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Performance of Water Melon under Mulching, Subsurface and Surface Drip Irrigation Systems in Semi-Arid Region

Mallikarjun Reddy[1], M. S. Ayyanagowdar[2], M. G. Patil[3], B. S. Polisgowdar[2],
M. Nemichandrappa[2] and J. R. Patil[4]
[1]Assistant Professor AC kalaburgi, UAS Raichur
[2]Professor, SWE department UAS, Raichur
[3]Dean (PGS) UAS, Raichur
[4]Dean (Agri.) AC kalaburgi
*Corresponding Author E-mail: mallureddycae2026@gmail.com

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ABSTRACT

The field experiment was conducted during 2014 and 2015 to assess the yield and yield traits of watermelon to evaluate effects of three main irrigation systems (like surface drip irrigation with mulching, surface drip irrigation without mulching and subsurface drip irrigation)and three sub treatments (80, 100 and 120% ET) using drip irrigation the yield varied from season to season. For summer season, watermelon yield varied from 71.18 t/ha (80% ET) of surface drip irrigation with mulching (T_1I_1) to 45.91 t/ha (120% ET) of subsurface drip irrigation (T_3I_3) and same trend was followed in the winter season. The maximum average fruit weight was found in 80% ET (4.20 kg) of surface drip irrigation with mulching (T_1I_1) and the lowest average fruit weight was found in 120% ET (3.45 kg) with subsurface drip irrigation (T_3I_3) and same trend was followed in second season. In both seasons, highest yield was recorded in the 80% ET of surface drip irrigation with mulching than the other treatments.

Key words: *Evapotranspiration, Drip irrigation, moisture, Subsurface, Crop water use*

INTRODUCTION

Water plays an important role in crop production. Irrigation water is often limited and therefore the techniques which help to conserve water in the field are needed. Mulching is a recommended practice of moisture conservation in arid and semiarid regions. Over the past decade, the use of plastic mulch in agriculture has emerged as a practice closely related to agricultural development in many developed countries. The agricultural and horticultural developments in U. S. A., Western Europe, Israel and Japan have been made possible through extensive utilization of plastic mulching. The cultivation of high values crops using methods like drip irrigation, green house plastic much *etc* can give large income to small farmers.

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Even with the rapid growth in production and use of plastics in India, the per capita consumption of plastics is only 2.2 kg which is very low as compared to consumption in developed countries like U. S. A., Germany and Japan where per capita consumption is above 60 kg. World average of per capita consumption of plastic is 16.2 kg. Sweet corn, tomatoes, cucumber, straw berry, lettuce, watermelon, okra, and grapes are the primary crops that are grown under plastic mulch. The notable advantage of use of plastic mulch is its impermeability, which prevents direct evaporation of moisture from the soil and thus cuts down water losses. Plastics like HDPE, LDPE, and LLDPE have been used as plastic mulch. Among these types of plastics, LDPE mulches are most commonly used. Recently LLDPE has been scoring over LDPE as a mulch material due to its two associated characteristics of better down gauging and puncture resistance, while checks weeds growth through it. American Society of Agricultural Engineering (www.asabe.org)has defined subsurface drip irrigation as, “application of water below the soil surface through emitters, with discharge rates typically in the same range”. At the beginning, “sub irrigation” and “Subsurface irrigation” sometimes were referred for both SDI, and sub irrigation (water table management). “Drip / trickle irrigation” could include either surface or subsurface drip / trickle irrigation or both. SDI may also be defined as placement of drip pipe or hose along with drip lateral under specified depth so that normal mechanical operations could be carried out to ensure its use for several years[3,4]. Subsurface drip irrigation has been successfully mostly used for the last 15-20 years efficiently. In this system mainline, sub-mainline, laterals and drip pipes are installed below the soil surface at specified depth (*i.e.* less than 12 cm deep).This chapter discusses effects of mulching, surface drip irrigation and subsurface irrigation on performance of water melon in the semi-arid region.

