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Introducing a Suitable Strategy to Improve Wheat Properties and Water Productivity under Moisture Stress Conditions in a Sandy Loam Soil

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ABSTRACT

One way of developing sustainable agriculture is to increase crop Water Productivity (WP). In drought conditions, cultivation management should result in reducing water consumption as well as lowering the negative impacts on crop yield and quality. This experiment was conducted to determine the influence of irrigation levels (full and deficit irrigation, providing 100 and 75% of the irrigation water requirement, respectively) and soil water retaining materials (organic fertilizer, superabsorbent at depths of 30 and 40 cm, superabsorbent mixed with soil, band application of superabsorbent, plastic installation at depths of 30 and 40 cm and control) on WP, leaf Relative Water Content (RWC), Electrolyte Leakage (EL), photosynthetic pigments, yield and yield components of wheat during the growing seasons of 2017 and 2018. The deficit irrigation caused an increase in WP and EL and decreased yield, yield components, RWC, and photosynthetic pigments, while the soil water retaining materials improved these properties. The average yields in the organic fertilizer treatment and installation of plastic at a depth of 40 cm were 9.55 and 8.76 tons ha^{-1}, respectively. The highest WP (1.89 kg m^{-3}) was observed in the organic fertilizer treatment. Application of cow manure and installation of plastic membrane did not have significant effect on wheat properties in the two water conditions. Overall, utilizing organic fertilizer and nylon membranes under deficit irrigation, improved wheat characteristics and WP. However, to reach a comprehensive conclusion, it is necessary to evaluate these treatments for several consecutive years with different soil and water conditions.

Keywords: Deficit irrigation, Drought conditions, Water retaining material.

INTRODUCTION

The world growing population, especially in developing countries, overloads pressure on the environment and, consequently, affects food security. In order to promote sustainable agriculture and maintain agricultural potential in those regions, optimal management of water and soil resources is necessary. Therefore, in addition to preventing water loss and excessive consumption, proper water management should also improve the quantitative and qualitative yield of the crops. Water scarcity often limits crop growth and production potential in agricultural lands because agricultural products are sensitive to water stress at different growth stages. Deficit irrigation is one of the effective solutions for optimizing water consumption under drought conditions that conserve water resources. This strategy applies to most crops and environmental conditions, especially in cases

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where water resources are limited. However, it should be noted that deficit irrigation negatively affects the physiological and morphological characteristics of the plants (Sattar *et al*., 2022; Parkash *et al*., 2021) and reduces crop yield. The proper sustainable management method to maximize agricultural production is to increase yield per unit of water consumption (Morison *et al*., 2008). Water productivity is an important concept in water management research (Amarasinghe and Smakhtin, 2014). One of the important factors causing water loss in agricultural lands and reducing water productivity is the light-textured cultivated soils. Because of high water infiltration rate in the light-textured soils, irrigation water and rainfall quickly penetrate the lower depths away from the root zone, and also soluble elements are quickly removed from the root zone by drainage water. Therefore, in this type of soil, cultivation management should be such that it can conserve water and nutrients in the root zone to minimize damage to crop yield in drought conditions, and thus increase water productivity.

Subsurface Water Retention Technology (SWRT) is a relatively new method developed by researchers at Michigan State University. In this method, impermeable membranes are placed below the plant root zone, which have the ability to control water and nutrients in the root growth environment (Guber *et al*., 2014). Water and nutrient retaining membranes turn marginal lands into profitable agricultural production through efficient use of water and soil resources, increasing soil water holding capacity, and uniform storage and distribution of water and nutrients in the root zone. This new technology increases water productivity and reduces nutrient leaching in farms located in humid, semi-arid and dry areas (Smucker and Basso, 2014). New machines are now being built to install the SWRT membrane (Figure 1). Use of superabsorbent is another way to maintain soil moisture. These materials are able to absorb water and aqueous solutions several times their weight (Chang *et al*., 2021). Application of organic fertilizer to the soil reduces bulk density, increases aggregate stability (Liu *et al*., 2021), improves soil structure, and increases water holding capacity (Mirzabaiki *et al*., 2020).

