THE ASIAN JOURNAL OF HORTICULTURE
Volume **9** | Issue 1 | June, 2014 | 150-159
e ISSN- 0976-724X | Open Access-*www.researchjournal.co.in* |

Research Paper

***Article history* :**
Received : 21.12.2013
Revised : 01.05.2014
Accepted : 11.05.2014

Nutrient analysis of paprika (*Capsicum annuum* var. longam) cv. KtPl-19 under drip fertigation system

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ABSTRACT : Paprika (*Capsicum annuum* var. *longam*) is one of the important natural colourants next to turmeric. Application of fertilizers through drip irrigation is known to play a vital role in enhancing the productivity and quality of many horticultural crops. In this view, studies on paprika (*Capsicum annuum* var. *longam*) were carried out at the College orchard, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, during 2006-2009 to find out the effect of different sources and levels of potassium with reference to nutrient analysis. The experiment was conducted for two seasons *viz.*, season I (June 2007- Jan 2008) and season II (July 2008- Feb 2009) to get the concurrent result. From the study, it was observed that the crop paprika responded well to the fertigation treatments. The result revealed that application of 100 % RDF as MAP, Multi-K and SOP increased the Dry matter content at all the stages of crop growth. Similarly, the treatment T_7 revealed the highest available soil N, P, K, Ca, Mg and S at different growth stages *viz.*, vegetative, flowering and harvesting stage. The same treatment T_7 also recorded higher nutrient uptake and less pungent.

KEY WORDS : Paprika, *Capsicum annuum* var.*longam.*, Drip fertigation, Dry matter production, Soil nutrient analysis, Nutrient uptake

HOW TO CITE THIS ARTICLE : Sathish, G., Ponnuswami, V., Geethalakshmi, I., Sundharaiya, K. and Marichamy, M.S. (2014). Nutrient analysis of paprika (*Capsicum annuum* var. longam) cv. KtPl-19 under drip fertigation system. *Asian J. Hort.*, **9**(1) : 150-159.

The word paprika was derived from the Greek or Latin "Peperi-piper" meaning pepper. Paprika in a fresh state is very rich in vitamin C (ascorbic acid). Paprika being a short duration crop and heavy yielder requires heavy manuring for proper growth and high productivity (Anonymous, 1995). This warranting optimum dose of manuring practices with both organic and inorganic nutrients to get the desired growth and yield (Sharma *et al*., 1996 and Hedge, 1997). It is well known fact that potassium improves fruit colour as well as oleoresin content in capsicum (Yodpetch, 2001). Further, micronutrients such as S, Mg and Ca are also known to considerably influence the growth, yield and quality of paprika. Balanced fertilization with sulphur enhances the quality in paprika, particularly the ascorbic acid content (Ni, 1993). Recently use of Sulphate of Potash (SOP) which suplies sulphur apart from K is also known to improve the growth, yield and quality of certain horticultural crops (Ramesh Kumar, 2004 in banana and Ananthi, 2002 in chillies). The efficient use of fertilizers is necessary for optimum crop growth and yield. Hence a knowledge about the availability of nutrients in the soil is very much essential. A clear understanding of specific nutrient requirement of the crop during various stages of growth would inturn substantially reduce the possible wastage of applied nutrients and improve both the potentiality of the plant and nutrient use efficiency. During the earlier vegetative stage, the plant vigourously absorbs nutrients to build up the plant frame work and some excess nutrients are stored within the plant itself and translocated to the fruit for further development.

With this background, an investigation was taken up to determine the effect of fertigation involving water soluble and conventional fertilizers in paprika cv. KtPl-19 with reference to dry matter production, soil and plant nutrient status and nutrient uptake.

RESEARCH METHODS

A field experiment was carried out at the University Orchard, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore during the period from 2006 to 2009 with paprika Var. Ktpl-19. The experimental field was located at 11^0 North latitude and 77^0 East longitude at an altitude of 426.6m above MSL. The soil of the experimental field was clayey loam in texture. The field experiment was laid out in a Randmized Block Design with seven treatments *viz.*, (T_1)- 100% Recommended normal fertilizer applied to soil with furrow irrigation*, (T_2)-Drip fertigation with water soluble fertilizer at 50 % RDF using polyfeed + urea+ MOP**, (T_3)-Drip fertigation with water soluble fertilizer at 75 % RDF using polyfeed + urea+ MOP**, (T_4)-Drip fertigation with water soluble fertilizer at 100 % RDF using polyfeed + urea+ MOP**, (T_5)-Drip fertigation with water soluble fertilizer at 50 % RDF using MAP + Multi -K + SOP**, (T_6)-Drip fertigation with water soluble fertilizer at 75 % RDF using MAP + Multi-K + SOP**, (T_7)-Drip fertigation with water soluble fertilizer at 100 % RDF using MAP + Multi-K + SOP** (** Water soluble fertilizers = MAP (12% N and 61%P), MOP (60% K), SOP (50%K and 18% S), Multi K (13 % N and 45 % K) and Polyfeed (19 % N, 19 % P and 19 % K)) and replicated thrice. The recommended dose of N: P: K @ 120:100:120 kg per hectare was followed in the experiments. Fertigation was scheduled on alternative days starting from second week after planting . Beds of experimental unit consisted of $19m^2$ and with a spacing of 60 × 45 cm. The treatments were imposed from 30 days after planting at harvesting stage. The data were subjected to statistical analysis (Panse and Sukhatme, 1985) and the results are presented in Tables (1 to 7).

– * RDF = Recommended dose of fertilizer ha^{-1} = 120: 100 : 120 NPK kg ha^{-1} (Horticulture Crop production manual, TNAU, 2004)

– ** Water soluble fertilizers = MAP (12% N and 61%P), MOP (60% K), SOP (50%K and 18% S), Multi K (13 % N and 45 % K) and Polyfeed (19 % N, 19 % P and 19 % K).

– Observations *viz.*, Dry matter production (g $plant^{-1}$), nutrient uptake at different growth stages *viz.*, vegetative, flowering and harvesting stage, available soil N, P, K, Ca, Mg and S at different growth stages *viz.*, vegetative, flowering and harvesting stage were taken and the data were statistically analyzed.