MATERIALS AND METHODS

During February 2014 to May 2014 and November 2014 to February 2015, the experiment was conducted at Main Agricultural Research Station, University of Agricultural Sciences (UAS), Raichur-India. The site was located at 16˚15' N latitude, 77˚20' E longitude and at an elevation of 389 m above mean sea level (MSL).The soil was clay loam in texture and had pH of 7.33. There were three irrigation sub-treatments (80, 100 and 120%of ET in drip irrigation) and three main irrigation treatments (Surface drip irrigation with mulching, Surface drip irrigation without mulching, and subsurface drip irrigation), in a split plot design with four replications. Seedlings of watermelon (var. Suger Queen)were transplanted at spacing of 2 m x 1 m The seedlings were transplanted in 36 beds of 10 m x 1 m (12 beds were drip with mulching, 12 beds were drip without mulching, and 12 beds were subsurface drip irrigation). One lateral of 16 mm diameter was used for each bed with an inline dripper at 90 cm distance and discharge of 4 lph. Irrigation was provided daily after calculating water requirement based on past 24 hours of pan evaporation.

RESULTS AND DISCUSSION

Watermelon yield

Table 1 presents watermelon yield (tons per hectare) for mulch, without mulch and subsurface treatment of different irrigation levels during summer and winter seasons. During summer season (first season), the main plot with mulch gave maximum yield (65.75 tons) followed by subsurface (49.36 tons). The treatment without mulch recorded minimum yield (48.92 tons). Among the different irrigation levels, the plants receiving water at 80% ET gavemaximum yield (57.50 tons) followed by 100% ET (55.38 tons). The lowest yield was noticed in 120% ET treatment (51.14 tons).

Table 1: Effects of different treatments on yield (t ha^{-1})of watermelon

Treatment	**During February 2014 to May 2014 (Summer)**				**During November 2014 to February 2015 (Winter)**			
	I_1	**I_2**	**I_3**	**Mean**	**I_1**	**I_2**	**I_3**	**Mean**
T_1	71.18	65.28	60.78	65.75	70.72	64.50	59.71	64.97
T_2	48.28	51.73	46.74	48.92	47.76	50.64	45.70	48.03
T_3	53.03	49.13	45.91	49.36	52.03	48.76	45.02	48.60
Mean	57.50	55.38	51.14		56.83	54.63	50.14	

	SEM ±	**CD at 5%**	**SEM ±**	**CD at 5%**
Main treatment	2.250	7.787	1.974	6.831
Sub treatment	0.535	1.591	0.667	1.982
I at same T	0.927	2.755	1.156	3.434
T at the same or different I	2.492	7.404	2.383	7.080

Main treatments: **Sub treatments:**

T_1: Mulch condition I_1: Irrigation at 80% ET using drip irrigation

T_2: Without Mulch condition I_2: Irrigation at 100% ET using drip irrigation

T_3: Subsurface drip irrigation I_3: Irrigation at 120% ET using drip irrigation

The interaction effects were significant. The treatment mulch with 80% ET recorded significantly maximum yield (71.18 tons) followed by 100% ET with mulch (65.28 tons). The significantly minimum yield was noticed in subsurface treatment of 120% ET (45.91 tons). Similar trends were followed in winter season (second season) as shown in Table 1. The main plot with mulch recorded the maximum yield (64.97 t) followed by subsurface treatment (48.60 t). The treatment without mulch recorded the minimum yield (48.03 t). Among the different irrigation levels, the plants receiving water at 80% ET recorded maximum yield (56.83 t) followed by 100% ET (54.63 t). The lowest yield was noticed in 120% ET treatment (50.14 t). The interaction effects were significant. The treatment mulch with 80% ET recorded the maximum yield (70.72 t) followed by 100% ET with mulch (64.50 t) which indicated significant differences with mulch and 120% ET (59.71 t). The minimum yield was noticed in subsurface treatment of 120% ET (45.02 t). Combination of mulch with drip irrigation in different irrigation levels recorded the maximum yield than the subsurface and without mulch with drip irrigation plots. The Table 1 shows that plastic mulch with 80% of irrigation noticed the maximum yield (71.18 t ha^{-1} in summer season) and70.72 t ha^{-1} in winter season). This was due to higher transpiration rate from the broader leaves even though plastic mulch reduces the evaporation from the soil. The present results obtained are in line with the findings of Tiwari *et al.*[7] and Vijay Kumar *et al*[8].