Figure 1. SWRT membrane installation equipment (Smucker and Basso, 2014).

The objectives of this study were to investigate the effect of soil water retaining material and irrigation regime on: 1) physiological characteristics of wheat and 2) yield, yield components, and water productivity for wheat production.

MATERIALS AND METHODS

Site Description and Experimental Design

This study was conducted during two growing seasons of 2017 and 2018, at the farm of South Kerman Agricultural and Natural Resources Research and Education Center (57° 51′ N, 28° 32′ E; 601 m) in southeast of Iran. The region has an average annual precipitation of 140 mm with maximum daily air temperature of 48 °C and minimum daily air temperature of 1°C. The daily rainfall and temperature during wheat growing season for both years of the study are shown in Figure 2. Some of the measured soil properties are presented in Table 1.

The experimental units were arranged as a strip plot in a randomized complete block design with three replicates. Each replicate consisted of 16 plots, arranged in an 8×2 array,

Table 1. Selected soil properties of the studied area.

Texture	P (ppm)	K (ppm)	Organic carbon (%)	EC (dS m^{-1})	pH
Sandy-Loam	2.8	200	0.18	0.78	8.4

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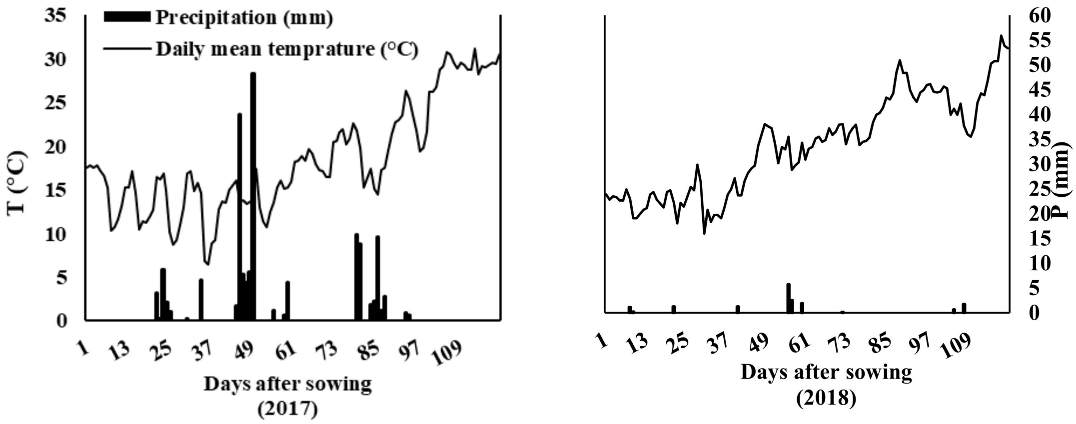

Figure. 2. Daily precipitation (mm) and mean temperature (°C) during the two growing seasons.

and eight levels of soil water retaining material and two levels of irrigation were assigned to the rows and columns, respectively. Each plot with an area of 4 m^2 (2 m wide and 2 m long) was planted with 0.20 m row spacing and a planting density of 400 seeds per m^2 (Semnaninejad *et al*., 2021; Moshatati *et al*., 2012).

Irrigation and Soil Water Retaining Material Treatments

Irrigation and Soil Water Retaining Material (SWRM) treatments are presented in Table 2. Irrigation was applied at two levels (full and deficit irrigation, providing 100 and 75% of the irrigation water requirement, respectively). Eight levels of SWRM included organic fertilizer, superabsorbent at depths of 30 and 40 cm, superabsorbent mixed with soil, band application of superabsorbent, and plastic installation at depths of 30 and 40 cm and control.

For the organic fertilizer treatment, 45 ton ha^{-1} of cow manure was incorporated into the soil ($SWRM_1$). To maintain the superabsorbent treatment, after digging out the soil to a depth of 30 or 40 cm, 200 kg ha^{-1} of superabsorbent was spread out and then the soil was placed back on it ($SWRM_2$ and $SWRM_3$). For other treatments, 200 kg ha^{-1} of superabsorbent was mixed with soil ($SWRM_4$). In the band application of superabsorbent, a band (2 cm wide), along the seed row, was considered at a depth of 5 cm below the wheat seed and four grams of superabsorbent was mixed with each kg of soil and then this mixture was placed in the

Table 2. Soil water retaining material treatments.