RESEARCH FINDINGS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarised under following heads:

Dry matter production (g $plant^{-1}$) :

In the pooled mean analysis, it was evident that the fertigation treatments had significant influence on dry matter production at different stages of crop growth. It was observed that, the treatment T_7 registered the highest dry matter production of 13.39 g $plant^{-1}$, 37.98 g $plant^{-1}$and 134.12 g $plant^{-1}$, at vegetative, flowering and harvesting stage, respectively. It was followed by T_6 (12.14 g $plant^{-1}$, 34.44 g $plant^{-1}$and 125.41 g $plant^{-1}$) and T_4 (12.03 g $plant^{-1}$, 34.31 g $plant^{-1}$and 122.41 g $plant^{-1}$ at vegetative, flowering and harvesting stage), respectively . It was also observed that the treatment T_6 and T_4 were on par with each other. However the treatment T_1 registered the lowest dry matter production of 8.47 g $plant^{-1}$, 24.02 g $plant^{-1}$and 87.58 g $plant^{-1}$ at vegetative, flowering and harvesting stage, respectively.

Significantly higher dry matter production of 13.42 g $plant^{-1}$ and 14.54 g $plant^{-1}$ at vegetative stage, 39.40 g $plant^{-1}$ and 39.28 g $plant^{-1}$ at flowering stage and 137.90 g $plant^{-1}$ and 138.12 g $plant^{-1}$ at harvesting stage during season I and II was recorded by T_7 . It was followed by T_6 (12.10 g $plant^{-1}$ and 12.21 g $plant^{-1}$ at vegetative stage, 34.13 g $plant^{-1}$ and 36.12 g $plant^{-1}$ at flowering stage and 125. 35 g $plant^{-1}$ and 126.62 g $plant^{-1}$ at harvesting stage during season I) and II) and T_4 (12.06 g $plant^{-1}$ and 12.42 g $plant^{-1}$ at vegetative stage, 34.00 g $plant^{-1}$ and 35.10 g $plant^{-1}$ at flowering stage and 123.89 g $plant^{-1}$ and 124.50 g $plant^{-1}$ at harvesting stage during season I and II, respectively and were on par with each other. While, the lowest dry matter production of 9.17 g $plant^{-1}$ and 9.46 g $plant^{-1}$ (vegetative stage), 24.66 g $plant^{-1}$ and 27.57 g $plant^{-1}$ (flowering stage) and 95.31 g $plant^{-1}$ and 97.65 g $plant^{-1}$ (harvesting stage) during season I and II were recorded by control (T_1) (Table 1).

Soil nutrient analysis:

To assess the availability of various nutrients in the soil and the effect of fertilizer application, leaf and soil analysis of nutrients were made through in plant analysis. For scheduling a effective fertilizer programme, analysis of plant nutrient status has been found useful highly to prevent the deficiency or excess of nutrient in any horticultural crop. The concentration and uptake of nutrient in plant however varies with the age of the crop, season, plant parts, stage of the crop and cultivars. Plant analysis serves as an elegant tool for understanding the growth and physiology of the plant at various phases of its growth (Hartz and Hochmuth, 1996).

Available soil nitrogen (kg ha^{-1}) :

In the pooled mean analysis it was observed that the highest available soil nitrogen contents were recorded by the treatment T_7 (226 kg ha^{-1} at vegetative stage, 233 kg ha^{-1} at flowering stage and 220 kg ha^{-1} at harvesting stage). It was followed by the treatments T_6 (209 kg ha^{-1}, 216 kg ha^{-1}and 203 kg ha^{-1} at vegetative, flowering and harvesting stage, respectively). However the treatment (T_1) recorded the lowest available soil nitrogen content at all the stages (181 kg ha^{-1}, 187 kg ha^{-1} and 174 kg ha^{-1} at vegetative, flowering and harvesting stage).

The different fertigation treatment at two seasons also showed significant difference on available soil nitrogen. The highest available soil nitrogen of 226 kg ha^{-1} and 227 kg ha^{-1} (vegetative stage), 232 kg ha^{-1} and 234 kg ha^{-1} (flowering stage) and 220 kg ha^{-1} and 220 kg ha^{-1} (harvesting stage) were recorded by the treatment T_7 during the season I and II. It was followed by T_6 (209 kg ha^{-1} and 210 kg ha^{-1} at vegetative stage, 215 kg ha^{-1} and 217 kg ha^{-1} at flowering stage and 203 kg ha^{-1} and 203 kg ha^{-1} at harvesting stage during season I and II). The lowest available soil nitrogen content of 181kg ha^{-1} and 182 kg ha^{-1} (vegetative stage), 187 kg ha^{-1} and 188 kg ha^{-1} (flowering stage) and 174 kg ha^{-1} and 175 kg ha^{-1} (harvesting stage) were recorded by control (T_1) during season I and II (Table 2).

Available soil phosphorus (kg ha^{-1}) :

In the pooled mean analysis it was observed that the highest available soil phosphorus values were recorded by the treatment T_7(19.28 kg ha^{-1} at vegetative stage, 19.45 kg ha^{-1} at flowering stage and 18.60 kg ha^{-1} at harvesting stage). It was followed by the treatments T_6 (17.07 kg ha^{-1}, 17.61 kg ha^{-1} and 15.66 kg ha^{-1} at vegetative flowering and harvesting stage, respectively). However, the control treatment (T_1) recorded the lowest available soil phosphorus values at all the three stages (11.28 kg ha^{-1}, 9.60 kg ha^{-1}and 9.02 kg ha^{-1} at vegetative, flowering and harvesting stage).

The different fertigation treatment at two seasons also showed significant difference on available soil phosphorus. The highest available soil phosphorus of 18.68 kg ha^{-1} and 19.88 kg ha^{-1} (harvesting stage), 18.85 kg ha^{-1} and 20.05 kg (flowering stage) and 18.00 kg ha^{-1} and 19.20 kg ha^{-1} (harvesting stage) were recorded by the treatment T_7 during both season I and II. It was followed by T_6 (16.47 kg ha^{-1} and 17.67 kg ha^{-1} at vegetative stage, 17.01 kg ha^{-1} and 18.21 kg ha^{-1} at flowering stage and 15.06 kg ha^{-1}and 16.26 kg ha^{-1} at harvesting stage during season I and II). The lowest available soil phosphorus values of 10.76 kg ha^{-1} and 11.80 kg ha^{-1} (vegetative stage), 9.00 kg ha^{-1} and 10.20 kg ha^{-1} (flowering stage) and 8.42 kg ha^{-1} and 9.62 kg ha^{-1} (harvesting stage) were recorded by control (T_1) during season I and II (Table 2).

