



Effect of Environment, Irrigation and Fertigation on Growth, Yield and Water Use Efficiency in Red Cabbage

Vishal Pandey¹, N N Firake² and S D Gorantiwar³

Dr. A. S. College of Agricultural Engineering and Technology,
Mahatma Phule Krishi Vidyapeeth, Rahuri – 413 722 (India)

ABSTRACT

A study was conducted on red cabbage at the Precision Farming Development Centre, Mahatma Phule Krishi Vidyapeeth in Rahuri, Maharashtra, India. The research compared two growing environments: inside a polyhouse and in an open field. It also tested three different irrigation levels (0.90 ETc, 0.75 ETc, and 0.60 ETc) and three fertilizer application rates (125% of the recommended dose (RD), 100% RD, and 75% RD). The results showed that red cabbage yielded the best under polyhouse conditions with the highest irrigation level (0.90 ETc) and the highest fertilizer rate (125% RD). Additionally, the highest water use efficiency was achieved with a slightly lower irrigation level (0.75 ETc) but still with the highest fertilizer rate (125% RD) inside the polyhouse.

Key Words: Environment condition, Fertigation regimes, Irrigation regimes, Polyhouse, Red cabbage

INTRODUCTION

Indian Government is promoting exotic vegetables, of which market value and nutrient content is quite higher than traditional vegetables. In this situation, to acquire proper knowledge of a particular vegetable, i.e. how the variety of that vegetable is responding to Indian climate and to the irrigation and fertigation regimes as well. A research experiment of red cabbage was under taken at Precision Farming Development Centre, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India. Red cabbage is new crop recently introduced in India. The native of this crop is Southern Europe, which requires cooler climate for its well development. It is proved by several researchers that there is significant role of environment, irrigation and fertigation on the growth and yield of crop. (Harel et al, 2014; Ojha et al, 2016; Umesha et al, 2011) Bhosale and Sonawane (2016) and (Santosh et al, 2017) reported similar results for different vegetables. (Paksoy, 2006) conducted a research experiment on different varieties of red cabbage with different methods of irrigation and reported that highest yield was obtained under drip irrigation, followed by sprinkler and furrow irrigation. (Kumar et al

2010), and (Gopala Reddy et al, 2017) also specified that drip irrigation was the most efficient and profitable method among all irrigation methods.

MATERIALS AND METHODS

The site of experiment was situated at 19° 47' N latitude and 74° 37' E longitudes at 657 m above mean sea level, in the central campus of Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India. The experiment was carried out in polyhouse and open field in split-split plot design with 18 treatments comprising of two environmental conditions i.e. polyhouse (E₁) and open field (E₂), three irrigation regimes 0.90 (I₁), 0.75 (I₂) and 0.60 (I₃) of crop evapo-transpiration and three fertigation regimes 125 (F₁), 100 (F₂) and 75 (F₃) % of RDF (recommended dose of fertilizer) with three replications. The size of the polyhouse was 25 × 20 m and open field was 20 × 18 m. The size of each raised beds in polyhouse and open field were 2.7 × 0.75 m and 4.5 × 0.75 m, respectively, with 0.3 m height and 0.5 m buffer strip was provided between two beds. Silver colour at top and black colour at bottom polyethylene mulch was used commonly in all the treatments. The width of mulch and thickness

Corresponding Author's Email - vishalpandey945.vp@gmail.com

1.Senior Research Fellow, MPKV, Rahuri

2.Head, Department of Irrigation and Drainage Engineering, MPKV, Rahuri

Head, Agricultural Engineering, MPKV, Rahuri

Effect of Environment, Irrigation and Fertigation on Growth, Yield

Table 1. Effect of different environmental condition, irrigation regimes and fertigation regimes on plant height, stem girth, E-W spread and N-S spread at harvest (120 DAT) of red cabbage plant

