The Pharma Innovation Journal 2022; 11(9): 2932-2938

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(9): 2932-2938

www.thepharmajournal.com
Received: 15-06-2022
Accepted: 23-07-2022

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Effect of irrigation and fertigation levels through pulse drip irrigation on water use efficiency of carrot (*Daucus carota* L.)

G Rawat, US Kadam, PM Ingle, HN Bhange, JS Dhekale and ST Patil

Abstract
Crop water use efficiency is an important factor for sustainable agriculture development, since it is necessary to get a higher production per unit of applied water. This study aimed to determine the effect of different pulse, irrigation and fertigation levels through drip irrigation on water use efficiency of carrot (*Daucus carota* L.), during the 2019-20 and 2020-2021 growing season in Dapoli, Konkan (MS). The irrigation water of 80, 100 and 120% of crop evapotranspiration (ETc) was applied through four pulses P_1, P_2, P_3 and P_4 with constant 30 minutes interval between each split. The water soluble fertilizer with rates 80, 100 and 120% of recommended dose of fertilizer (RDF) was applied through irrigation water. The study results revealed for average value of highest WUE with P_4 (1.19) pulse level, I_1 (1.19) irrigation level and F_3 (1.13) fertigation level. The maximum WUE on carrot was found in the interaction effect of P_4I_1 (1.32), P_4F_2 (1.23), F_2I_1 (1.22) and $P_4I_1F_1$ (1.37) expressed in, $t.ha^{-1}cm^{-1}$.

Keywords: Pulse, irrigation, fertigation, carrot and water use efficiency

Introduction
The demand of water resources is increasing due to world's growing population and social-economic development (Zapata y Segura, 1995) [22] which results scarcity of water through worldwide. The pressure on water resources is expected to further increase as the requirements for food production and industrial needs go up in parallel with the country's rapidly growing population (Webber *et al.*, 2006) [21]. Water resources are limited through worldwide and there is an urgent need to identify and adopt efficient irrigation management strategies because agricultural sector accounts over 85% of worldwide water usage for irrigation (Zegbe *et al.*, 2006) [23].

The pressurized irrigation systems such as sprinkler and drip can be used to decrease agricultural water demand by reducing water losses. Water savings can be achieved either by decreasing the frequency of irrigation events or by a systematic reduction of water for irrigation (Darwish *et al.*, 2006) [5]. Applying irrigation water in stages or pulses rather than all at one time can save water by giving the media time to moisten from the first pulse of water thereby allowing it to absorb subsequent irrigation more readily and reducing the total amount of water required. For example, instead of irrigating 4 different areas for 1 hour each (four hours total), studies have shown that by watering each area sequentially for 15 minute intervals and repeating this process twice, a 25% reduction in water usage (Scott, 2000) [17]. High irrigation frequency might provide desirable conditions for water movement in soil and for uptake by roots. (Segal *et al.*, 2000) [18]. the systems have undergone immense development in recent years and now allow the simple and accurate timing of irrigation events. The level of control includes the ability to "pulse" irrigation events to meet the needs of soils that have less than desirable infiltration rates, thus minimizing run off. (Thompson, 2001) [19]. Continuous water application is associated with increased water percolation under root zone. Intermittent irrigation strategy based on discharge pulses followed by breaks could improve water management in the field and increase irrigation efficiency (Oron, 1981) [14].

WUE can be maximized by applying deficit irrigation water, modern irrigation technology and irrigation scheduling as well as by improving agricultural practices that can result in the increase of crop yields even at deficit irrigation also. Drip irrigation is the response to pressure on limited fresh-water resources and plays an important role in the increase of WUE by controlling the water losses during irrigation. Nevertheless, there is still limited information on how to use it on conventional crops.

In experiments conducted by Rolbiecki *et al.* (2003) [16] with carrot cultivated on light soil, yield in dry years without irrigation was only 0.1 $t.ha^{-1}$, however with drip irrigation it was 37.1 $t.ha^{-1}$. Hassanli *et al.* (2010) [8] found that WUE was increased from 4.15 $kg.m^{-3}$ by furrow irrigation to 8.2 $kg.m^{-3}$ with drip irrigation in a sugar beet crop. The pulse irrigation is a recent technique which increases the crop yield up to certain level of deficit irrigation water applied through drip irrigation. Bakeer *et al.* (2009) [3] found that WUE was increased from 1.45 $kg.m^{-3}$ with continuous drip irrigation to 2.60 $kg.m^{-3}$ under four pulses and 75 % irrigation water requirement.