Available soil potassium (kg ha^{-1}) :

Different fertigation treatments showed highly

Table 1 : Effect of ferigation on dry matter production (g plant^{-1}) at different stages of crop growth in paprika cv. KtPl-19

Treatments	Dry matter production (g plant^{-1})								
	Vegetative stage			Flowering stage			Harvesting stage		
	Season		Mean	Season		Mean	Season		Mean
	I	II		I	II		I	II	
T_1	9.17	9.46	8.47	24.66	27.57	24.02	95.31	97.65	87.58
T_2	10.26	10.83	10.15	28.57	31.26	28.69	102.73	104.61	101.35
T_3	11.28	12.16	11.56	32.65	34.98	32.99	117.67	119.56	115.67
T_4	12.06	12.42	12.03	34.00	35.10	34.31	123.89	124.50	122.41
T_5	10.66	11.25	10.83	29.88	32.70	30.85	108.59	110.44	107.63
T_6	12.10	12.21	12.14	34.13	36.12	34.94	125.35	126.62	125.41
T_7	13.42	14.54	13.39	39.40	39.28	37.98	137.90	138.12	134.12
S.E.±	0.050	0.057	0.870	0.167	0.135	2.297	0.521	0.497	8.670
C.D. (P=0.05)	0.109	0.124	1.792	0.365	0.293	4.732	1.136	1.084	17.339
C.D. (P=0.01)	0.152	0.174	2.434	0.512	0.413	6.433	1.592	1.520	21.275

significant difference for available soil potassium. In the pooled mean data analysis, it was observed that the highest values were recorded by the treatment T_7 (376 kg ha^{-1} at vegetative stage, 367 kg ha^{-1} at flowering stage and 297 kg ha^{-1} at harvesting stage). It was followed by the treatment T_6 (344 kg ha^{-1}, 336 kg ha^{-1} and 266 kg ha^{-1} at vegetative, flowering and harvesting stage, respectively). The treatments (T_1) recorded the lowest available soil potassium at all the stages (310 kg ha^{-1}, 303 kg ha^{-1} and 232 kg h^{-1} at vegetative, flowering and harvesting stage.

The fertigation treatment at two different seasons also showed significant difference on available soil potassium. The highest available soil potassium of 375 kg $ha^{-1}$and 377 kg ha^{-1} (Vegetative stage), 367 kg ha^{-1} and 368 kg ha^{-1} (flowering stage) and 297 kg ha^{-1} and 298 kg ha^{-1} (harvesting stage) were recorded by the treatment T_7 during both seasons. It was flowered by T_6 (344 kg ha^{-1} and 345 kg ha^{-1} at vegetative stage, 336 kg ha^{-1} and 337 kg ha^{-1} at flowering stage and 266 kg ha^{-1} and 267 kg ha^{-1} at harvesting stage during season I and II). The lowest values of 310 kg ha^{-1} and 311 kg ha^{-1} (vegetative stage), 302 kg ha^{-1} and 304 kg ha^{-1} (flowering stage) and 232 kg ha^{-1} and 232 kg ha^{-1} (harvesting stage) were recorded by control (T_1) during season I and II (Table 3).

Available soil calcium (kg ha^{-1}) :

The results on fertigation treatments showed highly significant difference for available soil calcium. In the pooled mean analysis it was observed that the highest available soil calcium values recorded by the treatment T_7 (10.55 kg ha^{-1} at vegetative stage, 9.79 kg ha^{-1} at flowering stage and 9.45 kg ha^{-1} at harvesting stage). It was followed by the treatment T_6 (9.61 kg ha^{-1}, 8.76 kg ha^{-1} and 8.46 kg ha^{-1} at vegetative, flowering and harvesting stage, respectively) . However the control (T_1) recorded the lowest available soil calcium at all the three stages (7.58 kg ha^{-1}, 7.51 kg ha^{-1} and 6.55 kg ha^{-1} at vegetative, flowering and harvesting stage).

The fertigation treatment at two seasons also showed significant difference on available soil calcium. The highest available soil calcium of 10.00 kg ha^{-1} and 11.10 kg ha^{-1} (vegetative stage), 9.24 kg ha^{-1} and 10.34 kg ha^{-1} (flowering stage) and 8.90 kg ha^{-1} and 10.00 kg ha^{-1} (harvesting stage) were recorded by the treatment T_7 during both season I and II. It was flowered by T_6 (9.06 kg ha^{-1} and 10.16 kg ha^{-1} at vegetative stage, 8.21kg ha^{-1} and 9.32kg ha^{-1} at flowering stage and 7.91kg ha^{-1} and 9.01kg ha^{-1} at harvesting stage during season I and II). The lowest values of 7.03 kg ha^{-1} and 8.13 kg ha^{-1} (vegetative stages), 6.96 kg ha^{-1} and 8.06 kg ha^{-1} (flowering stage) and 6.00 kg ha^{-1} and 7.10 kg ha^{-1} (harvesting stage) were recorded by control (T_1) treatment during season I and II (Table 3).