Treatment	Symbol	Explanation
Irrigation	I_{100}	100% of the plant's irrigation water requirement
	I_{75}	75% of the plant's irrigation water requirement
	$SWRM_1$	organic fertilizer
	$SWRM_2$	Superabsorbent at depth of 30 cm
	$SWRM_3$	Superabsorbent at depth of 40 cm
Soil water retaining material	$SWRM_4$	Superabsorbent mixed with soil
	$SWRM_5$	Band application of superabsorbent
	$SWRM_6$	Plastic installation at depth of 30 cm
	$SWRM_7$	Plastic installation at depth of 40 cm
	$SWRM_8$	Control, without soil water retaining material

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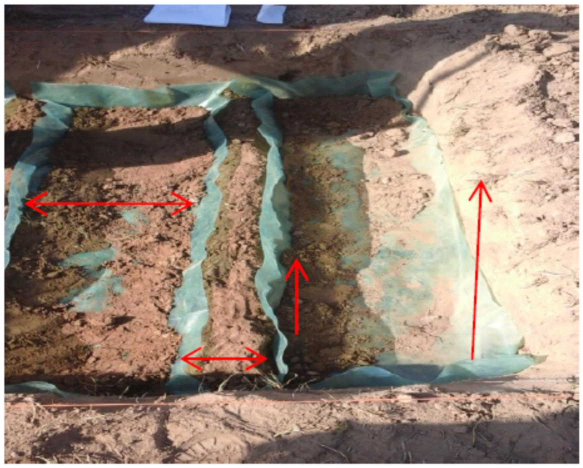

Figure 3. Method of placing nylon on the floor of the plot.

bands ($SWRM_5$). To install polyethylene nylon, according to Figure 3, after removing the soil to the desired depth, nylons with a width of 60 cm were placed in rows with 10 cm distance from each other on the floor of the plot. The two edges of the nylon were pushed up 10 cm high as the walls of the plot. Three nylons with a distance of 10 cm were considered for each plot. The removed soil was then returned to the previous position ($SWRM_6$ and $SWRM_7$). The control treatment was the plot without water retaining material ($SWRM_8$).

Irrigation and Crop Management

In this experiment, Surface Drip-tape Irrigation (SDI) system was used with an emitter spacing of 0.20 m. The amount of irrigation water for each treatment was measured with a water meter.

Irrigation was performed from planting up to the tillering stage, such that 0.20 m depth of each plot was considered as root zone. After the tillering stage, for the $SWRM_2$ and $SWRM_6$ treatments, a depth of 0.30 m was assumed as the depth of root development zone and for other SWRM treatments, a depth of 0.40 m was considered as the depth of root development.

After each irrigation event, the soil water (in full irrigation treatment) was measured at different times, and when the difference between soil moisture in management allowed depletion (θ_{MAD}) with soil moisture (θ_m) was within 5% θ_{MAD}, the next irrigation was done. θ_{MAD} was calculated by using Eq. (1):

$$\theta_{MAD}= \theta_{FC}-[(\theta_{FC}-\theta_{PWP})\times MAD] \quad (1)$$

Where, θ_{FC} is soil volumetric water content at Field Capacity ($m^3\ m^{-3}$), and θ_{PWP} is soil volumetric water content at Permanent Wilting Point ($m^3\ m^{-3}$), and MAD is Management Allowed Depletion (which was considered 0.5 in this study).