Average fruit weight

Data pertaining to average fruit weight of both seasons is presented in Table 2. In first season it can be observed that the main plot treatment with mulch has recorded the highest average fruit weight (3.99 kg) followed by subsurface treatment (3.54 kg) and without mulch plot (3.54 kg). In the different levels of irrigation, the plant receiving water at 80% ET showed the highest average fruit weight (3.81 kg), which was on par with 100% ET (3.73 kg). The minimum average fruit weight was found in 120% ET (3.58 kg). Among the interaction effected, the treatment with mulch and 80% ET has recorded the highest fruit weight (4.20 kg), which was on par with 100% ET with mulch treatment (3.95 kg). The lowest average fruit weight was recorded in 120% ET of subsurface treatment (3.45 kg). In second season, Table 2 shows that the main plot treatment with mulch has recorded the highest average fruit weight (3.97 kg) followed by subsurface treatment (3.43 kg) and without mulch plot (3.39 kg). In the different levels of irrigation, the plant receiving water at 80% ET showed the highest average fruit weight (3.69 kg) which was on par with 100% ET (3.63 kg). The minimum average fruit weight was found in 120% ET (3.48 kg). Among the interaction effects, the treatment mulch with 80% ET has recorded the highest fruit weight (4.15 kg), which was on par with 100% ET with mulch treatment (3.93 kg). The lowest average fruit weight was recorded in 120% ET of subsurface treatment (3.28 kg).

Table 2: Effects of different treatments on average fruit weight (kg)

Treatment	During February 2014 to May 2014 (Summer)				During November 2014 to February 2015 (Winter)			
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
T_1	4.20	3.95	3.83	3.99	4.15	3.93	3.83	3.97
T_2	3.53	3.63	3.48	3.54	3.35	3.53	3.30	3.39
T_3	3.70	3.60	3.45	3.58	3.58	3.45	3.28	3.43
Mean	3.81	3.73	3.58		3.69	3.63	3.47	

	SEM ±	CD at 5%	SEM ±	CD at 5%
Main treatment	0.15	0.53	0.14	0.49
Sub treatment	0.05	0.15	0.06	0.17
I at same T	0.09	0.25	0.10	0.29
T at the same or different I	0.18	0.54	0.18	0.54

Main treatments: **Sub treatments:**

T_1: Mulch condition I_1: Irrigation at 80% ET using drip irrigation

T_2: Without Mulch condition I_2: Irrigation at 100% ET using drip irrigation

T_3: Subsurface drip irrigation I_3: Irrigation at 120% ET using drip irrigation

Total soluble solids (TSS)

The effect of mulch, without mulch and subsurface drip irrigation with different irrigation levels on TSS of during seasons are presented Table 3. For first season, it can be seen that the treatment mulch showed the highest TSS value (14.40 brix) which was on par to subsurface (14.33 brix) and without mulch treatment (14.28 brix). In the sub plots, the irrigation at 120% ET recorded the maximum TSS (14.49 brix) and minimum TSS was found at 80% ET treatment (14.19 brix). Among the interaction effects, the treatment mulch with 120% ET recorded the highest TSS (14.58 brix), which was on par with combination of mulch with 100% ET (14.38 brix) and mulch with 80% ET (14.25 brix). The minimum TSS was found in 80% ET without mulch (14.13 brix). In second season, it can be seen that the treatment mulch showed the highest TSS value (14.35 brix), which was on par to subsurface (14.28 brix) and without mulch treatment (14.24 brix). In the sub plots, the irrigation at 120% ET recorded the maximum TSS (14.46 brix) and minimum TSS was found at 80% ET treatment (14.13 brix).Among the interaction effects, the treatment mulch with 120% ET recorded the highest TSS (14.53 brix), which was on par with combination of mulch with 100% ET (14.35 brix) and mulch with 80% ET (14.18 brix). The minimum TSS was found in 80% ET without mulch (14.08 brix) condition.

