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Water Use Efficiency of Drip Fertigated Sweet Pepper under the Influence of Different Kinds and Levels of Fertilizers

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Abstract

A field experiment was conducted to study the influence of different kinds and levels of fertilizers on water use efficiency of drip fertigated Sweet pepper at the Research Farm of the Department of Soil and Water Engineering, PAU, Ludhiana in the year 2012–2013. In the drip fertigation experiment, two types of fertilizers viz. Water Soluble Fertilizers (specialized fertilizers, WSF) and conventional fertilizers and three doses of NPK fertilizers were applied by drip irrigation. The drip fertigated treatments were T_1 (WSF applied at 80% RDF (recommended dose of fertilizer)), T_2 (WSF applied at 70% RDF), T_3 (WSF applied at 60% RDF), T_4 (Conventional fertilizer applied at 80% RDF), T_5 (Conventional fertilizer applied at 70% RDF) and T_6 (Conventional fertilizer applied at 60% RDF) and an additional control treatment (with furrow irrigation and 100% traditional fertilizer) was used for comparison. The irrigation was applied at 75% ET_C. The percentage water saving for drip fertigation treatment was 33.94% over the conventional irrigation. Out of all the treatments, water use efficiency for T_2 treatment was maximum (5.24 q/ha-cm) which was significantly par with T_4 (5.19 q/ha-cm) treatment. The minimum water use efficiency was in conventional method (2.69 q/ha-cm). While, for drip fertigated treatments, the minimum water use efficiency was in T_6 treatment (3.25 q/ha-cm).The statistical analysis showed that the water use efficiency of T_2 and T_4 treatment were significantly superior than all other treatments.

Keywords: Drip Irrigation, Fertigation, Sweet Pepper, Water Use Efficiency

1. Introduction

Water is a vital component for successful vegetable production[1]. The increased competition for water between agricultural, industrial, and urban consumers creates the need for continuous improvement of irrigation practices in commercial vegetable production[2]. Generally, vegetables crops require and consume comparatively more water owing to increase number of harvests.

Sweet pepper is one of the most popular and high value vegetable crops grown for its immature fruits throughout the world. Sweet pepper consumption in India has increased now- a- days due to increased demand by urban consumers. Water has been identified as one of the scarcest inputs, which can severely restrict agricultural growth unless it is carefully conserved and managed[3]. According to National Academy of Agricultural Sciences, water-table in 82 per cent area of Punjab has gone down substantially. The net annual groundwater draft in Punjab exceeds availability by 45 per cent. Based on the water table data collected regularly, it was brought out that in 9,058 sq km of central Punjab it has gone down by more than 20 metres in the past one decade and the trend is continuing with some districts[4]. Due to water scarcity, the available water resources should be very effectively utilized through water saving irrigation technologies. Hence in the present day context, lot of emphasis is being given in improving the irrigation practices to increase the crop production and to sustain the productivity levels. Maximizing of the yield is also essential to serve the increasing population of the country. Therefore, adoption of modern irrigation techniques is needed to be emphasized to increase water use efficiency and covering more area under cultivation. Furrow and basin irrigation

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methods are commonly adopted to irrigate vegetables crops, which causes adverse effects of cyclic over irrigation and water stress[5]. Drip irrigation is the most effective way to supply water and nutrients to the plants not only save water but also increases yield of fruit and vegetable crops[6]. It improves yield as well as quality of produce with appreciable water saving. Use of drip irrigation coupled with fertigation is gaining much importance, which act as slow release of fertilizer and hence nutrients are available to the plants over long period of growth, results in increase in crop growth and yield[7]. Drip fertigation allows nutrient placement directly into the root zone around the plants through the emitters near plant roots during critical periods of nutrient requirement[8].

Now a days, many types of fertilizers including specialized fertilizers and conventional fertilizers are available in the market to be applied through drip irrigation but, which fertilizers and at what dose must be applied is a problem for the farmers, hence present study was carried out to see the effects of water soluble fertilizers (specialized fertilizers) with conventional fertilizers on water use efficiency of drip irrigated sweet pepper.