Irrigation water depth for the first period (Equation 2) and other periods was calculated based on the Equations (3) and (4):

$$FID = (\theta_{FC}-\theta_i)\times D_r \quad (2)$$

$$ID_{100} = (\theta_{FC}-\theta_m)\times D_r \ (3) \quad ID_{75}= I_{100}\times 0.75 \ (4)$$

Where, FID is First Irrigation water Depth (mm), ID_{100} and ID_{75} are Irrigation water Depth in I_{100} and I_{75} treatments, respectively (mm), θ_i is initial soil volumetric water content before the first irrigation ($m^3\ m^{-3}$), θ_m is soil volumetric water content ($m^3\ m^{-3}$), and D_r is root Depth (mm).

The gross volume of irrigation water for treatments was calculated by using Equation (5):

$$V_G = \frac{(ID \times A)}{Ea} \quad (5)$$

Where, V_G is Volume of irrigation water (L), ID is Irrigation Depth (mm), A is plot Area (m^2), and E_a is irrigation Efficiency (which was 0.9 in this experiment). Table 3

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shows the amount of applied water (irrigation plus effective rainfall) for SWRM treatments.

For all treatments, nitrogen, potassium, and phosphorus fertilizers were applied based on soil test results and wheat requirement (Moshiri *et al*., 2014). No potassium and phosphorus were applied to the plots treated with organic fertilizer, but only in the second year, nitrogen was added to the soil of this treatment. Other recommended practices such as controlling diseases, insects and weeds were performed uniquely for all of the treatments.

Measurements and Statistical Analysis

To determine the plant Relative Water Content (RWC), 20 disks were taken from the leaves of each plot and were floated on distilled water for 4 hours (in a constant-temperature room), then, turgid weight was measured. Then, the leaves were dried in oven at 80°C (Barrs and Weatherley, 1962). Relative Water Content (RWC) was calculated by the following equation:

$$RWC=\frac{(FW-DW)}{(TW-DW)}\times 100 \qquad (6)$$

Where, FW, DW and TW are Fresh Weight, Dry Weight and Turgid Weight, respectively.

For the Electrolyte Leakage (EL) analysis, 0.1 g of leaves from each plot was cut to segments and incubated in 15 mL distilled water for 24 hours. The conductance of the solution was measured (EC_i). Then, leaf tissue in the incubation solution was placed in an autoclave at 120°C for 30 minutes. The conductance of this incubation solution (EC_{max}) was determined (Hu *et al*., 2010). EL was calculated using the following equation:

$$EL=\frac{EC_i}{EC_{max}}\times 100 \qquad (7)$$

For photosynthetic pigments, leaf disks were ground with 80% acetone (v/v) in mortar until the leaf tissue turned white. The absorbance of the extract was measured by means of a spectrophotometer at 470, 646, and 663 nm. The chlorophylls and carotenoid content was calculated according to Lichtenthaler and Welburn (1983).

Number of spikes was determined per m^2 of the plot. By counting 1,000 grains of wheat using seed counter machine and then weighing them, the weight of 1,000 grains was determined. Biological yield was determined by weighing the aerial parts of the wheat biomass. Grains harvested from each plot were weighed and grain yield was determined. Water productivity was measured by dividing grain yield by irrigation plus effective rainfall (Equation 8). Effective rainfall was calculated using the CropWat software and USDA S.C. method.

$$WP=\frac{\text{Yield}}{(\text{Applied water + effective rain})} \qquad (8)$$

Where, WP is in kg m^{-3}, yield is in kg ha^{-1}, and applied water and effective rain are in $m^3\ ha^{-1}$.

For economical evaluation, the net income was obtained based on differences between gross income (market prices of wheat grain and straw) and expenses (the cost of organic and chemical fertilizer, superabsorbent, nylon membrane and water).

The data were analyzed by using SAS version 9.1 statistical software and Least Significant Difference (LSD) test was used at 5% to show statistical differences between means and then the charts were drawn by Excel 2010 software.

Table 3. Applied water in soil water retaining material treatments.