Table 3: Effects of different treatments on TSS (^{o}Brix)

Treatment	During February 2014 to May 2014 (Summer)				During November 2014 to February 2015 (Winter)			
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
	^{o}Brix							
T_1	14.25	14.38	14.58	14.40	14.18	14.35	14.53	14.35
T_2	14.13	14.28	14.43	14.28	14.08	14.25	14.40	14.24
T_3	14.20	14.30	14.48	14.33	14.13	14.28	14.45	14.28
Mean	14.19	14.32	14.49		14.13	14.29	14.46	---
		SEM ±	**CD at 5%**		**SEM ±**		**CD at 5%**	
Main treatment		0.410	1.418		0.365		1.263	
Sub treatment		0.066	0.196		0.051		0.153	
T at same M		0.114	0.339		0.089		0.265	
M at the same or different T		0.430	1.279		0.379		1.127	

Main treatments: **Sub treatments:**

T_1: Mulch condition I_1: Irrigation at 80% ET using drip irrigation

T_2: Without Mulch condition I_2: Irrigation at 100% ET using drip irrigation

T_3: Subsurface drip irrigation I_3: Irrigation at 120% ET using drip irrigation

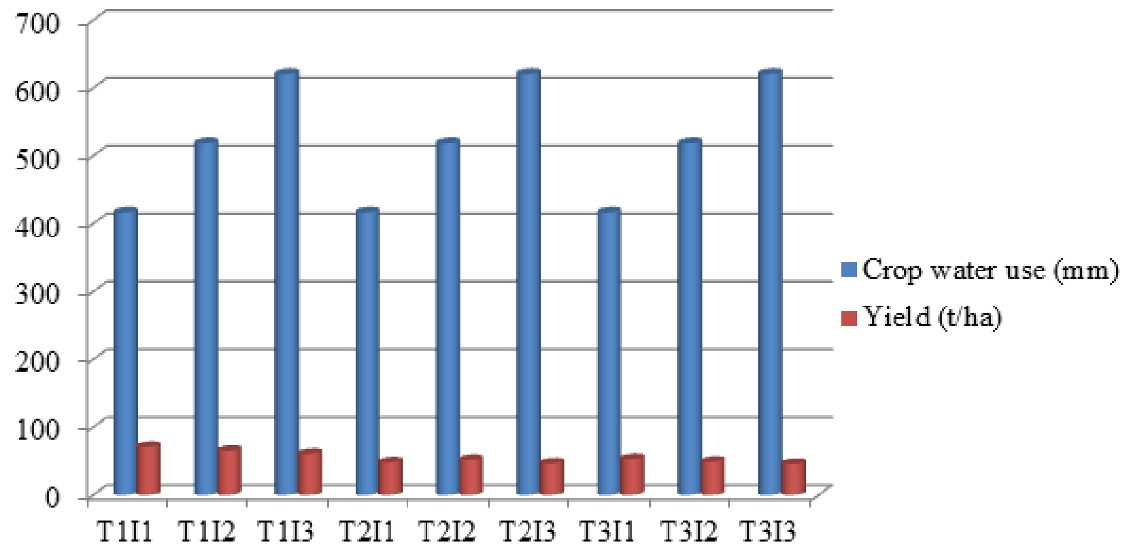


Fig. 1: Crop water production functions during summer (First season)

Crop water production functions (CWPF)