Available soil magnesium (kg ha^{-1}) :

Fertigation treatments tried in the present studies

Table 2 : Effect of fertigation on soil available Nitrogen (kg ha^{-1}) and Soil available phosphorus (kg ha^{-1}) at different stages of crop growth in paprika cv. KtPl-19

Treatments	Soil available Nitrogen (kg ha^{-1})									Soil available Phosphorus (kg ha^{-1})								
	Vegetative stage			Flowering stage			Harvesting stage			Vegetative stage			Flowering stage			Harvesting stage		
	Season		Mean	Season		Mean	Season		Mean	Season		Mean	Season		Mean	Season		Mean
	I	II		I	II		I	II		I	II		I	II		I	II	
T_1	181	182	181	187	188	187	174	175	174	10.76	11.80	11.28	9.00	10.20	9.60	8.42	9.62	9.02
T_2	189	190	189	195	196	195	183	184	183	11.49	12.69	12.09	10.42	11.62	11.02	9.01	10.21	9.61
T_3	198	199	198	204	205	204	192	193	192	13.78	14.98	14.38	14.09	15.29	14.69	11.12	12.40	11.76
T_4	208	209	208	214	216	215	202	202	202	15.24	16.44	15.84	15.83	17.03	16.43	13.10	14.30	13.70
T_5	193	194	193	199	201	200	187	188	187	13.18	14.38	13.78	13.65	14.85	14.25	11.42	12.62	12.02
T_6	209	210	209	215	217	216	203	203	203	16.47	17.67	17.07	17.01	18.21	17.61	15.06	16.26	15.66
T_7	226	227	226	232	234	233	220	220	220	18.68	19.88	19.28	18.85	20.05	19.45	18.00	19.20	18.60
S.E.±	0.535	0.535	0.378	0.535	0.548	0.383	0.542	0.526	0.378	0.099	0.101	0.071	0.125	0.125	0.088	0.121	0.121	0.085
C.D.(P=0.05)	1.165	1.165	0.779	1.165	1.194	0.789	1.182	1.147	0.778	0.217	0.219	0.146	0.272	0.271	0.182	0.263	0.262	1.176
C.D.(P=0.01)	1.663	1.633	1.0584	1.633	1.674	1.072	1.657	1.608	1.058	0.305	0.308	0.199	0.381	0.381	0.247	0.369	0.368	0.239

Table 3 : Effect of fertigation on soil available potassium (kg ha^{-1}) and soil available calcium (kg ha^{-1}) at different stages of crop growth in paprika cv. KtPl-19

Treatments	Soil available Potassium (kg ha^{-1})									Soil available Calcium (kg ha^{-1})								
	Vegetative stage			Flowering stage			Harvesting stage			Vegetative stage			Flowering stage			Harvesting stage		
	Season		Mean	Season		Mean	Season		Mean	Season		Mean	Season		Mean	Season		Mean
	I	II		I	II		I	II		I	II		I	II		I	II	
T_1	310	311	310	302	304	303	232	232	232	7.03	8.13	7.58	6.96	8.06	7.51	6.00	7.10	6.55
T_2	320	321	320	312	314	313	242	243	242	7.21	8.30	7.75	6.83	7.93	7.38	7.01	8.11	7.56
T_3	330	331	330	322	324	323	252	253	252	8.82	9.91	9.36	8.06	9.16	8.61	7.56	8.66	8.11
T_4	335	336	335	327	329	328	257	258	257	8.91	10.01	9.46	8.10	9.20	8.65	7.84	8.94	8.39
T_5	325	326	325	317	318	317	247	248	247	8.06	9.16	8.61	7.92	9.02	8.47	7.27	8.37	7.82
T_6	344	345	344	336	337	336	266	267	266	9.06	10.16	9.61	8.21	9.32	8.76	7.91	9.01	8.46
T_7	375	377	376	367	368	367	297	298	297	10.00	11.10	10.55	9.24	10.34	9.79	8.90	10.00	9.45
S.E.±	0.748	0.760	0.533	0.748	0.737	0.525	0.748	0.755	0.531	0.038	0.038	0.027	0.029	0.029	0.021	0.032	0.031	0.022
C.D. (P=0.05)	1.629	1.655	1.098	1.629	1.685	1.081	1.629	1.645	1.095	0.083	0.083	0.056	0.063	0.064	0.043	0.069	0.069	0.046
C.D. (P=0.01)	2.285	2.321	1.493	2.285	2.249	1.469	2.285	2.306	1.488	0.117	0.116	0.075	0.088	0.089	0.056	0.097	0.096	0.063

showed highly significant difference for the available soil magnesium. In the pooled mean analysis, it was noticed that the highest available soil magnesium values were recorded by the treatment T_7 (3.94 kg ha^{-1} at vegetative stage, 3.39 kg ha^{-1} at flowering stage and 3.19 kg ha^{-1} at harvesting stage). However, the treatments (T_1) registered the lowest available soil magnesium at all the three stages (2.30 kg ha^{-1}, 2.00 kg ha^{-1} and 1.75 kg ha^{-1} at vegetative, flowering and harvesting stage).

The different fertigation treatments at two seasons also showed significant difference on available soil magnesium. The highest available soil magnesium of 3.84 kg ha^{-1} and 4.04 kg ha^{-1} (vegetative stage), 3.54 kg ha^{-1} and 3.24 kg ha^{-1} (flowering stage) and 3.04 kg ha^{-1} and 3.34 kg ha^{-1} (harvesting stage) were recorded by the treatment T_7 during both season I and II. It was closely followed by T_6 (3.32 kg ha^{-1} and 3.52 kg ha^{-1} at vegetative stage, 3.02 kg ha^{-1} and 2.72 kg ha^{-1} at flowering stage and 2.52 kg ha^{-1} and 2.82 kg ha^{-1} at harvesting stage during season I and II). The lowest values of 2.20 kg ha^{-1} and 2.40 kg ha^{-1} (vegetative stages) and 1.90 kg ha^{-1} and 2.10 kg ha^{-1} (flowering stage) and 1.70 kg ha^{-1} and 1.80 kg ha^{-1} (harvesting stage) were observed by control (T_1) during season I and II (Table 4).

Available soil sulphur (kg ha^{-1}) :

Fertigation treatments showed highly significant difference for the available soil sulphur. In the pooled mean, analysis it was observed that the highest available soil sulphur values were recorded by the treatment T_7 (8.95 kg ha^{-1} at vegetative stage, 8.91 kg ha^{-1} at flowering stage and 8.31 kg ha^{-1} at harvesting stage). It was followed by the treatments T_6 (7.51 kg ha^{-1}, 8.20 kg ha^{-1} and 7.52 kg ha^{-1} at vegetative, flowering and harvesting stage, respectively. However, the lowest values (5.32 kg ha^{-1}, 5.95 kg ha^{-1} and 5.13 kg ha^{-1} at vegetative, flowering and harvesting stage) were recorded by the control (T_1).