2. Materials and Methods

The field experiment was carried out at the Research Farm of the Department of Soil and Water Engineering, PAU, Ludhiana, India (Latitude 30^0 56' N ,Longitude 75^0 52' E and situated at 247 meters above mean sea level) during the months of October–June(2012–2013). The experimental soil was sandy clay loam, low in available N, medium in available P (31.62 kg ha^{-1}) and high in available K (273 kg ha^{-1}). The soil had maximum pH value of 8.7, organic carbon content of 0.24 per cent and EC of 0.22 dS/m on different soil depth. The experiment was laid out in randomized block design and replicated thrice. In the drip fertigation experiment, two types of fertilizers viz. Water Soluble Fertilizers (specialized fertilizers, WSF) and conventional fertilizers and three doses of NPK fertilizers were applied by drip irrigation. The Water Soluble Fertilizers (specialized fertilizers, WSF) consisted of Ammonium Sulphate (N:P:K, 21-0-0),Phosphoric Acid (N:P:K ,0-80-0), Potassium Sulphate (N:P:K,0:0:50) and the Conventional Fertilizers consisted of Urea (N:P:K ,46:0:0), Monoammonium Phosphate (N:P:K,12:61:0) and Muriate of Potash (N:P:K, 0:0:60). The drip fertigated treatments were T_1 (WSF applied at 80% RDF (recommended dose of fertilizer)) which is (125:70:30) kg ha^{-1} for the sweet pepper as recommended by PAU, Ludhiana[9], T_2 (WSF applied at 70% RDF), T_3 (WSF applied at 60% RDF), T_4 (Conventional fertilizer applied at 80% RDF), T_5 (Conventional fertilizer applied at 70% RDF) and T_6 (Conventional fertilizer applied at 60% RDF) and an additional control treatment (with furrow irrigation and 100% traditional fertilizer as being presently adopted by Punjab state farmers) was used for comparison.

Sweet Pepper seedlings of Indra variety from raised nursery (which was raised in second week of October, 2012) were transplanted at 45cm X 30 cm spacing on raised bed of 60 cm width with a spacing 60 cm between each bed in experimental field on 17^{th} November, 2012. Sweet pepper is more sensitive to environment (particularly soil temperature and moisture). It was reported by Anonymous[9] that the Sweet pepper crop grow at soil temperatures between 18°C and 35°C. A few days after transplanting of crop, the sweet pepper crop was covered with 50 microns thickness poly sheet on 28^{th} Nov, 2012 with 185 cm width over the low tunnel frame heights of 60 cm above ground to protect crop from frost and other injury. The low tunnel cover was kept up to 23^{rd} February, 2013 and after that low tunnels were removed. The amount of water actually applied by way of drip irrigation system was based on meteorological data such as open pan evaporation, rainfall, sunshine hours, relative humidity, wind speed, temperature (Table 1).

Irrigation to all the treatments was scheduled based on 75% ET_C as found to best by Singh et al.[10]. Irrigation was applied every alternate day. The Reference evapotranspiration had been computed using the FAO-56 Penman Monteith equation as discussed by Allen et al.[11] in the following form:

$$ET_0 = \frac{0.408\,\Delta(R_n - G) + \gamma \dfrac{900}{T+273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34\,u_2)} \qquad (1)$$

Where,

ET_0 = Reference evapotranspiration in mm

R_n = Net radiation (MJ m^{-2} day^{-1})

G = Soil heat flux density (MJ m^{-2} day^{-1})

T = Mean daily air temperature at 2m height (°C)

Δ = Slope of the saturated vapour pressure curve (k Pa $^oC^{-1}$)

γ = Psychometric constant (k Pa $^oC^{-1}$)

Table 1. Meteorological parameters observed during crop growing period

Month	T_{max} Daily avg (^{O} C)	T_{min} Daily avg (^{O} C)	Sun-shine hours Daily avg	Rainfall (mm)	Open pan evaporation, Total in mm	Wind speed (Daily avg) (km/h)	Maximum Relative humidity (Daily avg) (%)	Minimum Relative humidity (Daily avg) (%)
Nov	26.6	10.5	6.6	0.0	60.6	1.9	91	40
Dec	19.4	7.4	5.2	17.4	48.9	4.1	92	58
Jan	17.0	5.1	5.2	8.2	43.6	3.6	94	60
Feb	20.5	9.7	6.4	96.4	56.7	4.9	98.0	67.0
March	27.6	13.2	9.2	35.6	114.0	3.9	94	50
April	34.2	18.3	9.1	4.4	199.9	4.3	65	24
May	40.6	23.0	9.7	1.2	326.4	5.7	50	26

e_s = Saturated vapour pressure (kPa)

e_a = Actual vapour pressure (kPa)

u_2 = Wind speed at 2 m height (m s^{-1})