The crop water production functions for water melon were developed for different treatments such as mulch, without mulch and subsurface drip irrigation and different irrigation levels are 80, 100 and 120% ET. The maximum yield was recorded in mulch with all irrigation levels during both seasons. During first season, crop water use was 416.57 mm in 80%, 518.71 mm in 100% and 620.85 mm in 120% ET. In the second season, crop water use was 236.23 mm, 293.29 mm and 350.35 mm in 80%, 100% and 120% ET, respectively. The results are presented in Fig.1 and

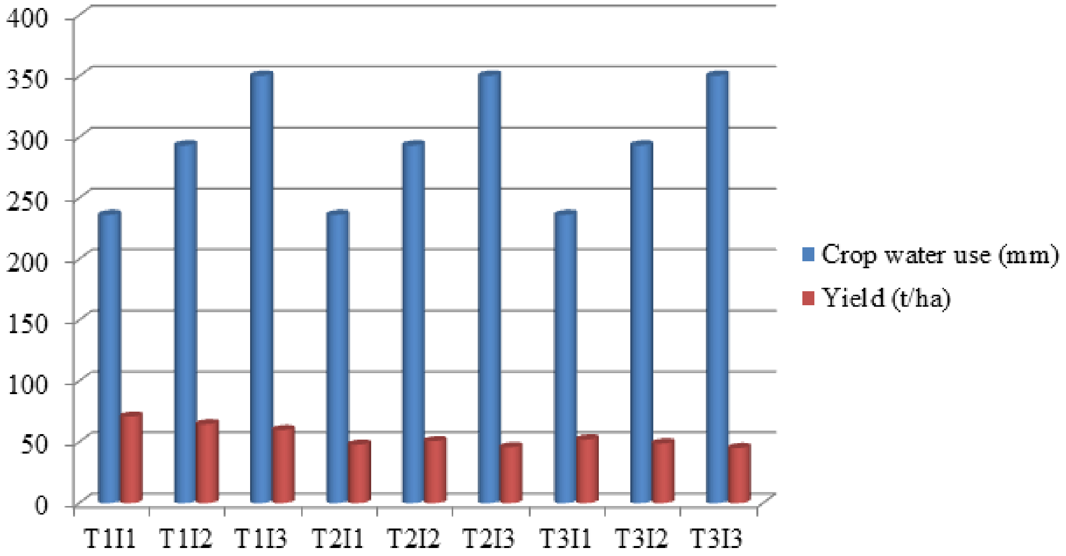
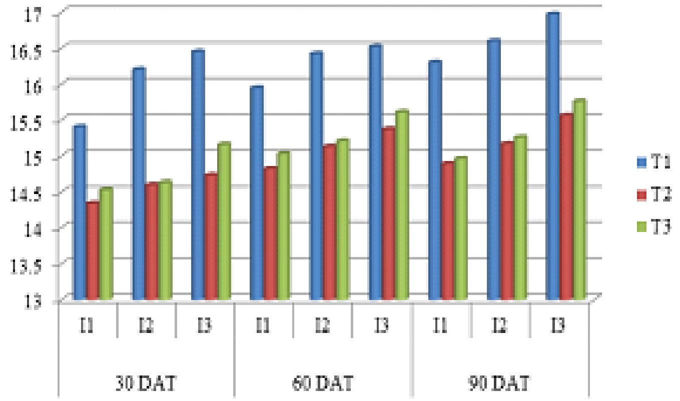


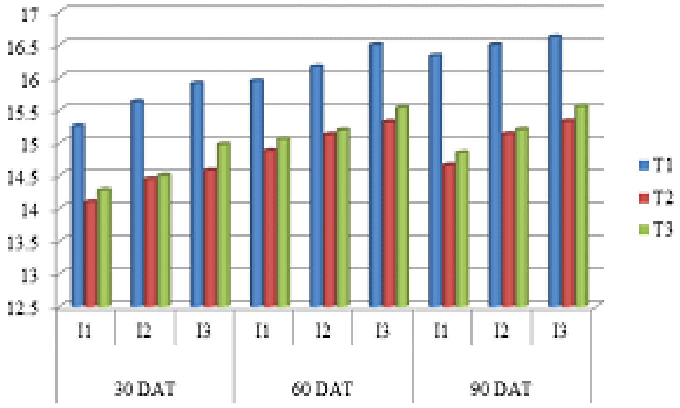
Fig. 2: Crop water production functions during winter (Second season)