Treatment	Irrigation plus effective rainfall ($m^3\ ha^{-1}$)
$SWRM_1$	5094
$SWRM_2$	4769
$SWRM_3$	5716
$SWRM_4$	5680
$SWRM_5$	5727
$SWRM_6$	4633
$SWRM_7$	5415
$SWRM_8$	5693

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RESULTS

RWC, EL and Photosynthetic Pigments of Flag Leaf

There was significant effect of Irrigation (I), Soil Water Retaining Material (SWRM) and I×SWRM on the Relative Water Content (RWC) and the Electrolyte Leakage (EL) (Table 4). The deficit irrigation treatment reduced RWC by 5.75% compared to the full irrigation. The highest RWC obtained was, respectively, for $SWRM_1$, $SWRM_7$, and $SWRM_4$ treatments. Deficit irrigation caused an increase in the EL. The highest amount of EL was observed for the $SWRM_8$ (48.36%) and $SWRM_5$ (46.11%) treatments. The $SWRM_1$, $SWRM_4$, and $SWRM_7$ treatments had, respectively, lower EL (no significant differences among them).

Full irrigation significantly increased chlorophyll a, chlorophyll b, and carotenoid contents. Deficit irrigation treatment led to a decrease of more than 6, 7, and 5%, for chlorophyll a, chlorophyll b, and carotenoid contents, respectively, compared to full irrigation. Amount of chlorophyll a in $SWRM_1$ treatment was not significantly different from $SWRM_6$, $SWRM_4$, and $SWRM_7$ treatments. The highest amount of carotenoid belonged to, respectively, $SWRM_1$, $SWRM_2$, $SWRM_6$, $SWRM_7$ and $SWRM_4$ treatments, with no significant differences between them (Table 4).

According to the interaction effects of I×SWRM (Figure 4-a), the highest RWC belonged to the organic fertilizer treatment under full irrigation conditions ($SWRM_1I_{100}$). The amount of RWC in the $SWRM_8$ treatment under deficit irrigation conditions ($SWRM_8I_{75}$) was 60.36%, which was significantly different from that of $SWRM_8I_{100}$ (74.33%). For the $SWRM_5$ treatment, a significant difference was also observed between the deficit irrigation conditions (69.92%) and full irrigation conditions (79.43%), but for the other treatments there were no significant differences between the two irrigation conditions in terms of leaves RWC.

The highest and lowest EL was obtained for, respectively, $SWRM_8I_{75}$ (54%) and $SWRM_1I_{100}$ treatments (39.8%). The amounts of EL in $SWRM_5$ and $SWRM_8$ treatments were significantly different in the two irrigation conditions (Figure 4-b).

The interaction effects of irrigation × soil water retaining material on chlorophyll a are shown in Figure 4-c. For the control treatment, a significant decrease of chlorophyll a was observed under deficit irrigation condition compared to the full irrigation, while for the other treatments, the difference between deficit and full irrigation conditions were not significant.

Growth Parameters

Irrigation (I) and Soil Water Retaining Material (SWRM) had significant effect on growth parameters of wheat. Deficit irrigation reduced wheat growth attributes (Table 5). The highest growth trait of wheat was obtained in $SWRM_1$ and $SWRM_7$ treatments. According to Table 5, the $SWRM_1$, $SWRM_7$, and $SWRM_4$ increased grain yield by 31, 20.16, and 13.16%, respectively, compared to the control. Deficit irrigation led to a significant decrease in biological yield and number of spike per m^2. The highest amount of biological yield was observed for the $SWRM_1$, which was not significantly different from the $SWRM_7$ treatment. There was no significant effect of irrigation and SWRM treatments on the weight of 1000 grains.

Water Productivity (WP) was significantly affected by soil water retaining materials and irrigation treatments (Table 5). Deficit irrigation (I_{75}) led to an increase in the WP by 10.3% compared to the full irrigation. The highest WP belonged to, respectively, $SWRM_1$, $SWRM_6$, $SWRM_2$, and $SWRM_7$.

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Table 4. Mean values of RWC, EL, and photosynthetic pigments and summary of analysis of variance (mean square value).