Treatment	At harvest, 120 DAT			
	Plant Height, cm	Stem girth, mm	E-W spread, cm	N-S spread, cm
A. Environmental factor				
E ₁ : Polyhouse	33.46	14.76	46.43	50.30
E ₂ : Open field	29.13	16.40	38.55	43.03
S.E.m±	0.13	0.26	0.15	0.26
C.D. at 5%	0.81	1.57	0.92	1.60
B. Irrigation level (I)				
I ₁ : 90% ETc	31.87	18.07	43.26	47.68
I ₂ : 75% ETc	31.55	15.40	42.55	46.88
I ₃ : 60% ETc	30.47	13.26	41.65	45.44
S.E.m±	0.06	0.14	0.36	0.39
C.D. at 5%	0.21	0.44	1.18	1.26
C. Fertigation level (F)				
F ₁ : 125% RD	32.63	16.67	43.29	48.54
F ₂ : 100% RD	31.19	15.32	42.68	46.65
F ₃ : 75% RD	30.08	14.74	41.49	44.81
S.E.m±	0.11	0.06	0.49	0.63
C.D. at 5%	0.33	0.18	1.44	1.84
C. Interaction (E X I)				
S.E.m±	0.09	0.19	0.51	0.55
C.D. at 5%	0.29	0.63	NS	NS
D. Interaction (E X F)				
S.E.m±	0.16	0.09	0.70	0.89
C.D. at 5%	NS	0.26	NS	NS
E. Interaction (I X F)				
S.E.m±	0.19	0.11	0.86	1.09
C.D. at 5%	0.57	0.32	NS	NS
F. Interaction (E X I X F)				
S.E.m±	0.28	0.15	1.21	1.55
C.D. at 5%	0.80	0.45	NS	NS

were 1.20 m and 25 micron respectively. The recommended dose of fertilizers of red cabbage in open field cultivation was 80:40:40 kg/ha (N: P: K). In the experiment, drip irrigation system was used for daily irrigation. Average emission uniformity of drip irrigation system was observed in the range of 89.16 % to 93.12 %.

RESULTS AND DISCUSSION

The maximum plant height (35.87 cm) was observed under T₁ = E₁I₁F₁ (Polyhouse x 0.90 ETc x

125 % RDF), which was significantly superior over other treatments. However, the minimum plant height was (25.91 cm) under T₁₈ = E₂I₃F₃ (Open field x 0.60 ETc x 75 % RDF) treatment (Table 1). The effect of different factors i.e. environment, irrigation and fertigation are depicted in Fig. 1(a), (b) and (c) respectively and interaction of all three factor is depicted in Fig. 1(d) (Table 2). The maximum stem girth (20.66 mm) was observed under T₁ = E₂I₁F₁ (Open field x 0.90 ETc x 125 % RDF), which was significantly

Table 2. Interaction effect of different environmental condition, irrigation regimes and fertigation regimes on plant height (cm) at harvest (120 DAT) of red cabbage plant

Treatment	E1: Polyhouse			E2: Open field		
	I ₁ :0.9 ETc	I ₂ :0.75 ETc	I ₃ :0.6 ETc	I ₁ :0.9 ETc	I ₂ :0.75 ETc	I ₃ :0.6 ETc
	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)
F ₁ : 125% RDF	35.87	34.33	33.99	31.01	30.79	29.79
F ₂ : 100% RDF	33.27	33.85	32.44	29.58	29.21	28.78
F ₃ : 75% RDF	32.87	32.61	31.93	28.64	28.51	25.91
S.E.± = 0.28				CD at 5 % = 0.80		

Table 3. Interaction effect of different environmental condition, irrigation regimes and fertigation regimes on stem girth (mm) at 120 DAT (at harvest) of red cabbage plant

Treatment	E1: Polyhouse			E2: Open field		
	I ₁ :0.9 ETc	I ₂ :0.75 ETc	I ₃ :0.6 ETc	I ₁ :0.9 ETc	I ₂ :0.75 ETc	I ₃ :0.6 ETc
	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
F ₁ : 125% RDF	18.78	15.10	13.45	20.66	17.11	14.92
F ₂ : 100% RDF	16.78	14.18	12.29	18.56	16.49	13.65
F ₃ : 75% RDF	15.89	13.77	12.58	17.78	15.72	12.68
S.E.± = 0.15				CD at 5 % = 0.45		