WUE has remained as a research topic of interest to plant, soil and irrigation specialists due to the fact that water shortage for agriculture has generated a strong need to design strategies aimed at improving WUE (Behboudian and Singh, 2001) [4]. In addition, it can be used as a tool of plant management to improve crop yield and product quality. Water use efficiency (WUE) is generally used to express the ratio of total production per hectare to total depth of water applied throughout the season for a particular crop. It is influenced by a variety of factors, such as crop type, atmospheric environment, cultivation practices and soil conditions (Liu *et al.*, 2002) [9]. It is also worthy mention here that 84.5 % of the consumptive water rights are used in agricultural land irrigation (Novoa, 2004) [13]. Therefore, it is necessary to increase WUE and decreasing the volume of applied water without compromising with crop yield, especially in limited available water regions.

Water requirements of carrot crop ranges from 6000 and 9000 $m^3.ha^{-1}$ with an average pan evaporation of 6 to 7 $mm.d^{-1}$, depending mainly on the crop period, which lasts between 100 and 140 days (Villeneuve and Leteinturier, 1992) [20]. A study carried out on a carrot crop showed higher root production, total dry matter and WUE with a water application level of 100 % Epan (Prabhakar *et al.*, 1991) [15]. Moreover, Gibberd *et al.* (2003) [7] studied water application in a carrot crop cultivated in sandy soils and determined that a higher marketable carrot yield is obtained with water application level of 151% Epan.

However, there is little information available in India regarding carrot irrigation management with high efficiency systems. Therefore, this study aimed at determining water requirements and WUE, by applying different irrigation and fertigation levels on a carrot crop under pulse drip irrigation was conducted in Konkan region of Maharashtra state.

Materials and Methods

Experimental site

The field experiment was conducted at Instructional Farm of Department of Irrigation and Drainage Engineering, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. The two *rabi* seasons trial of carrot were carried out, first research trial from 30th November 2019 to 2nd March 2020, while second research trial from 25th November 2020 to 26th February 2021. The experimental site is situated at 17^0 45' 13.1" N latitude and 73^0 10' 47.4" E longitudes and altitude of 250 m. Climatic conditions are humid with average annual rainfall at Dapoli region is 3635 mm (Mandale, 2016) [11]. The average minimum and maximum temperatures are 18.5 °C to 31.0 °C, respectively. The relative humidity ranges from 55 percent to 99 percent (Gaikwad, 2013) [6]. The soil type of experimental field was sandy clay loam textured and having pH-6.5, EC-0.45 $dS.m^{-1}$, bulk density-1.68 $g.cm^{-3}$, basic infiltration rate- 6.03 $cm.hr^{-1}$, field capacity-26.02 % and permanent wilting point-12.50%.

The experimental design was strip-split plot and replicated three times. The unit plot size was 22.0 m × 15.10 m having a single bed of 2 m × 0.80 m. Plant to plant and row to row spacing was 5 cm and 20 cm, respectively. The plots were fertilized with the recommended dose of water soluble fertilizer 100**:**75**:**25 $Kg.ha^{-1}$ N, P_2O_5 and K_2O, respectively. The irrigation water of 63.9 and 67.2 millimeter had applied after sowing for the establishment of seedlings during 2019-20 and 2020-21, respectively. The inline lateral of 16 mm diameter with 4 Lph discharge having 40 cm spacing at 1.0 $Kg.cm^{-2}$ operating pressure was used. The daily water applied for carrot (*Daucus carota* L.) under pulse drip irrigation was worked out based on Penman-Monteith method (Allen *et al.* 1998) [2]. The available discharge and emission uniformity of the drip system were recorded as 2.25 $L.h^{-1}$ and 95.26% for the year 2019-20 and 2.25 $L.h^{-1}$ and 94.50% for the year 2020-21, respectively. Water application in pulse treatments was imposed on 25th December 2019, in first-year trial and 20th December 2020 in second-year trial. Water application in pulse treatments was terminated on 27th February 2020, in first year trial and 23rd February 2021, in second year trial. The carrot was harvested on 2nd March 2020, in the first-year and 26th February 2021, in the 2nd year, respectively. The statistical analysis was done by "analysis of variance" appropriate for the 'strip-split plot design' with the statistical software SAS.

Results and Discussion

Applied water volume

A. Gross depth of water applied

It was contemplated from Table 1, that total reference evapotranspiration during the crop growth period in year 2019-20 and 2020-21 was 325.3 mm and 296.1 mm, respectively. The crop evapotranspiration (net depth) during the year 2019-20 and 2020-21 was varied from 317.9 mm to 284.1 mm. From Table 1 total water applied under irrigation treatment I_1 (0.8 ETC) varied from 275.5 mm to 249.4 mm in the year 2014-15 and 2015-16, while it was ranged from 326.8 mm to 393.3 mm and 378.1 mm to 337.2 mm for irrigation treatments I_2 (1.0 ETC) and I_3 (1.2 ETC), respectively.