The fertigation treatments at two different seasons also showed significant difference on available soil sulphur. The highest available soil sulphur of 8.83 kg ha^{-1} and 9.07 kg ha^{-1} (vegetative stage), 8.82 kg ha^{-1} and 9.00 kg ha^{-1} (flowering stage) and 8.21 kg ha^{-1} and 8.41 kg ha^{-1} (harvesting stage) were recorded by the treatment T_7 during both season I and II. It was followed by T_6 (7.41 kg ha^{-1} and 7.62 kg ha^{-1} at vegetative stage, 8.10 kg ha^{-1} and 8.31 kg ha^{-1} at flowering stage and 7.42 kg ha^{-1} and 7.63 kg ha^{-1} at harvesting stage) during season I and II. The lowest available soil sulphur content of 5.22 kg ha^{-1} and 5.42 kg ha^{-1} (vegetative stage), 5.86 kg ha^{-1} and 6.04 kg ha^{-1} (flowering stage) and 5.03 kg ha^{-1} and 5.23 kg ha^{-1} (harvesting stage) were recorded by control (T_1) during season I and II (Table 4).

Nutrient uptake:

Nitrogen uptake (g plant^{-1}) :

Different fertigation treatments showed highly

Table 4 : Effect of fertigation on soil available magnesium (kg ha^{-1}) and soil available sulphur (kg ha^{-1}) at different stages of crop growth in paprika cv. KtPl-19

Treatments	Soil available magnesium (kg ha^{-1})									Soil available sulphur (kg ha^{-1})								
	Vegetative stage			Flowering stage			Harvesting stage			Vegetative stage			Flowering stage			Harvesting stage		
	Season		Mean	Season		Mean	Season		Mean	Season		Mean	Season		Mean	Season		Mean
	I	II		I	II		I	II		I	II		I	II		I	II	
T_1	2.20	2.40	2.30	1.90	2.10	2.00	1.70	1.80	1.75	5.22	5.42	5.32	5.86	6.04	5.95	5.03	5.23	5.13
T_2	2.61	2.81	2.71	2.31	2.01	2.16	1.81	2.11	1.96	6.03	6.24	6.13	6.87	7.08	6.97	5.67	5.86	5.76
T_3	3.02	3.22	3.12	2.86	2.56	2.71	2.36	2.66	2.51	6.87	7.07	6.97	7.24	7.45	7.34	5.82	6.02	5.91
T_4	3.16	3.36	3.26	2.92	2.62	2.77	2.42	2.72	2.57	7.20	7.41	7.30	8.02	8.22	8.11	7.40	7.61	7.50
T_5	2.83	3.03	2.93	2.53	2.23	2.38	2.03	2.33	2.17	6.46	6.66	6.56	7.43	7.62	7.52	6.04	6.24	6.14
T_6	3.32	3.52	3.42	3.02	2.72	2.87	2.52	2.82	2.67	7.41	7.62	7.51	8.10	8.31	8.20	7.42	7.63	7.52
T_7	3.84	4.04	3.94	3.54	3.24	3.39	3.04	3.34	3.19	8.83	9.07	8.95	8.82	9.00	8.91	8.21	8.41	8.31
S.E.±	0.018	0.018	0.013	0.018	0.015	0.012	0.016	0.018	0.012	0.040	0.041	0.029	0.034	0.034	0.024	0.041	0.041	0.029
C.D. (P=0.05)	0.040	0.040	0.027	0.041	0.033	0.025	0.035	0.040	0.025	0.088	0.090	0.059	0.074	0.075	0.050	0.090	0.090	0.060
C.D. (P=0.01)	0.056	0.057	0.036	0.057	0.047	0.034	0.049	0.056	0.034	0.124	0.125	0.081	0.105	0.1054	0.068	0.127	0.127	0.082

significant difference for the nitrogen uptake. In the pooled mean data analysis it was observed that the highest Nitrogen uptake values were recorded by the treatment T_7 (0.384 g plant^{-1} at vegetative stage, 1.199 g plant^{-1} at flowering stage and 3.795 g plant^{-1} at harvesting stage). It was followed by the treatment T_6 (0.322 g plant^{-1}, 1.018 g plant^{-1} and 3.275 g plant^{-1} at vegetative, flowering and harvesting stage, respectively). However the lowest values at all the stages 0.172 g plant^{-1}, 0.614 g plant^{-1} and 1.978 g plant^{-1} at vegetative, flowering and harvesting stage) were recorded by control treatments (T_1).

The fertigation treatment at two different seasons also showed significant difference on nitrogen uptake. The highest nitrogen uptake of 0.362 g plant^{-1} and 0.407 g plant^{-1} (vegetative stage), 1.178 g plant^{-1}and 1.221 g plant^{-1} (flowering stage) and 3.723 g plant^{-1} and 3.867 g plant^{-1} (harvesting stage) were recorded by the treatment T_7 during both season I and II. It was followed by T_6 (0.315 g plant^{-1} and 0.329 g plant^{-1} at vegetative stage, 0.989 g plant^{-1} and 1.047 g plant^{-1} at flowering stage and 3.259 g plant^{-1} and 3.292 g plant^{-1} at harvesting stage during season I and II). The lowest nitrogen uptake of 0.165 g plant^{-1} and 0.179 g plant^{-1} (vegetative stage), 0.567 g plant^{-1} and 0.661 g plant^{-1} (flowering stage) and 1.906 g plant^{-1} and 2.050 g plant^{-1} (harvesting) were recorded by control (T_1), respectively during season I and season II (Table 5).

Phosphorus uptake (g plant^{-1}) :

Fertigation treatments employed in the present investigation showed highly significant difference for the phosphorus uptake. In the pooled mean data analysis it was observed that the highest phosphorus uptake values were recorded by the treatment T_7 (0.090 g plant^{-1} at vegetative stage, 0.294 g plant^{-1} at flowering stage and 0.689 g plant^{-1} at harvesting stage). It was followed by the treatment T_6 (0.071 g plant^{-1}, 0.228 g plant^{-1} and 0.629 g plant^{-1} at vegetative, flowering and harvesting stage, respectively). However, the lowest phosphorus uptake values at all the three stages (0.024 g plant^{-1}, 0.116 g plant^{-1} and 0.192 g plant^{-1} at vegetative, flowering and harvesting stage) were exhibited by control (T_1) treatment.