Table 4. Effect of environmental condition, irrigation regimes and fertigation regimes on the yield, equatorial and polar diameter of red cabbage

Treatments	q/1008 m ²	Equatorial diameter	Polar diameter
A. Environment Condition (E)			
E ₁ : Polyhouse	32.65	201.13	278.73
E ₂ : Open field	18.95	128.38	90.18
S.E.m±	0.31	2.65	1.89
C.D. at 5%	1.88	16.11	11.53
B. Irrigation level (I)			
I ₁ : 90% ETc	31.88	197.91	227.66
I ₂ : 75% ETc	27.70	168.44	186.30
I ₃ : 60% ETc	17.83	127.92	139.41
S.E.m±	0.36	0.61	1.45
C.D. at 5%	1.18	1.97	4.73
C. Fertigation level (F)			
F ₁ : 125% RD	28.18	174.96	199.03
F ₂ : 100% RD	25.96	165.72	189.68
F ₃ : 75% RD	23.27	153.58	164.65
S.E.m±	0.28	1.14	1.21
C.D. at 5%	0.81	3.33	3.53

Effect of Environment, Irrigation and Fertigation on Growth, Yield

Treatments	q/1008 m ²	Equatorial diameter	Polar diameter
D. Interaction (E X I)			
S.E.m±	0.51	0.86	2.05
C.D. at 5%	1.68	2.79	6.69
E. Interaction (E X F)			
S.E.m±	0.39	1.61	1.71
C.D. at 5%	1.14	NS	4.99
F. Interaction (I X F)			
S.E.m±	0.48	1.97	2.10
C.D. at 5%	1.40	5.76	6.12
G. Interaction (E X I X F)			
S.E.m±	0.68	2.79	2.96
C.D. at 5%	1.98	8.14	8.65

Table 5. Interaction effect of different environmental condition, irrigation regimes and fertigation regimes on yield (q/1008 m²), head diameter (equatorial diameter in mm) and head diameter (polar diameter in mm), of red cabbage plant

Treatment	E ₁ : Polyhouse			E ₂ : Open field		
	I ₁ :0.9 ETc	I ₂ :0.75 ETc	I ₃ :0.6 ETc	I ₁ :0.9 ETc	I ₂ :0.75 ETc	I ₃ :0.6 ETc
	Yield, q/1008 m ²					
F ₁ : 125% RDF	43.74	36.74	26.09	25.95	22.18	14.39
F ₂ : 100% RDF	37.92	36.22	24.56	24.12	20.41	12.52
F ₃ : 75% RDF	37.18	32.48	18.94	22.37	18.15	10.49
S.E.± = 0.68				CD at 5 % = 1.98		
Equatorial head diameter, mm						
F ₁ : 125% RDF	243.33	221.65	172.23	165.77	138.54	108.24
F ₂ : 100% RDF	235.36	202.36	165.89	161.43	131.17	98.14
F ₃ : 75% RDF	232.19	190.82	146.34	149.38	126.09	76.68
S.E. ± = 2.79				CD at 5 % = 8.14		
Polar head diameter, mm						
F ₁ : 125% RDF	332.18	308.55	255.34	136.31	88.28	73.50
F ₂ : 100% RDF	331.45	293.03	238.91	129.53	85.65	59.52
F ₃ : 75% RDF	309.31	256.82	182.96	127.16	85.45	26.22
S.E.± = 2.96				CD at 5 % = 8.65		

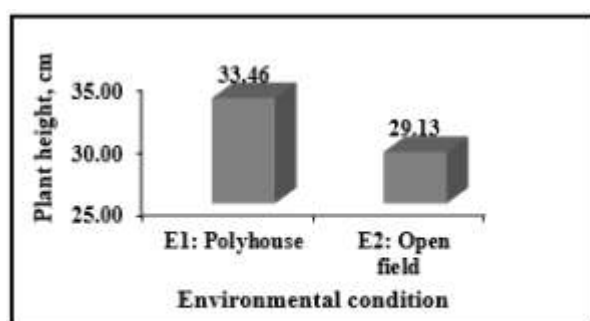
superior over other treatments. However, the minimum stem girth was (12.58 mm) under T₉= E₁I₃F₃ (Polyhouse x 0.60 ETc x 75 % RDF) treatment (Table 1). The effect of different factors i.e. environment, irrigation and fertigation are depicted in Fig. 2(a), (b) and (c) respectively and interaction of all three factor is depicted in Fig. 2(d) (Table 3). There was no significant difference

was noticed in plant spread in N-S and E-W direction under different treatments (Table 1).