Treatment	RWC%	EL%	Cl. a (mg g^{-1})	Cl. b (mg g^{-1})	Carotenoid (mg g^{-1})
Irrigation level (%)					
100	79.51 a	41.97 b	1.27 a	0.51 a	0.52 a
75	74.94 b	45.27 a	1.19 b	0.47 b	0.49 b
Soil Water Retaining Material					
Organic manure	82.69 a	40.05 d	1.33 a	0.54 a	0.54 a
Superabsorbent at depth of 30 cm	76.26 c	43.43 bc	1.23 bcd	0.5 a	0.53 ab
Superabsorbent at a depth of 40 cm	76.36 c	44.34 bc	1.19 cde	0.47 a	0.49 cd
Superabsorbent mixture with soil	80.54 ab	41.72 cd	1.28 abc	0.5 a	0.5 bc
Band application of superabsorbent	74.67 c	46.11 ab	1.11 e	0.47 a	0.48 cd
Plastic installation at depth of 30 cm	78.28 bc	43.18 bcd	1.29 ab	0.49 a	0.51 abc
Plastic installation at depth of 40 cm	81.63 ab	41.76 cd	1.25 abcd	0.49 a	0.51 abc
Control	67.35 d	48.36 a	1.16 de	0.47 a	0.46 d
Mean Square					
Irrigation level	501.42^{*}	261.29^{**}	0.15^{*}	0.03^{**}	0.02^{*}
SWRM	286.6^{**}	84.55^{**}	0.06^{**}	0.006^{ns}	0.007^{**}
Irrigation level×SWRM	68.44^{*}	43.74^{**}	0.04^{*}	0.001^{ns}	0.001^{ns}

Significance: ** P≤ 0.01, * P≤ 0.05, ^{ns} Not significant.

Table 5. Mean values of yield, Biological Yield (BY), Number of the Spike in m^2 (NSSM), 1000 Grain Weight (1000 GW) and WP and summary of analysis of variance (mean square value).

Treatment	Yield (ton ha^{-1})	BY (ton ha^{-1})	NSSM	WP (kg m^{-3})	1000 GW (g)
Irrigation level (%)					
100	8.42 a	23.11 a	819.21 a	1.45 b	39.02 a
75	7.64 b	20.09 b	713.33 b	1.6 a	38.87 a
Soil Water Retaining Material					
Organic manure	9.55 a	25.03 a	889.65 a	1.89 a	39.76 a
Superabsorbent at depth of 30 cm	8.01 bcd	20.85 cde	764.02 bc	1.69 b	38.81 a
Superabsorbent at a depth of 40 cm	7.58 cde	19.08 e	771.04 b	1.33 cd	38.88 a
Superabsorbent mixture with soil	8.25 bc	22.49 bc	794.18 b	1.46 c	38.31 a
Band application of superabsorbent	6.85 e	21.09 bcde	708.49 c	1.2 d	38.26 a
Plastic installation at depth of 30 cm	7.97 cd	21.63 bcd	761.08 bc	1.73 b	38.54 a
Plastic installation at depth of 40 cm	8.76 b	22.95 ab	815.18 b	1.63 b	40.27 a
Control	7.29 de	19.69 de	626.52 d	1.28 d	38.72 a
Mean Square					
Irrigation level	14.48^{**}	218.42^{**}	269038.74^{**}	0.58^{**}	0.5^{ns}
SWRM	8.61^{**}	43.13^{**}	70830.57^{**}	0.71^{**}	6.07^{ns}
Irrigation level×SWRM	0.3^{ns}	4.32^{ns}	13780.59^{*}	0.21^{ns}	1.07^{ns}

Significance: ** P≤ 0.01, * P≤ 0.05, ^{ns} Not significant.