Table 1: Month wise and seasonal gross depth of water applied in different irrigation levels for carrot

Season	Month → / Irrigation level ↓	November (*)	December (*)	December (**)	January	February (#)	Total
2019-2020	ET_0	3.6	69.3	20.7	125.4	106.3	325.3
	ET_c	2.5	58.9	21.2	132.9	102.3	317.9
	$I_1(0.8ET_c$	2.6	61.3	17.7	109.4	84.6	275.5
	$I_2(1.0ET_c)$	2.6	61.3	21.9	136.0	105.0	326.8
	$I_3(1.2ET_c)$	2.6	61.3	26.2	162.6	125.5	378.1
2020-2021	ET_0	20.7	56.1	36.2	96.6	87.2	296.8

	ET_c	15.3	49.4	37.5	97.6	84.3	284.1
	I_1 (0.8ET_c	15.9	51.3	31.2	81.2	69.8	249.4
	I_2(1.0ET_c)	15.9	51.3	38.8	100.7	86.6	293.3
	I_3(1.2ET_c)	15.9	51.3	46.3	120.2	103.5	337.2
*	General irrigation for establishment of crop from 30 November to 24 December 2020 (I^{st} trial) and 25 November to 19 December 2020 (II^{nd} trial)						
**	Water application in pulse treatments were imposed from 25 December 2020 (I^{st} trial) and 20 December 2020 (II^{nd} trial)						
#	Water application in pulse treatments were terminated 27 February 2020 (I^{st} trial) and 23 February 2021 (II^{nd} trial)						

B. Effect of different input variables on WUE carrot

I. Effect of pulse on WUE of carrot

The effect of pulse levels on water use efficiency of carrot during the year 2019-2020, 2020-2021 and pooled data of both the years are reported in Table 2 and as represented in Fig. 1.

Table 2: Effect of pulse irrigation on the water use efficiency ($t.ha^{-1}cm^{-1}$) of carrot

Pulse	2020	2021	Pooled
P_1	0.90	1.07	0.97
P_2	0.97	1.14	1.05
P_3	1.05	1.23	1.13
P_4	1.10	1.29	1.19
S.E.(m)±	0.00	0.01	0.00
C.D. at 5%	0.01	0.02	0.01

Table 3: Effect of irrigation levels on the water use efficiency ($t.ha^{-1}cm^{-1}$) of carrot

Irrigation Level	2020	2021	Pooled
I_1	1.11	1.29	1.19
I_2	1.03	1.22	1.12
I_3	0.88	1.04	0.95
S.E.(m)±	0.00	0.01	0.00
C.D. at 5%	0.01	0.02	0.01

The data reported in Table 2 shows that the water use efficiency found to increase significantly from P_1 to P_4. The highest water use efficiency 1.10, 1.29 and 1.19 $t.ha^{-1}cm^{-1}$ was found in pulse level P_4 during 2020, 2021 and pooled data which was significantly superior to other pulse level. The Table 2 further revealed that minimum water use efficiency i.e. 0.90, 1.07 and 0.97 $t.ha^{-1}cm^{-1}$ was found in P_1. It may be due to congenial condition found in crop root zone in four pulse irrigation. The result of present study have similar trend with findings of Bakeer *et al.* (2009) [3] in case of potato crop where maximum water use efficiency was found in P_4 pulse irrigation level.