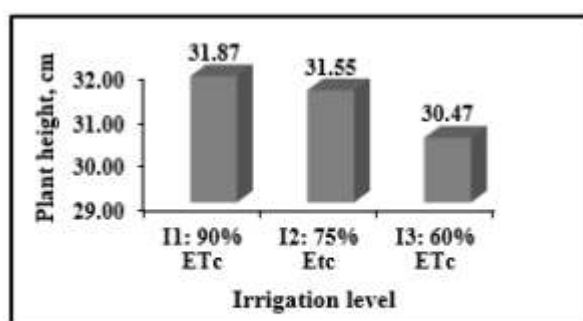
The maximum yield per 1008 m² area of polyhouse was 43.74 q was observed under T₁= E₁I₁F₁ (Polyhouse x 0.90 ETc x 125 % RDF), which was significantly superior over other treatments. However, the minimum yield per 1008 m² area of polyhouse was 10.49 q under T₁₈= E₂I₃F₃ (i.e. open

Table 6. Total depth of irrigation water applied over the growth period of red cabbage

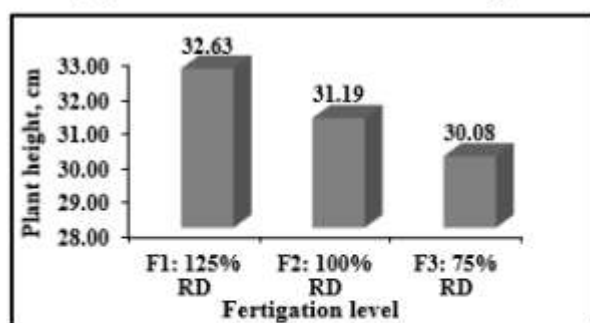
Treatment No.	Treatment	Total water required, mm	Water use efficiency, kg/m ³
T ₁	Polyhouse x 90 % ETc x 125% RDF	356.47	20.11
T ₂	Polyhouse x 90 % ETc x 100% RDF	356.47	17.44
T ₃	Polyhouse x 90 % ETc x 75% RDF	356.47	17.10
T ₄	Polyhouse x 75 % ETc x 125% RDF	297.05	20.28
T ₅	Polyhouse x 75 % ETc x 100% RDF	297.05	19.99
T ₆	Polyhouse x 75 % ETc x 75% RDF	297.05	17.93
T ₇	Polyhouse x 60 % ETc x 125% RDF	237.64	17.995
T ₈	Polyhouse x 60 % ETc x 100% RDF	237.64	16.94
T ₉	Polyhouse x 60 % ETc x 75% RDF	237.64	13.06
T ₁₀	Open Field x 90 % ETc x 125% RDF	362.29	11.74
T ₁₁	Open Field x 90 % ETc x 100% RDF	362.29	10.91
T ₁₂	Open Field x 90 % ETc x 75% RDF	362.29	10.12
T ₁₃	Open Field x 75 % ETc x 125% RDF	311.60	11.67
T ₁₄	Open Field x 75 % ETc x 100% RDF	311.60	10.74
T ₁₅	Open Field x 75 % ETc x 75% RDF	311.60	9.55
T ₁₆	Open Field x 60 % ETc x 125% RDF	260.91	9.04
T ₁₇	Open Field x 60 % ETc x 100% RDF	260.91	7.87
T ₁₈	Open Field x 60 % ETc x 75% RDF	260.91	6.59