The crop evapotranspiration was computed as under:

$$ET_c = K_c\, ET_o \qquad (2)$$

Where,

ET_c = Crop evapotranspiration (mm)

K_c = Crop coefficient, The value of Kc for different stages were taken as reported by Dorenbos et al.[12] The volume of water applied per plant was computed as given below:

$$v = \frac{0.75\, ET_c\, A_c\, A_w}{U} \qquad (3)$$

Where,

V = Volume of water applied per plant in drip irrigation system (litre)

A_c = Cropped area (m^2) which is calculated by row to row spacing (m) × plant to plant spacing (m^2)

A_w = Fractional wetted area which was taken as 75% as discussed by Mane et al.[13]

U = Christiansen uniformity coefficient

Time of irrigation is calculated with the help of formula as given below:

$$T\,(drip) = \frac{N_p\, V}{N_e\, Q} \qquad (4)$$

Where,

T (drip) = Drip Irrigation time (hours)

N_p = Number of plants served by one lateral

V = Volume of water applied per plant in drip irrigation system (litre)

Ne = Number of emitter in one lateral

Q = Average emitter discharge (litre/hr)

In the control plot, the water was applied by furrow irrigation after 30 mm net cumulative pan evaporation, which was computed as under:

$$T\,(\text{furrow}) = \frac{d\, w\, i}{360q} \qquad (5)$$

Where,

T (furrow) = Furrow irrigation time (hrs)

d = Depth of water to be applied (cm)

l = Furrow length (m)

w = Furrow spacing (m)

q = Discharge available at furrow (lps)

In the first two month of growing period of sweet pepper required fertilizer doses of NPK were applied once in a week to all treatments through drip irrigation. After that, fertilizer application was twice in week. All the fertilizers were applied in equal split doses. Total number of fertigation required for whole experiment was 35.The details of fertilizers in kg/ha in drip fertigated treatment as given in Table 2. In the control plot, the fertilizer was applied as according to recommendation of PAU, Ludhaina[9].

Table 2. Requirement of fertilizer

Type of Fertilizer		Fertilizer Doses Treatments 80% RDF	70% RDF	60% RDF
		(Kg/ha)		
Water soluble	Ammonium sulphate	476.19	416.67	357.14
	Phosphoric Acid	70	61.25	52.5
	Potassium Sulphate	48	42	36
Conventional	Urea	193.44	169.26	145.08
	Monoammonium Phosphate	91.80	80.33	68.85
	Muriate of Potash	40	35	30

Total weight of matured green fruits harvested from each picking in each replication was recorded till final harvest and the total yield of fruits per hectare under different treatments computed per hectare.

The total fruit yield obtained for each treatment was divided by the quantity of water used for each treatment. Water use efficiency was worked out and expressed as:

$$WUE = \frac{\text{Yield}}{\text{Total amount of water used}} \tag{6}$$

The data collected from the present field experiment were subjected to statistical analysis using randomized block design and using ANalysis of VAriance (ANOVA) techniques. The significance of differences was tested at 5 percent levels.

3. Results and Discussion

3.1 Sweet Pepper Yield

The effects of drip fertigation treatment on Sweet pepper yield are shown in Figure 1. There was no statistically significant yield difference between treatment T_2 (301.94 q/ha) and treatment T_4 (299.14q/ha). The drip fertigation treatments (T_2, T_4) showed a statistically significant higher yield as compared with all drip fertigated treatment and control furrow irrigated. This may be due to the uniform distribution and adequate availability of nutrients and moisture in the root zone of the crop. The results are in accordance with Gupta et al.[1], Veeranna et al.[14] and Kong et al.[15]. The yield of treatments with drip fertigation of 70% and 80% of RDF treatments with both types of fertilizers were significantly higher than that of control furrow treatment while 60% dose produced less yield as compared with control treatment.

