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Effect of Different Sources and Levels of Potassium on Physiological Parameters of Paprika (*Capsicum annuum* var. *longam*) Cv. KtPl-19 under Drip Fertigation System

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Paprika (*Capsicum annuum* var. *longam*) is one of the important natural food colourants gaining importance in international spice trade. Investigations were carried out in paprika (*Capsicum annuum* var. *longam*) cv. Ktpl-19 at the Department of Spices and Plantation Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore to study the influence of drip fertigation on physiological traits, 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. The experiment was laid out in a randomized block design, replicated thrice with seven treatments and replicated thrice. Observations on physiological traits *viz.,* Dry matter production (g plant^{-1}), Leaf Area Index (LAI), Total chlorophyll content (mg g^{-1}) and Relative water content (per cent) were taken from randomly selected plants and the data were statistically analyzed. The experiment was conducted for two seasons *viz.*, season I (June 2007- Jan. 2008) and season II (July 2008- Feb. 2009). From the study, it was observed that the crop paprika responded well to the fertigation treatments. Application of 100 % RDF as MAP, Multi-K and SOP through drip irrigation registered the highest values for Dry matter production (134.12 g plant^{-1}), LAI (0.73), Total chlorophyll content (2.15 mg g^{-1}) and RWC (66.88 per cent) at harvesting stage. It was followed by the treatment T_6 and T_4 during both season I and season II.

Key words : Paprika, *Capsicum annuum* var. *longam*, Dry Matter Production, Leaf Area Index, Total Chlorophyll Content, Relative Water Content

Paprika (*Capsicum annuum* var. *longam*) is the Hungarian word for plants in the genus *Capsicum*, belonging to the family Solanaceae which has its origin from Western Hemisphere of the world. International spice traders use the term paprika for non pungent, red capsicum powder. Capsicum in a fresh state is very rich in vitamin C (ascorbic acid). Paprika is the ground product from the mild or sweet varieties of capsicum, where as red chilli peppers are blends of different varieties of more pungent pepper (Tainter and Grenis, 2003). The powder is mainly used for adding natural colour to the finished products and to make the products more acceptable by the consumers. Besides colouring it is also used for flavouring and garnishing of eggs, cheese, meat dishes, sea foods and salads etc.

This warrants correct manuring practices with both organic and inorganic nutrients to get the desired growth and yield (Sharma *et al*., 1996 and Hedge, 1997). Further, micronutrients such as S, Mg and Ca are also known to considerably influence the growth, yield and quality of paprika. The physiological attributes of the crops were closely related to yield and quality parameters. Dry matter production, chlorophyll content, relative water content and leaf area index are some of the physiological parameters which have considerable significance on growth and yield parameters in paprika.

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Materials and Methods

A field experiment was conducted at the University Orchard, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore. The experimental field was located at 11° North latitude and 77° East longitude at an altitude of 426.6m above MSL. The field experiment was laid out in Randomized Block Design (RBD) with three replications 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)) will taken up for the experiment. The spacing adopted was 60cm between rows and 45 cm between plants. The fertilizer dose of N: P: K @ 120:100:120 kg per hectare was applied uniformly for all the experiments. Other cultural practices and plant protection measures were given according to the recommendation of TNAU, Coimbatore. Biometrical observations on physiological traits *viz*., Dry Matter Production, Leaf Area Index, Total Chlorophyll Content and Relative Water Content were estimated as per the standard procedure. The data were subjected to statistical analysis (Panse and Sukhatme, 1985) and the results are presented in **Table 1& 2.**

Results and Discussion

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, 37.98 and 134.12 g plant^{-1}, at vegetative, flowering and harvesting stage respectively and it was followed by T_6 (12.14, 34.44 and 125.41 g plant^{-1}) and T_4(12.03, 34.31 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, 24.02 and 87.58 g plant^{-1} at vegetative, flowering and harvesting stage respectively.