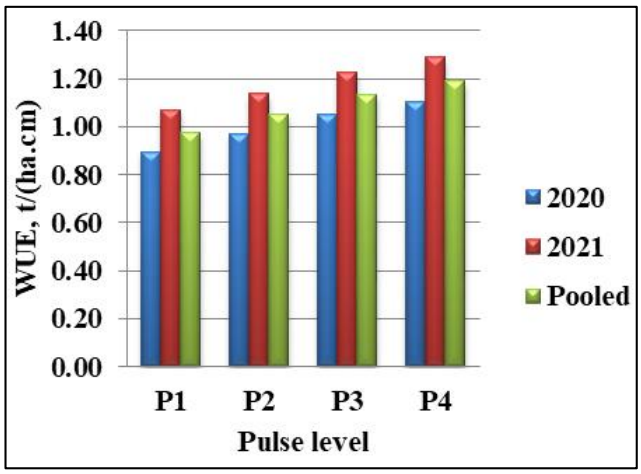

Fig 1: Effect of different pulse levels on WUE (t/(ha.cm)) of carrot

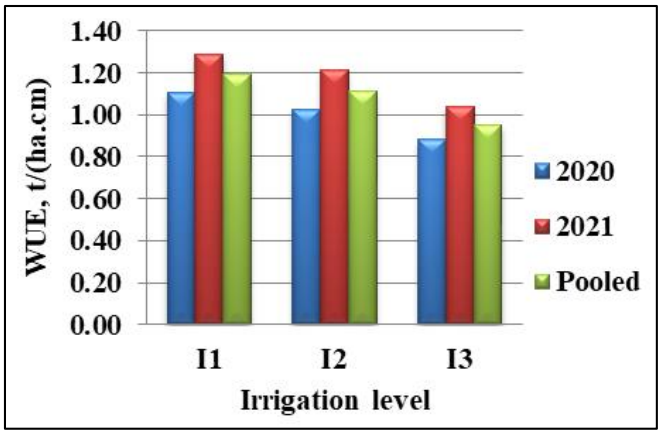

Fig 2: Effect of different irrigation levels on water use efficiency ($t.ha^{-1}cm^{-1}$) of carrot

II. Effect of irrigation levels on WUE of carrot

It is observed from the data reported in Table 3 that during the year 2020, 2021 and pooled data, the water use efficiency of carrot decreases from I_1 to I_3. The maximum and minimum water use efficiency of carrot during 2020, 2021 and pooled analysis was observed from Table 3 that 1.11, 1.29 and 1.19 $t.ha^{-1}cm^{-1}$ in I_1 and 0.88, 1.04 and 0.95 $t.ha^{-1}cm^{-1}$ in I_3 irrigation level. The results of present study on effect of different irrigation levels on WUE are as similar as with findings of Abdel-Mawly (2004) [1] in case of carrot crop where maximum water use efficiency was found in I_3 irrigation level which was 75 % ETc of applied water.

III. Effect of fertigation levels on WUE of carrot

The effect of fertigation levels on water use efficiency of carrot during the year 2020, 2021 and pooled data of both the years and presented in tabular and graphical form in Table 4 and Fig 3. It is reported in Table 4 that during the year 2020, 2021 and pooled data, the water use efficiency of carrot increases from F_1 to F_3 except during 2021 where WUE for F_2 and F_3 are equal. The maximum water use efficiency of carrot was observed to be 1.06, 1.21 and 1.13 $t.ha^{-1}cm^{-1}$ in F_3 fertigation level during 2020, 2021 and pooled analysis, further it is observed that water use efficiency of carrot for F_2 and F_3 are equal during the trial of 2021. It also observed that minimum water use efficiency of carrot i.e. 0.94, 1.12 and 1.02 $t.ha^{-1}cm^{-1}$ was found in F_1 fertigation level during 2020, 2021 and pooled analysis respectively.

Table 4: Effect of fertigation levels on the water use efficiency ($t.ha^{-1}cm^{-1}$) of carrot

Fertigation Levels	2020	2021	Pooled
F_1	0.94	1.12	1.02
F_2	1.02	1.21	1.11
F_3	1.06	1.21	1.13
S.E.(m)±	0.00	0.01	0.00
C.D. at 5%	0.01	0.03	0.01

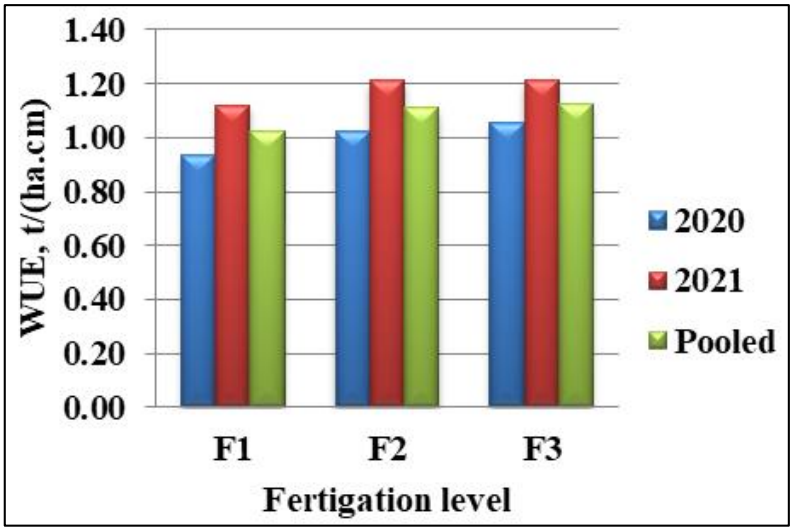

Fig 3: Effect of different fertigation levels on water use efficiency of carrot

The results of current study on effect of different fertigation levels on WUE are as related as with findings of Abdel-Mawly (2004) [1] in case of carrot crop where WUE was found to be increased on increasing level of nitrogen from 0 kg/fed to 120 g/fed.