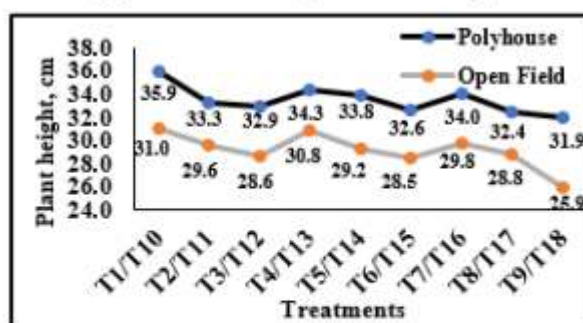
(a) Effect of environment on height



(b) Effect of irrigation on height



(c) Effect of fertigation on height



(d) Interaction effect of all factors

Fig. 1 Effect of treatments on an average height of red cabbage plant at harvest

Effect of Environment, Irrigation and Fertigation on Growth, Yield

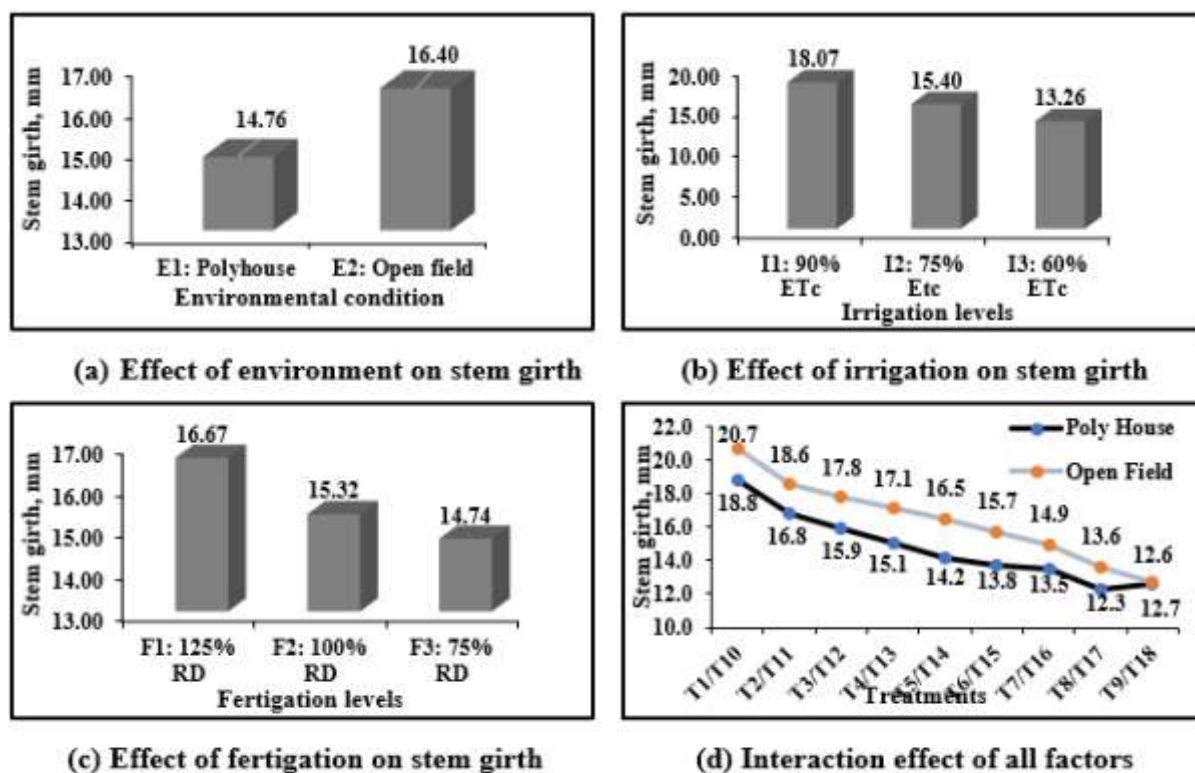


Fig. 2 Effect of treatments on an average stem girth of red cabbage plant at harvest