Table 1. Effect of fertigation 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	11.26	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
SEd	0.050	0.057	0.870	0.167	0.135	2.297	0.521	0.497	8.670
CD(0.05)	0.109	0.124	1.792	0.365	0.293	4.732	1.136	1.084	17.839
CD(0.01)	0.152	0.174	2.434	0.512	0.413	6.433	1.592	1.520	21.275

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 9.17g 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). 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 were used. Better dry matter accumulation in this 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 portioning of assimilates to both fruits and vegetative parts of the plants.

It was found that the different fertigation treatments had significant influence on leaf area index at different stages of crop growth. It was observed that the treatment, T_7 registered the highest LAI of 0.47, 0.94 and 0.73 at vegetative, flowering and harvesting stage respectively and it was followed by T_6 (0.41, 0.83 and 0.65) and T_4 (0.37, 0.73 and 0.56 at vegetative, flowering and harvesting stage). However, the treatment T_1 registered the lowest LAI of 0.26, 0.55 and 0.44 at vegetative, flowering and harvesting stage respectively.

Significantly higher LAI of 0.48 and 0.50 at vegetative stage, 0.98 and 1.00 at flowering stage and 0.76 and 0.78 at harvesting stage during season I and II were recorded by T_7. It was followed by T_6 (0.40 and 0.43 at vegetative stage, 0.82 and 0.84 at flowering stage and 0.64 and 0.66 at harvesting

Table 2. Effect of fertigation on Leaf Area Index and Total Chlorophyll Content (mg g^{-1}) at different stages of crop growth in Paprika cv. KtPl-19

Treatments	Leaf Area Index									Total Chlorophyll Content (mg g^{-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	0.26	0.28	0.26	0.54	0.56	0.55	0.43	0.45	0.44	1.52	1.59	1.55	1.78	1.85	1.81	1.62	1.65	1.63
T_2	0.29	0.31	0.29	0.59	0.61	0.59	0.46	0.48	0.46	1.62	1.79	1.66	1.98	2.05	1.95	1.82	1.85	1.70
T_3	0.32	0.34	0.33	0.63	0.65	0.64	0.49	0.51	0.50	1.80	1.87	1.83	2.06	2.14	2.10	1.90	1.93	1.91
T_4	0.36	0.38	0.37	0.72	0.74	0.73	0.55	0.57	0.56	1.85	1.92	1.87	2.11	2.18	2.13	1.95	1.98	1.93
T_5	0.30	0.32	0.31	0.62	0.64	0.62	0.48	0.50	0.48	1.79	1.86	1.79	2.05	2.12	2.06	1.89	1.92	1.86
T_6	0.40	0.43	0.41	0.82	0.84	0.83	0.64	0.66	0.65	2.00	2.07	1.99	2.26	2.33	2.25	2.10	2.13	2.01
T_7	0.48	0.50	0.47	0.98	1.00	0.94	0.76	0.78	0.73	2.09	2.16	2.10	2.35	2.43	2.36	2.19	2.22	2.15
SEd	0.003	0.003	0.029	0.005	0.006	0.061	0.004	0.004	0.047	0.007	0.007	0.134	0.007	0.007	0.155	0.007	0.007	0.151
CD(0.05)	0.006	0.006	0.060	0.011	0.011	0.126	0.009	0.009	0.098	0.016	0.015	0.276	0.015	0.015	0.320	0.016	0.016	0.312
CD(0.01)	0.009	0.009	0.082	0.016	0.017	0.171	0.014	0.013	0.133	0.022	0.020	0.376	0.020	0.021	0.434	0.022	0.022	0.424

stage) and T_4 (0.36 and 0.38 at vegetative, 0.82 and 0.84 flowering stage and 0.64 and 0.66 at harvesting stage during season I and II respectively). While, the lowest LAI of 0.26 and 0.28 (vegetative stage), 0.54 and 0.56 (flowering stage), 0.43 and 0.45 (harvesting stage) was observed during season I and II respectively by the untreated control (T_1) (table 2).