IV. Interaction effect of pulse and irrigation levels on WUE of carrot

The interaction effect of pulse and irrigation levels on water use efficiency of carrot during the year 2020, 2021 and pooled data of both the years are reported in Table 5 and depicted graphically in Fig. 4.

Table 5: Effect of pulse and irrigation levels on the water use efficiency ($t.ha^{-1}cm^{-1}$) of carrot

Treatment combination	P_1I_1	P_1I_2	P_1I_3	P_2I_1	P_2I_2	P_2I_3	P_3I_1	P_3I_2	P_3I_3	P_4I_1	P_4I_2	P_4I_3	S.E.	C.D.
2020	0.95	0.92	0.81	1.07	0.99	0.84	1.15	1.08	0.93	1.25	1.11	0.96	0.01	0.02
2021	1.14	1.11	0.96	1.26	1.16	0.99	1.36	1.25	1.08	1.4	1.34	1.13	0.01	0.04
Pooled	1.04	1.01	0.88	1.16	1.08	0.92	1.25	1.16	0.99	1.32	1.21	1.03	0.01	0.02

The interaction effect of pulse and irrigation levels on water use efficiency of carrot during the year 2020, 2021 and pooled data of both the years were found significant. The table revealed that values of water use efficiency of carrot during 2020, 2021 and pooled data was found highest in P_4I_1 which are 1.25, 1.40 and 1.32 $t.ha^{-1}cm^{-1}$ respectively and superior to all other treatment combinations. The data reported in Table 5 also revealed that minimum water use efficiency of carrot i.e. 0.81, 0.96 and 0.88 $t.ha^{-1}cm^{-1}$ was found in treatment combination P_1I_3.

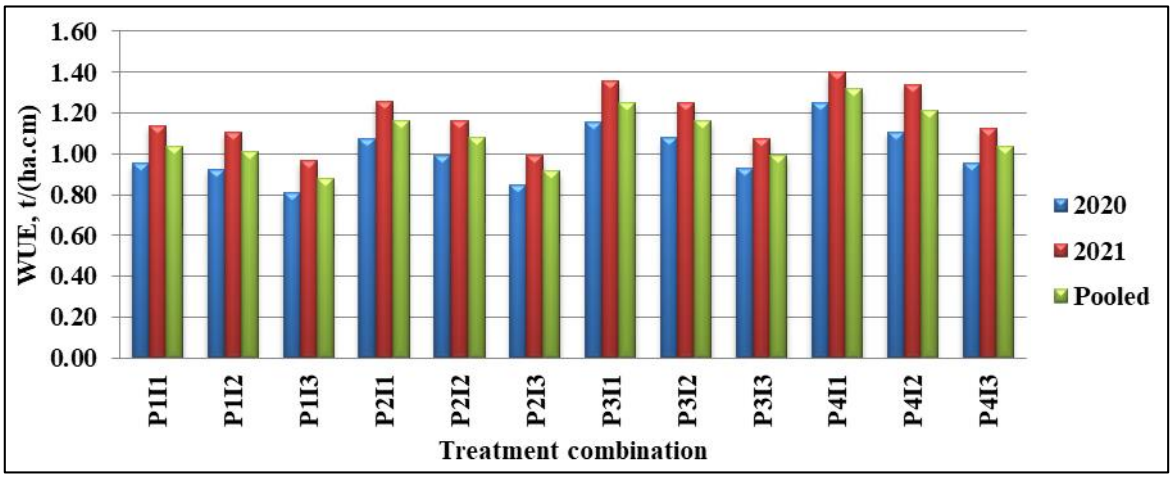

Fig 4: Effect of different pulse and irrigation levels on WUE ($t.ha^{-1}cm^{-1}$) of carrot

The interaction effect of pulse irrigation and irrigation levels on WUE have as similar as results to the scientists Madane *et al.* (2018) [10] in case of white onion crop where water use efficiency was increased by increasing number of irrigation pulses from P_1 (one time) to P_4 (four time) and decreasing irrigation level from 120% to 80 % ETc of total applied water. They found maximum WUE from combined levels of pulse irrigation (P_4) and irrigation level (I_1) i.e. P_4I_1.

V. Interaction effect of pulse and fertigation levels on WUE of carrot

The interaction effect of pulse and fertigation levels on water use efficiency of carrot during the year 2020, 2021 and pooled data of both the years are reported in Table 6 and depicted graphically in Fig. 5.

