	27.81	27.42	27.62
T_2	86.74	84.77	85.75	17.61	16.97	17.29	67.65	68.64	68.14	50.46	52.28	51.37	15.95	15.18	15.57	51.94	52.43	52.18
T_3	95.12	93.53	94.33	14.84	14.26	14.55	71.68	72.48	72.08	54.01	54.82	54.41	17.35	16.95	17.15	60.32	59.35	59.84
T_4	100.7	98.06	99.41	19.58	18.78	19.18	74.21	75.37	74.79	48.06	48.54	48.30	15.49	15.31	15.40	48.00	45.73	46.89
T_5	106.2	103.22	104.7	22.14	21.42	21.78	77.35	78.14	77.74	60.88	62.06	61.47	23.55	22.85	23.20	86.36	84.31	85.34
T_6	116.3	113.65	115.0	20.15	19.31	19.73	79.34	80.60	79.97	61.46	63.07	62.27	21.59	21.01	21.30	79.93	77.96	78.95
T_7	122.8	120.74	121.0	23.85	23.55	23.70	84.11	85.03	84.57	58.54	60.49	59.52	18.67	17.86	18.26	70.32	69.53	69.93
C.D. ($p<0.05$)	12.57	12.80	12.68	4.01	3.98	4.02	5.18	4.94	5.04	5.55	6.02	5.36	2.25	2.01	2.22	11.80	8.37	9.86
S.E(d)	6.28	6.40	6.34	1.99	1.97	2.01	2.59	2.47	2.52	2.78	3.01	2.68	1.12	1.01	1.11	5.90	4.18	4.93

Soil application of recommended dose of fertilizers, respectively and was found significantly superior to all other treatments except treatment T_6 of hybrid where it was at par with T_5 recording 19.38 and 21.30 fruits plant^{-1} in cultivar and hybrid, respectively (Table 1 and 2). Lowest number of fruits per plant was recorded in treatment T_1 (control) with only 9.65 and 11.66 fruits in cultivar and hybrid, respectively. Fruit weight also varied significantly with different fertigation treatments. Among different fertigation levels, treatment T_6 i.e., 100% of each of RDF and micronutrients increased fruit weight significantly over T_1 (control),T_2,T_3 and T_4 with an average fruit weight of 59.27, 59.44g and 61.46, 63.07g in cultivar Nishat 1 and Shalimar Capsicum Hybrid 2 during *Kharif* 2017 and 2018, respectively (Table 1 and 2) and was superior to all other treatments but was at par with T_5 i.e., 75% of each of RDF and micronutrients with an average fruit weight of 58.57g and 59.08 g in Nishat 1 and 60.88g and 62.06g in Shalimar Capsicum Hybrid 2, respectively. The control i.e. T_1, however, recorded lowest average fruit weight of 35.06g and 35.73g and 36.85g and 37.16g during Kharif 2017 and 2018, respectively in cultivar Nishat 1 and Shalimar Capsicum Hybrid 2. Pooled over years also revealed significance of treatment T_6, recording average fruit weight of 59.36g and 62.27g in cultivar Nishat 1 and Shalimar Capsicum Hybrid-2, respectively. Improvement in fruit weight and yield by different levels of fertigation treatments was also reported by Abdul (1). The higher fruit yield recorded with fertigation treatment T_5 and T_6 was probably attributed to optimum water and nutrient availability around the root zone with minimum leaching and better uptake. This might have increased various physiological processes like higher photosynthetic rate resulting in more number of fruits and higher fruit weight associated with increased plant growth and leaf pigments.

Different levels of fertigation influenced the plant height significantly. On the basis of pooled results, T_7 i.e. 125% of each of RDF and micronutrients recorded maximum plant height of 118.82 cm and 121.02 cm in cultivar Nishat 1 and Shalimar Capsicum Hybrid 2 respectively followed by T_5 while it was significantly lowest in treatment control (T_1) recording 72.07cm and 74.78cm in cultivar Nishat 1 and Shalimar Capsicum hybrid 2, respectively. Leaf area which is responsible for photosynthetic efficiency in plants was significantly influenced by fertigation treatments. Among all treatments, Treatment T_7 i.e., 125% of each of RDF and micronutrients recorded maximum leaf area of 22.32, 21.81 cm^2 and 23.85, 23.55 cm^2 during *kharif* 2017 and 2018 in cultivar Nishat 1 and Shalimar Capsicum Hybrid 2, respectively (Table 1 and 2) and was found significantly superior to all other treatments except T_5 and T_6 which were at par with T_7. Treatment T_5 i.e., 75% of each of RDF and micronutrients recorded a leaf area of 19.76, 19.13 cm^2 and 22.14, 21.42 cm^2 during *kharif* 2017 and 2018 in cultivar Nishat 1 and hybrid SCH-2 respectively. Pooled analysis also revealed significance of treatment T_7 recording highest leaf area of 21.81 and 23.70 cm^2 in cultivar and hybrid, respectively while lowest leaf area of 10.42,10.22 and 10.32 cm^2 in Nishat 1 and 11.46,10.89 and 11.17cm^2 in Shalimar Capsicum Hybrid 2 was recorded with treatment T_1 (control) during *kharif* 2017, 2018 and pooled over years, respectively. Enhanced plant height and leaf area is attributed to higher and regular uptake of nutrients at sufficient levels eliminating thereby stress resulting progressive increase in plant height and leaf area. Higher availability of nutrients at regular intervals in root zone of fertigated treatments thereby improving availability of native as well as applied nutrients and their better translocation from roots to different parts was also reported by Abid Khan *et al.* (2) and Khan *et al.* (8) leading to improvement in plant height and leaf area.

Leaf chlorophyll content is an index of plant production capacity and is an indication of photosynthetic and metabolic activity. From the Table 1 and 2, it was clear that treatment,T_7 i.e., 125% of each of RDF and micronutrients recorded maximum chlorophyll content of 82.36 and 84.57 mg 100g^{-1} in cultivar and hybrid, respectively in pooled over years which was statistically at par with treatment, T_6 i.e., 100% each of RDF and micronutrients recording chlorophyll content of 78.84 and 79.97 mg 100g^{-1} in cultivar and hybrid, respectively followed by T_5.The lowest chlorophyll content of 62.65 and 66.21 mg 100g^{-1} was recorded in treatment T_1 (control) which was significantly lower than treatments T_5,T_6 and T_7 both in cultivar and hybrid, respectively. These results are in conformity with the findings of Sable *et al.* (13).

From the above results, it was clear that among all fertigation levels, the treatments T_6 and T_7 proved superior in terms of plant height(cm), leaf chlorophyll content(mg/100g) and leaf area(cm^2) but were at par with treatment T_5 i.e., 75% each of recommended dose of fertilizers and micronutrients could not translate into higher fruit yield but the treatment T_5 having healthy and better plant growth with chlorophyll rich green leaves probably lead to greater photosynthesis resulting in higher accumulation of photosynthates in the form of larger and more number of fruits per plant .This ultimately translated into higher fruit yield per plant and per hectare. From the ongoing results and discussion it could be concluded that treatment T_5 i.e., 75% each of recommended dose of fertilizers (120:90:30 NPK $kgha^{-1}$ for cultivar Nishat 1 and 150:120:60 NPK $kgha^{-1}$ for Shalimar Capsicum Hybrid 2) and micronutrients (0.5% i.e. 5mg/l) is recommended for realizing higher fruit weight, fruit number and fruit yield per plant/unit area.

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