Leaf area index is physiological measure of vegetative growth of plants and the assimilatory surface on which the production and accumulation of dry matter takes place. Increased LAI of the present study might be attributed due to continuous and uninterrupted supply of optimum water and nutrients (Singh *et al*., 2004) and also due to easy availability of nutrients from water soluble fertilizers and also better mobilization of nutrients in the plants, as a result of split application of fertilizers. This optimum leaf area index was found to be vital for the plant to perform sufficiently photosynthetic activity. Parthasarathy *et al*., (1999) reported that leaf area index in radish significant increased with increased fertilizer application. Similar results were also reported in potato by Martinez – Canades *et al.,* (1985) and Awari and Hiwase (1994).

The fertigation treatments had significant influence on total chlorophyll content at different stages of crop growth. It was observed that the treatment, T_7 registered the highest chlorophyll content of 2.10 mg g^{-1}, 2.36 mg g^{-1} and 2.15 mg g^{-1} at vegetative, flowering and harvesting stages respectively and it was followed by T_6 (1.99 mg g^{-1}, 2.25 mg g^{-1} and 2.01 mg g^{-1}) and T_4 (1.87mg g^{-1}, 2.13 mg g^{-1} and 1.93 mg g^{-1} at vegetative, flowering and harvesting stage). However, the control treatment T_1 registered the lowest chlorophyll content of 1.55 mg g^{-1}, 1.81 mg g^{-1} and 1.63 mg g^{-1} at vegetative, flowering and harvesting stage.

Significantly higher chlorophyll content of 2.09 mg g^{-1} and 2.16 mg g^{-1} at vegetative stage, 2.35 mg g^{-1} and 2.43 mg g^{-1} at flowering stage and 2.19 mg g^{-1} and 2.22 mg g^{-1} at harvesting stage during season I and II was recorded by T_7. It was followed by T_6 (2.00 mg g^{-1} and 2.07 mg g^{-1} at vegetative stage and 2.10 mg g^{-1} and 2.13 mg g^{-1} at flowering stage and 2.26 mg g^{-1} and 2.33 mg g^{-1} at harvesting stage) during season I and II and T_4 (1.85 mg g^{-1} and 1.92 mg g^{-1} at vegetative stage, 2.11 mg g^{-1} and 2.18 mg g^{-1} at flowering stage and 1.95 mg g^{-1} and 1.98 mg g^{-1} at harvesting stage) during season I and II. While the lowest chlorophyll content of 1.52 mg g^{-1} and 1.59 mg g^{-1} (vegetative stage), 1.78 mg g^{-1} and 1.85 mg g^{-1} (flowering stage), 1.62 mg g^{-1} and 1.65 mg g^{-1} (harvesting stage) respectively during season I and II were obtained by control (T_1)(table 2). Chlorophyll content has a direct bearing on photosynthetic activity which may in turn result in synthesis of more carbohydrate contents. In the present study, perceptive differences in total chlorophyll contents were observed between fertigated plants and conventionally fertilized plants at all the three stages *viz*., vegetative, flowering and harvesting stage of crop growth. This clearly suggested that fertigation was more efficient in maintaining a better photosynthetic efficiency which further maintained a better physiological status of the plant. In the present study, fertigation with water soluble fertilizers *viz.,* SOP, MAP and Multi-K as a source of K had a remarkable effect in the chlorophyll content. This might be better related to the role of efficiency of water soluble fertilizers vs conventional fertilizers. The treatments containing SOP as K source resulted in higher chlorophyll synthesis which could be ascribed to the role of sulphur which is present in only SOP, not in other sources (Srinivasan, 2000). There was also an increase in chlorophyll content to the corresponding increase

Table 3. Effect of fertigation on Relative Water Content (per cent) at different stages of crop growth in Paprika cv. KtPl-19