Table 6: Effect of pulse and fertigation levels on the water use efficiency (t.ha^{-1}cm^{-1}) of carrot

Treatment combination	P_1F_1	P_1F_2	P_1F_3	P_2F_1	P_2F_2	P_2F_3	P_3F_1	P_3F_2	P_3F_3	P_4F_1	P_4F_2	P_4F_3	S.E.	C.D.
2020	0.8	0.9	0.98	0.89	0.98	1.04	1	1.08	1.08	1.06	1.14	1.12	0.01	0.02
2021	0.98	1.09	1.14	1.07	1.18	1.17	1.18	1.25	1.25	1.24	1.33	1.29	0.01	0.04
Pooled	0.88	0.99	1.05	0.98	1.08	1.11	1.09	1.16	1.16	1.14	1.23	1.19	0.01	0.02

The data from table revealed that water use efficiency found significantly affected with pulse and fertigation treatment. The highest values of water use efficiency during 2020, 2021 and pooled data was found in P_4F_2 which are 1.14, 1.33 and 1.23 t.ha^{-1}cm^{-1} respectively, which is superior to other treatment combinations. The data reported in Table 6 also revealed that minimum water use efficiency of carrot i.e. 0.80, 0.98 and 0.88 t.ha^{-1}cm^{-1} was found in treatment combination P_1F_1.

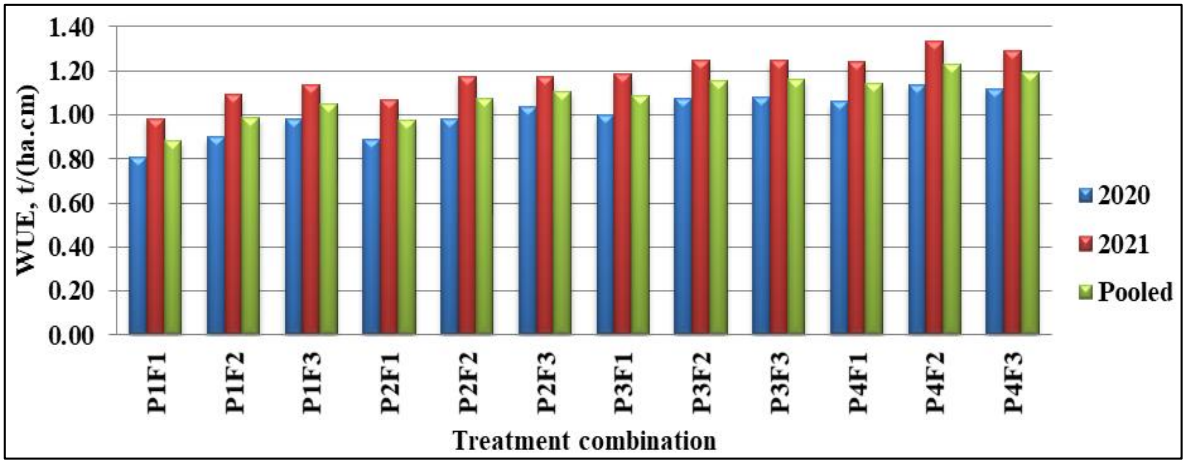

Fig 5: Interaction effect of pulse and fertigation levels on WUE (t.ha^{-1}cm^{-1})

VI. Interaction effect of fertigation and irrigation levels on WUE of carrot

The interaction effect of irrigation and fertigation levels on water use efficiency of carrot during the year 2020, 2021 and pooled data of both the years are reported in Table 7 and depicted graphically in Fig. 6.

Table 7: Effect of irrigation and fertigation levels on the water use efficiency (t.ha^{-1}cm^{-1}) of carrot

Treatment combination	F_1I_1	F_2I_1	F_3I_1	F_1I_2	F_2I_2	F_3I_2	F_1I_3	F_2I_3	F_3I_3	S.E.(m)	C.D. 5%
2020	1.05	1.13	1.15	0.92	1.05	1.1	0.84	0.88	0.92	0.01	0.01
2021	1.26	1.33	1.27	1.12	1.25	1.27	0.97	1.06	1.09	0.01	0.03
Pooled	1.15	1.22	1.2	1.02	1.15	1.18	0.9	0.97	1	0.01	0.02

The interaction effect of irrigation and fertigation levels on water use efficiency of carrot during the year 2020, 2021 and pooled data of both the years were found significant. It is observed from the Table 7 that maximum water use efficiency i.e. 1.13, 1.33 and 1.22 t.ha^{-1}cm^{-1} was found during 2020, 2021 and pooled data in F_2I_1 which is superior to other treatment combinations except during 2020 where F_3I_1 is highest. The table further revealed that minimum values of water use efficiency were found in treatment combination F_1I_3 (0.84, 0.97 and 0.90 t.ha^{-1}cm^{-1}).