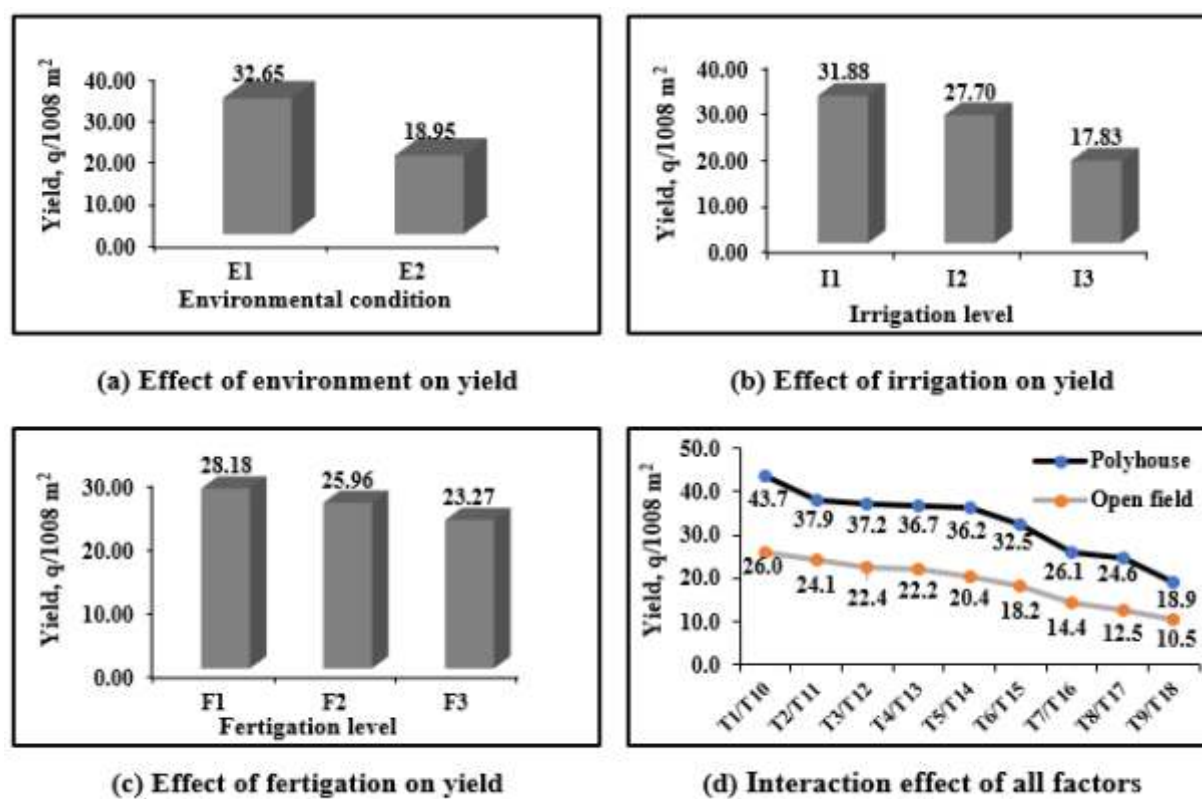


Fig. 3 Effect of treatments on an average yield of red cabbage plant

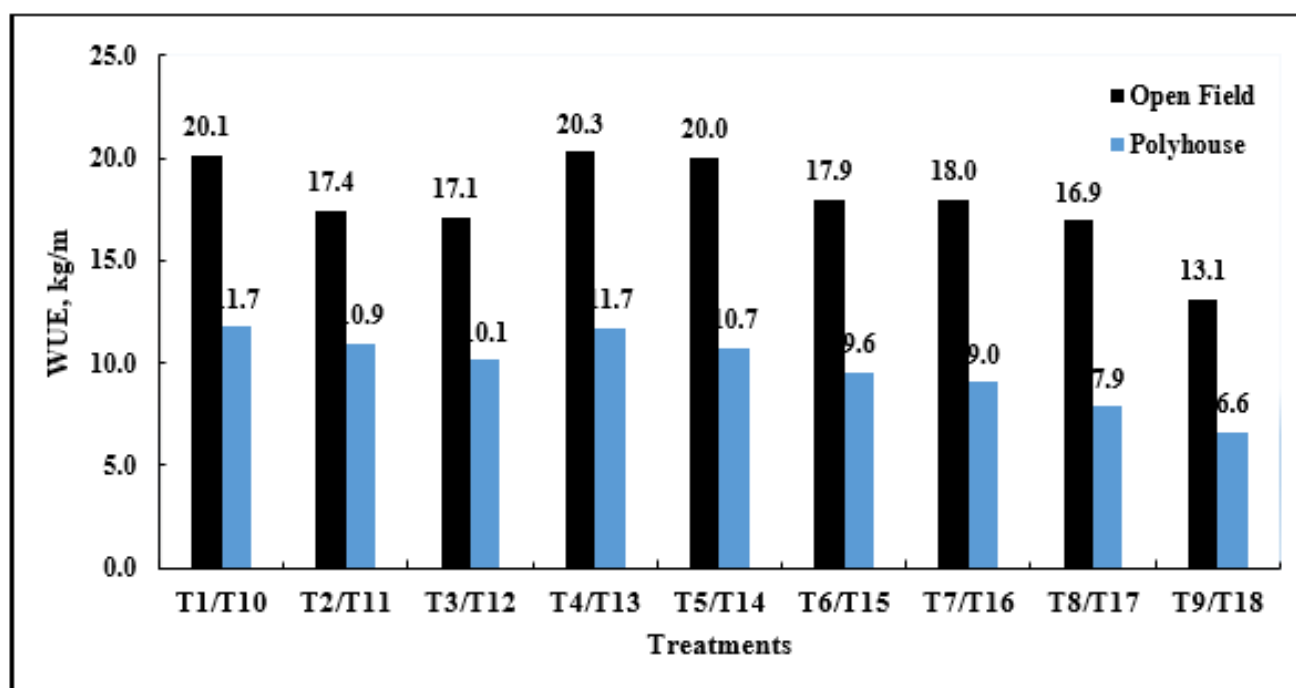


Fig. 4 Water use efficiency (WUE) of red cabbage as affected by treatments

field x 0.60 ETc x 75 % RDF) (Fig. 3) (Table 4). The maximum equatorial diameter (243.33 mm) was observed under $T_1 = E_1 I_1 F_1$ (Polyhouse x 0.90 ETc x 125 % RDF), which was significantly superior over other treatments and the minimum (76.68 mm) was noticed under $T_{18} = E_2 I_3 F_3$ (Open field x 0.60 ETc x 75 % RDF) treatment (Table 4). The maximum polar diameter (332.18 mm) was observed under $T_1 = E_1 I_1 F_1$ (Polyhouse x 0.90 ETc x 125 % RDF), which was significantly superior over other treatments while the minimum was (26.22 mm) under $T_{18} = E_2 I_3 F_3$ (Open field x 0.60 ETc x 75 % RDF) (Table 4). The maximum depth of water (362.29 mm) was applied in treatment I_1 (0.90 ETc) in open field and minimum (237.64 mm) in treatment I_3 (0.60 ETc) in polyhouse (Table 6). The highest water use efficiency (20.28 kg/m) was found in treatment $T_4 = E_1 \times I_2 \times F_1$ (Polyhouse x 0.75 ETc x 125 % RDF) whereas the lowest water use efficiency (6.59 kg/m³) in treatment $T_{18} = E_2 I_3 F_3$ (Open field x 0.60 ETc x 75 % RDF) (Table 6). The water use efficiency of red cabbage due to different treatment is depicted in Fig.(4).

CONCLUSION

The study revealed that, there was

significant effect of environment, irrigation and fertigation on the yield and some growth factors, on the red cabbage. Cultivation of red cabbage under polyhouse with drip irrigation at 0.90 ETc and fertigation at 125 % RDF resulted in 59.50 % higher yield and 57.63 % higher water use efficiency was resulted under polyhouse with drip irrigation at 0.75 ETc and fertigation at 125 % RDF, over that of best treatment of open field cultivation. However, in case of open field condition with drip irrigation of 0.90 ETc and fertigation at 125 % RDF resulted in maximum yield and water use efficiency of red cabbage.