Treatments	Relative Water Content (per cent)								
	Vegetative stage			Flowering stage			Harvesting stage		
	Season		Mean	Season		Mean	Season		Mean
	I	II		I	II		I	II	
T1	73.12	73.86	73.49	83.35	84.31	83.83	64.64	66.29	65.43
	(58.80)	(59.28)	(59.04)	(66.00)	(66.76)	(66.38)	(53.52)	(54.52)	(54.02)
T2	74.21	74.73	74.16	83.62	84.52	84.00	64.92	65.61	65.33
	(59.51)	(59.85)	(59.18)	(66.21)	(66.93)	(66.57)	(53.69)	(54.10)	(53.89)
T3	75.16	75.45	75.28	84.38	86.53	84.15	65.47	66.22	65.91
	(60.14)	(60.33)	(60.23)	(66.82)	(68.61)	(67.71)	(54.02)	(54.47)	(54.25)
T4	76.73	76.80	76.29	84.78	86.89	85.71	66.17	67.29	66.44
	(61.20)	(61.22)	(61.21)	(67.14)	(68.91)	(68.03)	(54.44)	(54.13)	(54.29)
T5	75.08	75.39	74.99	83.86	85.17	84.37	65.21	66.89	65.80
	(60.08)	(60.29)	(60.19)	(66.40)	(67.46)	(66.93)	(53.86)	(54.88)	(54.38)
T6	76.87	76.91	76.85	85.12	87.29	86.09	66.19	67.32	66.75
	(61.29)	(61.32)	(61.30)	(67.42)	(69.27)	(67.84)	(54.46)	(55.14)	(54.80)
T7	77.25	77.41	77.19	85.14	87.32	86.22	66.59	67.29	66.88
	(61.55)	(61.66)	(61.61)	(67.44)	(69.29)	(68.37)	(54.70)	(55.13)	(54.91)
SEd	0.043	0.030	0.026	0.020	0.035	0.020	0.016	0.015	0.011
CD (0.05)	0.094	0.069	0.055	0.045	0.077	0.042	0.034	0.034	0.022
CD (0.01)	0.132	0.094	0.074	0.063	0.108	0.057	0.048	0.047	0.031

in the levels of SOP. Sulphur is primarily involved in chlorophyll synthesis, thus resulting in increased chlorophyll content in the leaves (Ramesh Kumar, 2004).

It was observed that different fertigation treatments had significant influence on relative water content at different stages of crop growth. It was observed that the treatment, T_7 registered the highest relative water content of 77.19 per cent, 86.22 per cent and 66.88 per cent at vegetative, flowering and harvesting stages respectively and it was followed by T_6 (76.85 per cent, 86.09 per cent and 66.75 per cent) and T_4 (76.29 per cent, 85.71 per cent and 66.44 per cent). However, the control T_1 registered the lowest relative water content of 73.49 per cent, 83.83 per cent and 65.43 per cent at vegetative, flowering and harvesting stages.

The treatment T_7 significantly recorded higher relative water content of 77.25 per cent and 77.41 per cent plant vegetative stage, 85.14 per cent and 87.32 per cent at flowering stage and 66.59 per cent and 67.29 per cent at harvesting stage during season I and II. It was followed by T_6 (76.87 per cent and 76.91 per cent at vegetative stage, 85.152 per cent and 87.29 per cent at flowering stage and 66.19 per cent and 67.32 per cent at harvesting stage during season I and II) and T_4 (76.73 per cent and 76.80 per cent at vegetative stage, 84.78 per cent and 86.89 per cent at flowering stage and 66.17 per cent and 67.29 per cent at harvesting stage) during season I and II. While, the lowest relative water content of 73.12 per cent and 73.86 per cent (vegetative stage), 83.35 per cent and 84.31 per cent (flowering stage) and 64.64 per cent and 66.29 per cent (harvesting stage) during season I and II was noticed by control (T_1)(table 3). Relative water content represents the ability of the plants to retain tissue water status under the stress situations and the plants retaining more tissue water are expected to perform better through maintaining proper hydration of their protoplasm and turgidity of the assimilatory cells. In the present investigation, treatment (T_7) plants showed higher relative water content than the control (T_1). The reduction in leaf relative water content observed under control (T_1) could be mainly attributed to increased light intensity which might have caused an increase in transpiration rate with limited stomatal diffusive resistance (Dhindsa *et al*., 1981). Application of 100 per cent water soluble fertilizer greatly improved the water status of the plants. Accumulation of potassium ions in cells leads to a higher osmotic pressure, which in turn enhances turgor pressure of the cell.

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