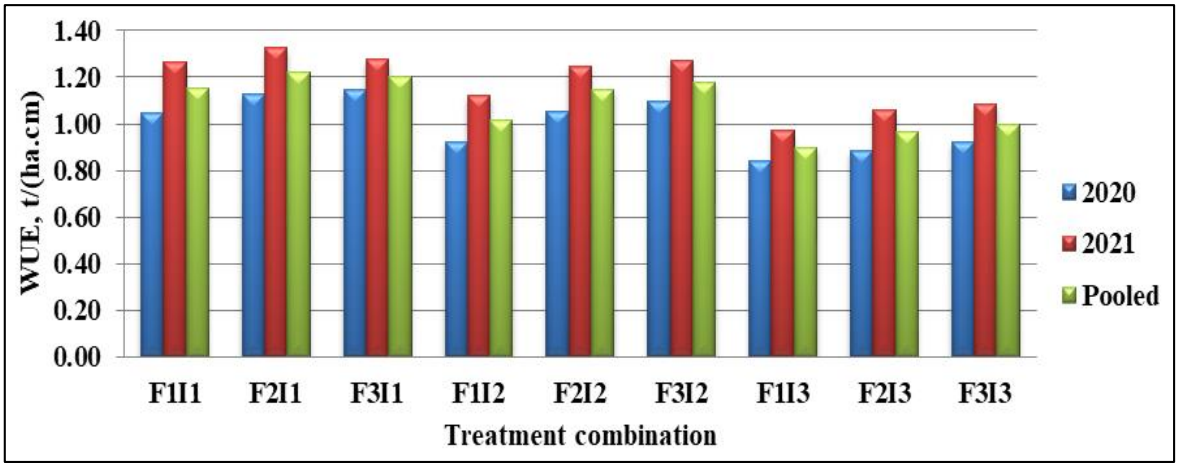

Fig 6: Interaction effect of irrigation and fertigation levels on water use efficiency (t.ha^{-1}cm^{-1})

The result of interaction effect of irrigation and fertigation levels on carrot is related to findings of Mankotia and Sharma (2020) [12] in case of potato crop where water use efficiency was found maximum at optimum level of fertigation and lowest level of irrigation water. It is observed from present study result that maximum WUE obtained from treatment combination 'F_2I_1'which is optimum level of fertigation and lowest level of irrigation.

VII. Interaction effect of pulse, irrigation and fertigation levels on WUE of carrot

The interaction effect of pulse, irrigation and fertigation levels on water use efficiency of carrot during the year 2020, 2021 and pooled data of both the years are reported in Table 8 and depicted graphically in Fig. 7. It is found from Table 8 that water use efficiency influenced with pulse, irrigation and fertigation levels. Further, it is reported in Table 8 that maximum water use efficiency was observed in treatment combination of $P_4I_1F_1$ which is at par with $P_4I_1F_2$ and significantly superior to all other treatment combinations except $P_4I_1F_2$. It is clearly indicated that maximum pulses i.e. P_4 with minimum irrigation and fertigation level i.e. I_1 and F_1 creates the conditions for pleasant crop growth which ultimately results in achieving significant yields and water use efficiency. The maximum and minimum water use efficiency for 2020, 2021 and pooled data of both the years was observed 1.27, 1.47 and 1.37 t.ha^{-1}cm^{-1} in treatment combination $P_4I_1F_1$ and 0.78, 0.90 and 0.83 t.ha^{-1}cm^{-1} in $P_1I_3F_1$ respectively.

Table 8: Interaction effect of pulse, irrigation and fertigation levels on the water use efficiency (t.ha^{-1}cm^{-1}) of carrot