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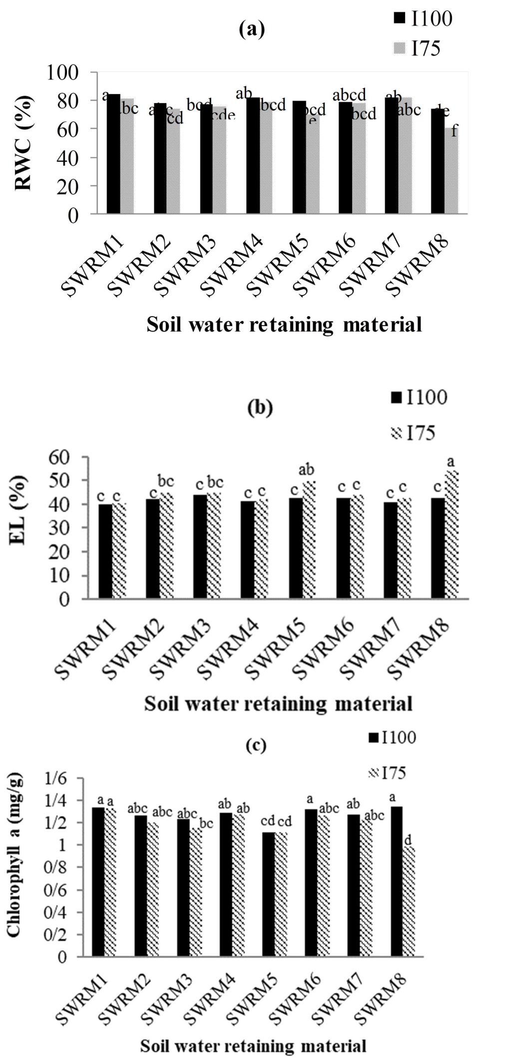

Figure 4. Effect of irrigation and soil water retaining materials on RWC (a), EL (b), and Chlorophyll a content (c).

The interaction effects of irrigation×soil water retaining material on number of spikes per m^2 showed that deficit irrigation significantly reduced the number of spikes per m^2 in $SWRM_2$, $SWRM_3$, $SWRM_4$, $SWRM_7$ and $SWRM_8$ (Figure 5). The highest number of spikes per m^2 (913.57) was obtained under full irrigation in combination with organic fertilizer.

Economic Analysis

The highest net income in the first year belonged to the $SWRM_1$ treatment, while all other treatments resulted in a lower benefit than the control. This is due to the expenses of the first year for the SWRM treatments. In the second year, the $SWRM_2$ treatment had only 0.55%, higher net income compared to the control. However, the $SWRM_3$ and $SWRM_5$ treatments reduced net income by 4.7 and 17.85%, respectively, compared to the control. In the second year, the net income in $SWRM_1$, $SWRM_4$, $SWRM_6$ and $SWRM_7$ increased by 37.1, 12.4, 10.5, and 16.2%, respectively, compared to the control. This could be due to the higher gross income, and using less chemical fertilizer and water in these treatments. In the $SWRM_1$ treatment, the net income in the second year decreased by 6.5% compared to the first year, because of lower yield and urea fertilizer application. The $SWRM_4$, $SWRM_6$ and $SWRM_7$ treatments in the second year showed an increase of, respectively, 110.9, 27.8, and 12.7% net income compared to the first year (Table 6).

DISCUSSION

Deficit irrigation led to a decrease in RWC and an increase in EL of wheat leaf. Similar results have been reported by Das *et al*. (2017) and Beltrano and Ronco (2008). The results of this experiment showed that, in deficit irrigation conditions, electrolytes leakage can be prevented by use of SWRM treatment. Low RWC led to greater membrane vulnerability, resulting in the release of more electrolytes (Molaahmad Nalousi *et al*., 2014). Based on the results of this experiment, deficit irrigation decreased photosynthetic pigments. This phenomena (decrease in chlorophyll content under deficit irrigation) could be due to the increase in the production of oxygen free radicals, which cause peroxidation and

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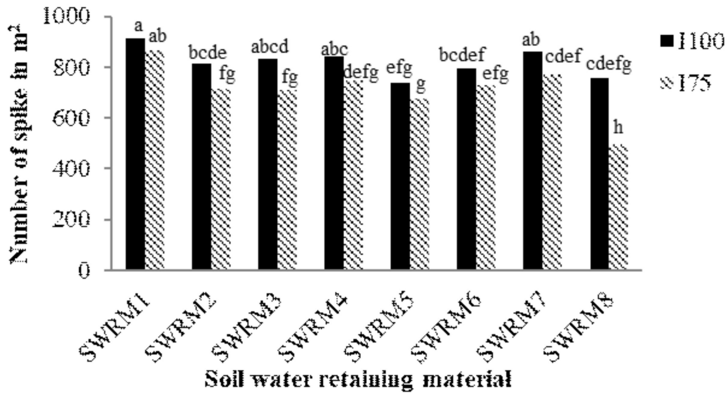

Figure 5. Effect of irrigation and soil water retaining materials on the number of spike/m^2.