Soil Water Dynamics

The evolution of soil moisture storage during the growing season for selected soil depths of both seasons are presented in Figs.3, 4 and 5. The results showed that there were greater variations in soil moisture storage in the surface soil layers compared with the deeper soil layers. The variation was more pronounced when depths (surface, 0.15 m and 0.30 m) were compared.



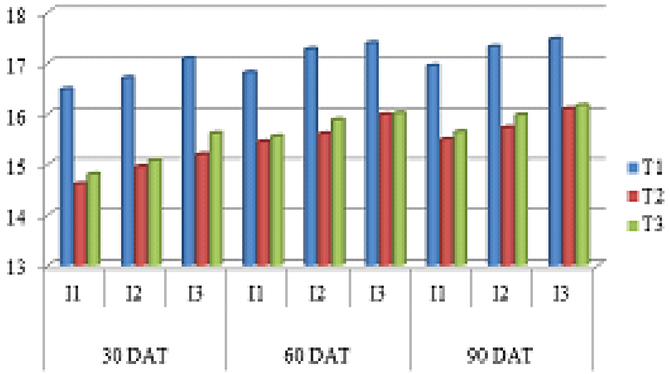
Soil moisture storage at surface level during summer: Y – axis, water depth in mm



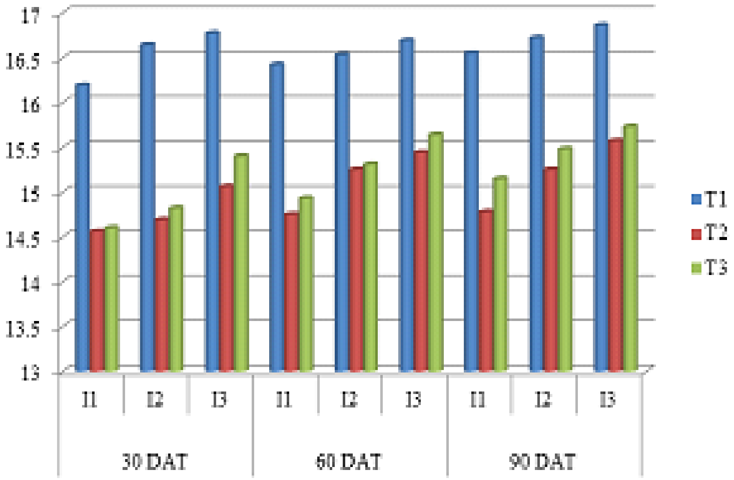
Soil moisture storage at surface level during winter: Y – axis, water depth in mm

Fig. 3: Soil moisture storage in selected surface level of soil layers for the 80, 100

and 120% ET of irrigation treatments (T_1, T_2, T_3),The pronounced variation in the surface layer of 0.15 m could be attributed to water uptake by plant roots, soil surface evaporation and drainage occurring in this zone. The intermittent wetting and drying of the soil profile caused high variation in the surface soil layers. Unlike in the surface soil layers, smaller variations were observed in the sub soil because the effective maximum rooting depth was 0.30 m. This explains the smaller variations in the deeper soil layers because only fewer roots could reach this depth to extract soil water. The interaction the combination of mulch, without mulch and subsurface with different levels of irrigation by 120 per cent of ET shows the maximum soil moisture at all the irrigation methods. This was due to moisture distribution under drip irrigation is three dimensional function covering vertical, lateral and diagonal movements whereas, it is a unidirectional movement under surface irrigation[2]. These results are in line with the findings of Raina *et al*[6].