Treatment combination	2020	2021	Pooled
$P_1I_1F_1$	0.78	0.99	0.88
$P_1I_1F_2$	0.97	1.18	1.07
$P_1I_1F_3$	1.11	1.24	1.17
$P_1I_2F_1$	0.86	1.06	0.95
$P_1I_2F_2$	0.92	1.10	1.01
$P_1I_2F_3$	0.99	1.16	1.07
$P_1I_3F_1$	0.78	0.90	0.83
$P_1I_3F_2$	0.81	0.99	0.89
$P_1I_3F_3$	0.85	1.01	0.92
$P_2I_1F_1$	0.97	1.17	1.06
$P_2I_1F_2$	1.13	1.34	1.23
$P_2I_1F_3$	1.13	1.27	1.20
$P_2I_2F_1$	0.90	1.10	1.00
$P_2I_2F_2$	0.98	1.19	1.08
$P_2I_2F_3$	1.10	1.20	1.15
$P_2I_3F_1$	0.81	0.92	0.87
$P_2I_3F_2$	0.83	1.00	0.91
$P_2I_3F_3$	0.89	1.04	0.97
$P_3I_1F_1$	1.18	1.42	1.30
Treatment combination	**2020**	**2021**	**Pooled**
$P_3I_1F_2$	1.15	1.37	1.25
$P_3I_1F_3$	1.13	1.28	1.20
$P_3I_2F_1$	0.95	1.14	1.04
$P_3I_2F_2$	1.13	1.27	1.20
$P_3I_2F_3$	1.15	1.34	1.24
$P_3I_3F_1$	0.87	0.99	0.92
$P_3I_3F_2$	0.94	1.11	1.02
$P_3I_3F_3$	0.97	1.13	1.04
$P_4I_1F_1$	1.27	1.47	1.37
$P_4I_1F_2$	1.27	1.42	1.34
$P_4I_1F_3$	1.21	1.31	1.25
$P_4I_2F_1$	0.99	1.19	1.08
$P_4I_2F_2$	1.18	1.43	1.30
$P_4I_2F_3$	1.16	1.40	1.27
$P_4I_3F_1$	0.92	1.07	0.99
$P_4I_3F_2$	0.96	1.15	1.05
$P_4I_3F_3$	0.98	1.17	1.07
S.E.(m)±	0.01	0.02	0.01
C.D. at 5%	0.03	0.06	0.03

The pioneer research work on interaction effect of different pulse, irrigation and fertigation levels on water use efficiency of carrot has some similarities with findings of the scientists Madane *et al.* (2018) [10] and Mankotia and Sharma (2020) [12]. Madane *et al.* (2018) [10] found for white onion crop that water use efficiency was increased by increasing number of irrigation pulses from P_1 (one time) to P_4 (four time) and decreasing irrigation level from 120% to 80 % ETc of total applied water. Whereas, the result of Mankotia and Sharma (2020) [12] revealed that water use efficiency was found maximum at optimum level of fertigation and lowest level of irrigation water. The result obtained from present study providing maximum WUE from treatment combination of '$P_4I_1F_1$'which is highest level of pulse irrigation and lowest level of fertigation and irrigation.

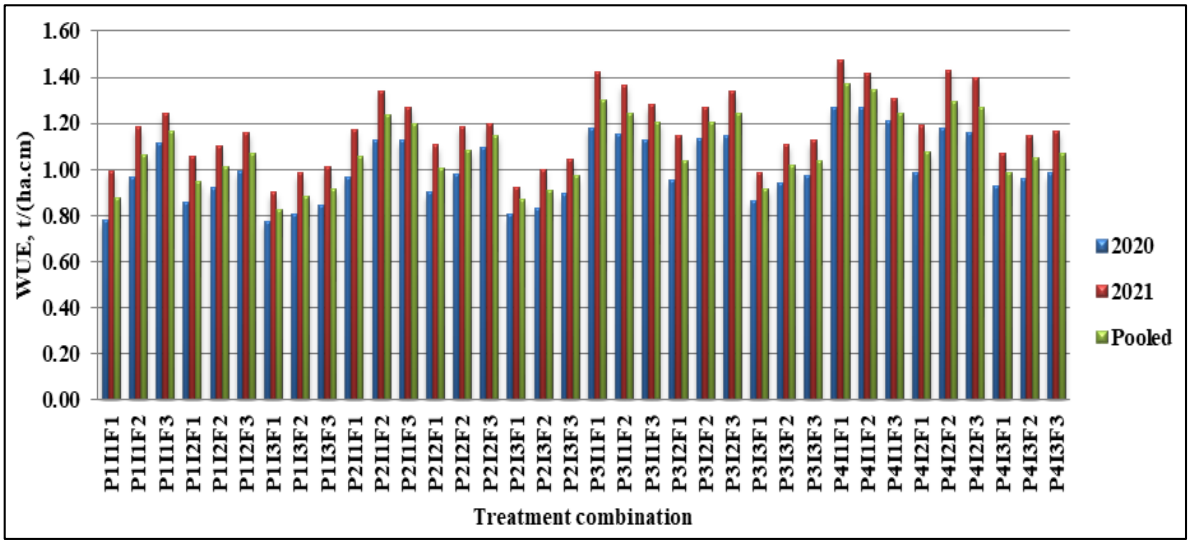

Fig 7: Interaction effect of pulse, irrigation and fertigation levels on the water use efficiency (t.ha^{-1}cm^{-1})

Conclusion

The water use efficiency is a pivot point about which it is to be fixed the input resources for a particular crop to obtain the yield as output. In present study input resources was water and fertilizer quantity along with recent technology pulse irrigation. The result concluded from present study that the 80 % deficiency in crop water requirement and recommended dose of fertilizer can be adopted for achieve maximum water use efficiency at four number of pulses in agro-climatic region of Konkan area of Maharashtra.

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