The fertigation treatment at two season trait also showed significant difference on phosphorus uptake. The highest phosphorus uptake of 0.080 g plant^{-1} and 0.101 g plant^{-1} (vegetative stage), 0.274 g plant^{-1} and 0.315 g plant^{-1} (flowering stage) and 0.689 g plant^{-1}and 0.690 g plant^{-1} (harvesting stage) were recorded by the treatment T_7 during the two seasons. It was followed by T_6 (0.070 g plant^{-1}, 0.073 g plant^{-1} at vegetative stage, 0.205 g plant^{-1} and 0.252 g plant^{-1}at flowering stage and 0.626 g plant^{-1} and 0.633 g plant^{-1} at harvesting stage during seasons I and II). The lowest phosphors uptake values of 0.018 g plant^{-1} and 0.028 g plant^{-1} (vegetative stages), 0.098 g plant^{-1} and 0.137 g plant^{-1} (flowering stage) and 0.190 g plant^{-1} and 0.195 g plant^{-1} (harvesting stage) were recorded by the control (T_1), respectively during season I and II (Table 5).

Table 5 : Effect of fertigation on Nitrogen uptake (g plant^{-1}) and Phosphorus uptake (g plant^{-1}) uptake at different stages of crop growth in paprika cv. KtPl-19

Treatments	Nitrogen uptake (g plant^{-1})									Phosphorus uptake (g plant^{-1})								
	Vegetative stage			Flowering stage			Harvesting stage			Vegetative stage			Flowering stage			Harvesting stage		
	Season		Mean	Season		Mean	Season		Mean	Season		Mean	Season		Mean	Season		Mean
	I	II		I	II		I	II		I	II		I	II		I	II	
T_1	0.165	0.179	0.172	0.567	0.661	0.614	1.906	2.050	1.978	0.018	0.028	0.024	0.098	0.137	0.116	0.190	0.195	0.192
T_2	0.205	0.227	0.217	0.714	0.812	0.762	2.26	2.406	2.333	0.030	0.043	0.036	0.114	0.156	0.135	0.205	0.313	0.250
T_3	0.270	0.310	0.290	0.881	0.979	0.931	2.824	2.989	2.906	0.045	0.062	0.053	0.163	0.209	0.186	0.470	0.478	0.473
T_4	0.313	0.316	0.314	0.986	0.982	0.984	3.097	3.237	3.166	0.060	0.072	0.066	0.204	0.245	0.225	0.495	0.498	0.497
T_5	0.234	0.258	0.246	0.776	0.882	0.829	2.497	2.650	2.573	0.042	0.056	0.048	0.149	0.196	0.173	0.325	0.331	0.328
T_6	0.315	0.329	0.322	0.989	1.047	1.018	3.259	3.292	3.275	0.070	0.073	0.071	0.205	0.252	0.228	0.626	0.633	0.629
T_7	0.362	0.407	0.384	1.178	1.221	1.199	3.723	3.867	3.795	0.080	0.101	0.090	0.274	0.315	0.294	0.689	0.690	0.689
S.E.+	0.002	0.003	0.002	0.007	0.007	0.005	0.022	0.021	0.015	0.001	0.001	0.0009	0.002	0.003	0.002	0.007	0.007	0.005
C.D. (P=0.05)	0.005	0.006	0.004	0.016	0.014	0.010	0.049	0.047	0.032	0.002	0.003	0.002	0.005	0.006	0.003	0.014	0.015	0.001
C.D. (P=0.01)	0.007	0.008	0.005	0.022	0.020	0.014	0.068	0.066	0.043	0.003	0.004	0.003	0.007	0.008	0.004	0.020	`0.021	0.013

Table 6 : Effect of fertigation on potassium uptake (g plant^{-1}) and calcium uptake (g plant^{-1}) uptake at different stages of crop growth in paprika cv. KtPl-19

Treatments	Potassium uptake (g plant^{-1})									Calcium uptake (g plant^{-1})								
	Vegetative stage			Flowering stage			Harvesting stage			Vegetative stage			Flowering stage			Harvesting stage		
	Season		Mean	Season		Mean	Season		Mean	Season		Mean	Season		Mean	Season		Mean
	I	II		I	II		I	II		I	II		I	II		I	II	
T_1	0.247	0.264	0.256	0.764	0.882	0.823	2.763	2.929	2.847	0.137	0.151	0.143	0.493	0.551	0.521	1.715	1.855	1.785
T_2	0.287	0.314	0.300	0.914	1.031	0.973	3.081	3.242	3.162	0.164	0.184	0.173	0.599	0.656	0.628	1.951	2.092	2.021
T_3	0.338	0.385	0.361	1.142	1.259	1.200	3.765	3.945	3.855	0.191	0.218	0.206	0.750	0.769	0.760	2.471	2.630	2.549
T_4	0.361	0.376	0.368	1.224	1.263	1.245	4.088	4.233	4.161	0.217	0.223	0.218	0.780	0.807	0.793	2.725	2.863	2.794
T_5	0.309	0.337	0.323	0.986	1.111	1.050	3.366	3.423	3.395	0.181	0.191	0.186	0.657	0.719	0.688	2.171	2.319	2.244
T_6	0.375	0.390	0.382	1.262	1.336	1.299	4.261	4.431	4.346	0.229	0.231	0.230	0.819	0.866	0.842	2.883	2.912	2.899
T_7	0.429	0.479	0.454	1.492	1.536	1.514	4.826	4.972	4.899	0.268	0.305	0.286	0.982	1.024	1.003	3.171	3.453	3.312
S.E.+	0.002	0.007	0.002	0.009	0.001	0.006	0.026	0.007	0.018	0.002	0.002	0.001	0.006	0.005	0.004	0.019	0.020	0.013
C.D. (P=0.05)	0.005	0.014	0.004	0.020	0.002	0.012	0.056	0.015	0.037	0.004	0.004	0.003	0.012	0.012	0.008	0.040	0.043	0.028
C.D. (P=0.01)	0.007	0.020	0.005	0.028	0.003	0.016	0.079	0.020	0.050	0.006	0.006	0.004	0.017	0.017	0.011	0.057	0.060	0.038