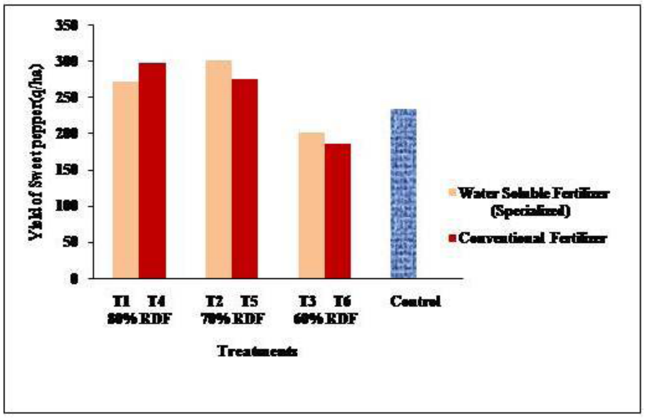

Figure 1. Effect of different treatments on yield of Sweet pepper

3.2 Irrigation Water Requirement

Quantity of irrigation water required under different treatments is presented in Table 3. The amount of water applied by drip fertigation was 57.6 cm with 83 number of irrigation, which was applied with 75% ET_c. The amount of water applied in conventional irrigated control treatment was 87.2 cm. Thus, the water applied in drip fertigation was 33.94 % less as compared to conventional irrigation method. The results are in accordance with that of Fanish[16], Tanaskovik et al.[17] and Deolankar et al.[18] who all reported that the drip irrigated treatments saved considerably amount of water as compared with traditional method of irrigation.

3.3 Water Use Efficiency

The data obtained for water use efficiency per ha under different treatments are presented in Table 4. The data clearly revealed that in all the drip fertigated treatments

Table 3. Irrigation water applied under different treatments

Irrigation treatment	Pre irrigation depth (cm)	Total number of irrigations	Total depth of irrigation water applied (cm)	Percentage saving over furrow irrigation
Drip irrigation	3	83	57.6	33.94
Conventional irrigation	3	27	87.20	

water use efficiency was maximum in T_2 treatment (5.24 q/ha-cm) followed by the all other treatments. Among the conventional drip fertigation treatment, T_4 (5.19 q/ha-cm) gave the maximum water use efficiency followed by T_5 (4.8 q/ha-cm) and T_6 (3.25 q/ha-cm) treatments. Among the water soluble drip fertigation treatment T_2 (5.24 q/ha-cm) gave the maximum water use efficiency followed by T_1 (4.72 q/ha-cm) and T_3 (3.51 q/ha-cm) treatments. Amongst all the treatments, the WUE was maximum (5.24 q/ha-cm) in T_2 treatment, while it was minimum in T_6 (3.25 q/ha-cm) treatment. Out of all the treatments, water use efficiency for T_2 treatment was maximum (5.24 q/ha-cm) which was significantly par with T_4 (5.19 q/ha-cm) treatment. The minimum water use efficiency was in conventional method (2.69 q/ha-cm) while, for drip fertigated treatments, the minimum water use efficiency was in T_6 treatment (3.25 q/ha-cm).When we compare water use efficiency in all drip fertigated treatment with control furrow irrigated treatment.It was observed that all these treatments, water use efficiency were significantly better than control furrow irrigated treatment. This may be due to the fact that optimum level of fertilizer doses enhances the water requirement resulting in better yield. The results are in accordance with Sharma et al.[19] and Veeranna et al.[14].

Statistical analysis for different treatments given in Table 4 revealed that there was significant effect of fertigation on WUE. The treatments T_2 and T_4 gave significantly higher WUE than all other treatments, while there was no significant difference between T_2 and T_4 treatments with each other.

4. Conclusion

The drip fertigated experiment concluded that WUE was maximum (5.24q/ha-cm) in T_2 treatment, while it was minimum in T_6 (3.25 q/ha-cm) treatment. The treatments T_2 and T_4 gave significantly higher WUE than all other treatments, while there was no significant difference between T_2 and T_4 treatments with each other.

The WUE of best drip fertigated treatment was 94.79% more than the control furrow irrigated treatment presently being used by farmers. The best drip fertigation treatment saves 33.94% of water as well as 20% of fertilizer as compared to control furrow irrigated method for growing sweet pepper. Hence, drip fertigation by applying 80% of conventional fertilizer may be adopted in comparison to costly specialized fertilizer available in the market for raising of sweet pepper.

Table 4. Effect of different treatments on water use efficiency

Irrigation Method	Type of Fertilizer	Fertilizer Dose (% RDF)	Treatments	Water Use Efficiency (q/ha/cm)
Drip	Water Soluble (specialized)	80	T_1	4.72
		70	T_2	5.24
		60	T_3	3.51
		80	T_4	5.19
	Conventional	70	T_5	4.80
		60	T_6	3.25
Conventional	Conventional	100		2.69
		CD (5%)	0.41	

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