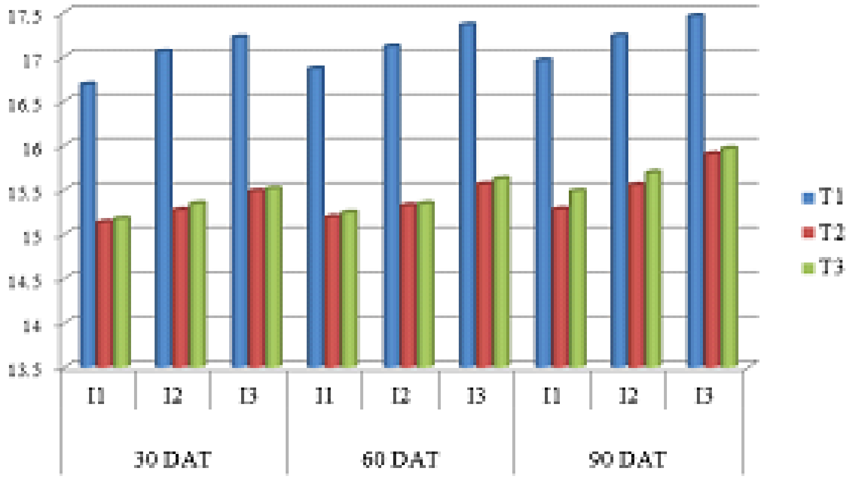


Soil moisture storage at 15 cm depth during summer, Y- axis, depth in mm

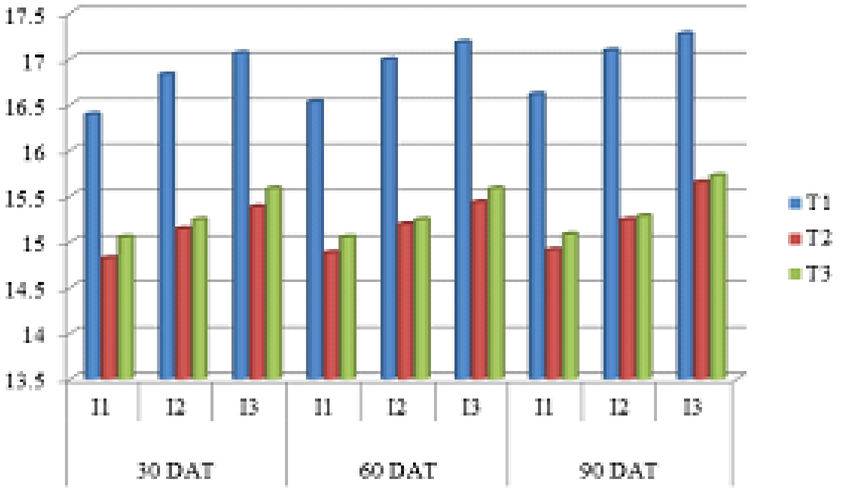


Soil moisture storage at 15 cm depth during winter, Y- axis, depth in mm

Fig. 4: Soil moisture storage in selected 15 cm depth of soil layers for the 80, 100 and 120% of ET of irrigation treatments (T_1, T_2, T_3)



Soil moisture at 30 cm depth during summer, Y- axis, depth in mm



Soil moisture at 30 cm during winter, Y- axis, depth in mm

Fig. 5: Soil moisture storage in selected 30 cm depth of soil layers for the 80, 100 and 120% ET of irrigation treatments (T_1, T_2, T_3)

LIST OF ABBREVIATIONS

CWPF: Crop water production functions
ET: Evapotranspiration
T: Treatment
%: Percentage
TSS: Total Soluble salts
HDPE: High-density polyethylene
LDPE: Low-density polyethylene
SDI: Surface drip irrigation
SSDI: Subsurface drip irrigation
LLDPE: Linear Low-density polyethylene

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