Potassium uptake (g plant^{-1}) :

There was highly significant difference for the potassium uptake between the fertigation treatments. In the pooled mean analysis, it was noted that the highest potassium uptake values were recorded by the treatment T_7 (0.454 g plant^{-1} at vegetative stage, 1.514 g plant^{-1} at flowering stage and 4.899 g plant^{-1} at harvesting stage). The next best followed by the treatment was T_6 (0.382 g plant^{-1},1.299 g plant^{-1} and 4.346 g plant^{-1} at vegetative, flowering and harvesting stage, respectively). However (T_1) control recorded the lowest potassium uptake at all the three stages 0.256 g plant^{-1}, 0.823 g plant^{-1} and 2.847 g plant^{-1} at vegetative, flowering and harvesting stage).

The fertigation treatment at two seasons trait conducted also showed significant difference on potassium uptake. The highest potassium uptake of 0.429 g plant^{-1} and 0.479 g plant^{-1} (Vegetative stage), 1.492 g plant^{-1} and 1.536 g plant^{-1} (flowering stage) and 4.826 and 4.972 g plant^{-1} (harvesting stage) were recorded by the treatment T_7 during season I and II. It was followed by T_6 (0.375 g plant^{-1} and 0.390 g plant^{-1} at vegetative stage, 1.262 g plant^{-1} and 1.336 g plant^{-1} at flowering stage and 4.261 g plant^{-1} and 4.431 g plant^{-1} at harvesting stage as the second best treatment during season I and II). The least values of 0.247 g plant^{-1} and 0.264 g plant^{-1} (vegetative stage), 0.764 g plant^{-1} and 0.882 g plant^{-1} (flowering stage) and 2.763 g plant^{-1} and 2.929 g plant^{-1} (harvesting stage) were recorded by control (T_1) during season I and II (Table 6).

Calcium uptake (g plant^{-1}) :

Different fertigation treatments registered highly significant difference for the calcium uptake. In the pooled mean analysis, it was observed that the highest calcium uptake values were recorded by the treatment T_7 (0.286 g plant^{-1} at vegetative stage, 1.003 g plant^{-1} at flowering stage and 3.312 g plant^{-1} at harvesting stage). It was followed by the treatment T_6 (0.230 g plant^{-1} and 0.842 g plant^{-1} and 2.899 g plant^{-1} at vegetative, flowering and harvesting stage, respectively). However treatment (T_1) recorded the lowest calcium uptake values at all the three stages of plant growth (0.143 g plant^{-1}, 0.521 g plant^{-1} and 1.785 g plant^{-1} at vegetative, flowering and harvesting stage).

The fertigation treatment experimented at two seasons also showed significant difference on calcium uptake. The highest calcium uptake of 0.268 g plant^{-1} and 0.305 g plant^{-1} (vegetative stage), 0.982 g plant^{-1} and 1.024 g plant^{-1} (flowering stage) and 3.171 g plant^{-1} and 3.453 g plant^{-1} (harvesting stage) were recorded by the same treatment T_7 during both season I and II. It was closely followed by T_6 (0.229 g plant^{-1} and 0.231 g plant^{-1} at vegetative stage, 0.819 g plant^{-1} and 0.866 g plant^{-1} at flowering stage and 2.883 g plant^{-1} and 2.912 g plant^{-1} at harvesting stage during season I and II). The lowest values of calcium uptake 0.137 g plant^{-1} and 0.151 g plant^{-1} (vegetable stage), 0.493 g plant^{-1} and 0.551 g plant^{-1} (flowering stage) and

Table 7 : Effect of fertigation on magnesium uptake (g plant^{-1}) and sulphur uptake (g plant^{-1}) uptake at different stages of crop growth in paprika cv. KtPl-19

Treatments	Magnesium uptake (g plant^{-1})									Sulphur uptake (g plant^{-1})								
	Vegetative stage			Flowering stage			Harvesting stage			Vegetative stage			Flowering stage			Harvesting stage		
	Season I	Season II	Mean	Season I	Season II	Mean	Season I	Season II	Mean	Season I	Season II	Mean	Season I	Season II	Mean	Season I	Season II	Mean
T_1	0.036	0.047	0.041	0.197	0.248	0.222	0.476	0.585	0.530	0.100	0.113	0.108	0.320	0.358	0.340	1.048	1.171	1.109
T_2	0.051	0.064	0.058	0.257	0.281	0.270	0.616	0.732	0.675	0.123	0.140	0.132	0.399	0.406	0.403	1.232	1.359	1.295
T_3	0.067	0.085	0.076	0.326	0.349	0.338	0.823	0.956	0.888	0.146	0.173	0.160	0.489	0.489	0.488	1.529	1.673	1.602
T_4	0.072	0.086	0.079	0.374	0.386	0.380	0.991	1.120	1.055	0.156	0.182	0.169	0.510	0.526	0.518	1.734	1.743	1.738
T_5	0.053	0.067	0.060	0.268	0.327	0.297	0.760	0.883	0.821	0.127	0.146	0.135	0.418	0.457	0.437	1.411	1.435	1.423
T_6	0.084	0.097	0.090	0.409	0.433	0.421	1.128	1.266	1.197	0.169	0.183	0.176	0.511	0.577	0.544	1.754	1.899	1.826
T_7	0.107	0.130	0.118	0.471	0.512	0.491	1.379	1.519	1.449	0.187	0.232	0.210	0.628	0.669	0.648	1.930	2.071	2.000
S.E.+	0.001	0.0009	0.0008	0.003	0.003	0.002	0.010	0.0009	0.008	0.001	0.005	0.002	0.003	0.003	0.002	0.011	0.011	0.008
C.D. (P=0.05)	0.003	0.002	0.002	0.007	0.006	0.005	0.021	0.002	0.016	0.003	0.010	0.005	0.008	0.008	0.005	0.025	0.024	0.016
C.D. (P=0.01)	0.004	0.003	0.002	0.010	0.009	0.006	0.033	0.002	0.022	0.004	0.015	0.007	0.010	0.010	0.007	0.035	0.034	0.022

1.715 g plant^{-1} and 1.855 g plant^{-1} (harvesting stage) were recorded by control (T_1) during season I and II (Table 6).