REFERENCES

- Bhosale S and Sonawan S S (2016). Automated monitoring and controlling of yhouse environment. *Int J Ad Res Com Engg and Tech (IJARCET)* **5**(8) :2333-2338
- Gopala Reddy A R, Santosh D T, and Tiwari K N (2017). Effect of Drip Irrigation and Fertigation on Growth, Development and Yield of Vegetables and Fruits. *Int J Curr Microbiol App Sci* **6**(2), 1471–1483. <https://doi.org/10.20546/ijcmas.2017.60>

Effect of Environment, Irrigation and Fertigation on Growth, Yield

- 2.165.
- Harel D, Fadida H, Slepoy A, Gantz S, and Shilo K (2014). The effect of mean daily temperature and relative humidity on pollen, fruit set and yield of tomato grown in commercial protected cultivation. *Agron* **4**:167-177.
- Kumar D S and Palanisamib K (2010). Impact of Drip Irrigation on Farming System: Evidence from Southern India. Department of Agricultural Economics, Tamil Nadu Agricultural University, Tamil Nadu. *Agric Econ Res Rev* **23**: 265-272.
- Ojha R K, Abhivyakti A, Kumari P, and Job M (2016). Effect of plastic mulches on soil temperature and tomato yield inside and outside the polyhouse. *Agric Sci Dig - A Res J l* **3 6 (4)** : 3 3 3 - 3 3 6 . <https://doi.org/10.18805/asd.v36i4.6479>
- Paksoy B (2006). Effect of irrigation methods on red cabbage (*Brassica oleracea* L. var. capitata Subvar. F. rubra) yield and some plant characteristics. *Pak J Biol Sci* **9**(13): 2531–2534.
- Santosh D T, Tiwari K N, and Singh V K (2017). Influence of different protected cultivation structures on water requirements of winter vegetables. *Int J of Agric Envir and Biotech*, **10**(01), 93-103. <https://doi.org/10.5958/2230-732X.2017.00004.3>
- Gopala Reddy A R, Santosh D T, and Tiwari K N (2017). Effect of Drip Irrigation and Fertigation on Growth, Development and Yield of Vegetables and Fruits. *Int J Curr Microbiol App Sci* **6**(2), 1471–1483. <https://doi.org/10.20546/ijcmas.2017.602.165>
- Harel D, Fadida H, Slepoy A, Gantz S, and Shilo K (2014). The effect of mean daily temperature and relative humidity on pollen, fruit set and yield of tomato grown in commercial protected cultivation. *Agron* **4**:167-177.
- Kumar D S and Palanisamib K (2010). Impact of Drip Irrigation on Farming System: Evidence from Southern India. Department of Agricultural Economics, Tamil Nadu Agricultural University, Tamil Nadu. *Agric Econ Res Rev* **23**: 265-272.
- Ojha R K, Abhivyakti A, Kumari P, and Job M (2016). Effect of plastic mulches on soil temperature and tomato yield inside and outside the polyhouse. *Agric Sci Dig - A Res J l* **3 6 (4)** : 3 3 3 - 3 3 6 . <https://doi.org/10.18805/asd.v36i4.6479>
- Paksoy B (2006). Effect of irrigation methods on red cabbage (*Brassica oleracea* L. var. capitata Subvar. F. rubra) yield and some plant characteristics. *Pak J Biol Sci* **9**(13): 2531–2534.
- Santosh D T, Tiwari K N, and Singh V K (2017). Influence of different protected cultivation structures on water requirements of winter vegetables. *Int J of Agric Envir and Biotech*, **10**(01), 93-103. <https://doi.org/10.5958/2230-732X.2017.00004.3>
- Umesha B, Vjyalaxmi and Reddy M (2016). Effect of Weather Parameters on Growth and Yield Parameters of Tomato under Natural Poly House. *Indian J Nat Sci* **1** (9):654-662.

Received on 21/10/2023 Accepted on 15/4/2024