Magnesium uptake (g plant^{-1}) :

In the present investigation fertigation treatments showed highly significant difference for the magnesium uptake. In the pooled mean analysis, it was pertinent to note that the highest magnesium uptake values were recorded by the treatment T_7 (0.118 g plant^{-1} at vegetative stage, 0.491 g plant^{-1} at flowering stage and 1.449 g plant^{-1} at harvesting stage). It was followed by the treatment T_6 (0.090 g plant^{-1}, 0.421 g plant^{-1} and 1.197 g plant^{-1} at vegetative, flowering and harvesting stage, respectively). However the control treatment (T_1) recorded the lowest magnesium uptake values at all the three stages of (0.041 g plant^{-1}, 0.222 g plant^{-1} and 0.530 g plant^{-1} at vegetative, flowering and harvesting stage).

The fertigation treatment at two season trait also showed significant difference on magnesium uptake. The highest magnesium uptake of 0.107 g plant^{-1} and 0.130 g plant^{-1} (vegetative stage), 0.471 g plant^{-1} and 0.512 g plant^{-1} (flowering stage) and 1.379 g plant^{-1} and 1.519 g plant^{-1} (harvesting stage) were recorded by the treatment T_7 during both seasons. It was followed by the treatment T_6 (0.084 g plant^{-1} and 0.097 g plant^{-1} at vegetative stage, 0.409 g plant^{-1} and 0.433 g plant^{-1} at flowering stage and 1.128 g plant^{-1} and 1.266 g plant^{-1} at harvesting stage during season I and II). The lowest values of 0.036 g plant^{-1} and 0.047 g plant^{-1} (vegetative stage), 0.197 g plant^{-1} and 0.248 g plant^{-1} (flowering stage) and 0.476 g plant^{-1} and 0.585 g plant^{-1} (harvesting stage) were observed by control (T_1) during season I and II (Table 7).

Sulphur uptake (g plant^{-1}) :

There was highly significant difference for the sulphur uptake among the fertigation treatments. In the pooled mean analysis it was evinced that the highest sulphur uptake values were recorded by the treatment T_7 (0.210 g plant^{-1} at vegetative stage 0.648 g plant^{-1} at flowering and 2.000 g plant^{-1} at harvesting stage). It was followed by the treatment T_6 (0.176 g plant^{-1}, and 0.544 g plant^{-1} and 1.826 g plant^{-1} at vegetative, flowering and harvesting stages, respectively). However the control treatment (T_1) recorded the lowest sulphur uptake values at all the three stages (0.108 g plant^{-1}, 0.340 g plant^{-1} and 1.109 g plant^{-1} vegetative, flowering and harvesting stage).

The fertigation treatment at two season trait also showed significant difference on sulphur uptake. The highest sulphur uptake of 0.187 g plant^{-1} and 0.232 g plant^{-1} (vegetative stage), 0.628 g plant^{-1} and 0.669 g plant^{-1} at (flowering stage) and 1.930 g plant^{-1} and 2.071 g plant^{-1} (harvesting stage) were also recorded by the treatment T_7 during season I and II. The lowest values of 0.100 g plant^{-1} and 0.113 g plant^{-1} (vegetative stage), 0.320 and 0.358 g plant^{-1} (flowering stage) and 1.048 g plant^{-1} and 1.171 g plant^{-1} (harvesting stage) were exhibited by control (T_1) during season I and II, respectively (Table 7).

Dry matter production in the present investigation was favorably influenced by fertigation treatments, especially when water soluble fertilizers such as SOP, MAP and Multi-K was used. Better dry matter accumulation in treatments having water soluble fertilizers might be due to the fact that nitrogen is the nutrient element responsible for enhancing the photosynthetic activity. Better availability and absorption of potassium could have helped translocation of metabolites especially sugars and carbohydrates to the sink and thereby increased the plant growth. This is in agreement with Thakur *et al.* (1991) in cauliflower and El-Sherif *et al.* (1993) in tomato.

Besides, the treatments involving SOP as a source of potash registered higher dry matter content which may be related to the higher chlorophyll content and better nutrient uptake recorded in this treatment. The dry matter production of the plant showed an increase even after fruiting stage, which revealed better partioning of assimilates to both fruits and vegetative parts of the plants.

Effect of fertigation on nutrient status:

In the present investigation the application of 100 per cent RDF as SOP, MAP and Multi-K produced significant desirable results on nutrient content of plant samples. Increased nutrient status in different plant parts at different phases of crop growth might be due to accumulation of carbohydrate, which may take place gradually, with the progressive advancement of crop growth. Application of 100 per cent RDF as SOP, MAP and Multi-K registered the highest N content in plant samples. The fertigation resulted in the enhanced absorption of N by the crop that ultimately led to higher yield. Similar findings were also reported by Papadopoulos (1987) in tomato and Colla *et al.* (2001) in celery.

The relatively higher P content in plant samples revealed the effectiveness of the application of 100 per cent RDF as SOP, MAP and Multi-K. Papadopoulos (1992) opined that increased levels of phosphorus increased the yield of potato cv. Spunta. In the present study drip fertigation with 100 per cent RDF as SOP, MAP and Multi-K enhanced the absorption of potassium at all phases of crop growth. Similar trend of results have been documented by El-Sherif *et al.* (1993) in tomato and Singh (1988) in chillies. The present study revealed that application of 100 per cent RDF as SOP, MAP and Multi-K registered maximum calcium, magnesium and sulphur contents in plant samples. Application of 100 per cent RDF as SOP, MAP and Multi-K increased the nutrient content in plant samples. The better photosynthetic efficiency coupled with formation of better sink by vigorous vegetative growth and developing fruits would have encouraged further absorption of more and more nutrients. It is in confirmation with the findings of More and Shinde (1991).

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