Table 6. Economic analysis of wheat production in different treatments.

Treatments	Net income (US\$ ha^{-1})		Percent of change
	2017	2018	
$SWRM_1$	543	459	-6.5
$SWRM_2$	198	329	87.4
$SWRM_3$	147	324	140
$SWRM_4$	197	368	111
$SWRM_5$	373	269	-18.5
$SWRM_6$	320	362	27.8
$SWRM_7$	382	380	12.7
$SWRM_8$	498	327	-25.8

decomposition of these pigments (Afkari, 2018). Kubar *et al*. (2022) reported that the use of organic manure increased the chlorophyll content in wheat leaves, which confirms the results of this experiment.

Previous studies found negative effects of deficit irrigation on growth parameters of wheat (Sattar *et al*., 2022; Mu *et al*., 2021), confirming the results of the present experiment. Hao *et al*. (2019) reported that deficit irrigation had a negative effect on photosynthetic activity of the plant, while Mahmood *et al*. (2019) concluded that full irrigation caused the plant leaves to stay green for a longer time. The results showed a positive effect of organic manure on the number of spikes per m^2. In another study by Koutroubas *et al*. (2016), application of organic manure to wheat significantly increased number of spikes per m^2 and biological yield because of increasing supply of water and nutrients. In this study, organic manure increased wheat grain yield, which is in agreement with the results reported by El-Hamdi *et al*. (2019). They reported that applying manure into soil significantly increased wheat grain yield because of the availability of the more necessary nutrient elements. In this experiment, plastic membrane improved the yield of wheat, which is consistent with the results of Shorafa *et al*. (2014). Application of moisture-retaining membranes in the soil depth maintains soil moisture and modulates soil temperature during the plant growth period, leading to increased grain yield (Amirpour *et al*., 2016). To improve water productivity, yield must be increased or the amount of water consumption declined. Previous studies have reported an increase in WP in deficit irrigation conditions (Bijanzadeh *et al*., 2021; Zhao *et al*., 2020), which is consistent with the results of this experiment. As shown by the results of this

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experiment, Zoghdan and Ali (2019) also reported that organic fertilizer increased WP.

CONCLUSIONS

Higher water consumption and lower precipitation due to the recent changes in climate, especially in dry regions, necessitate a fundamental alteration in agricultural management strategies. In this study, different soil amendments and deficit irrigation scenarios were tested for this purpose. It is concluded that deficit irrigation improves WP, but negatively affects wheat growth parameters. By reducing the negative effects of water stress, the SWRM treatment could improve some wheat characteristics. For most of the measured properties, no significant differences were observed between the $SWRM_2$, $SWRM_3$ and $SWRM_5$ treatments and the control. Therefore, applying these treatments is not recommended for the studied region. Cow manure and impermeable nylon membrane in such light-textured soil had positive effects on wheat growth parameters. Since nylon will remain in soil for several years with no cost, it is necessary to evaluate the long-term (starting from the second year) effects of these treatments.

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معرفی استراتژی مناسب جهت بهبود خواص گندم و بهره وری آب در شرایط تنش رطوبتی در خاک لوم شنی

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چکیده

یکی از راه های توسعه کشاورزی پایدار، افزایش بهره وری آب (WP) است. در شرایط خشکی، مدیریت کشت باید باعث کاهش مصرف آب و همچنین کاهش اثرات منفی بر عملکرد و کیفیت محصول شود. این آزمایش در طول فصول رشد ۱۳۹۶ و ۱۳۹۷ به منظور تعیین تأثیر سطوح آبیاری و مواد نگهدارنده آب خاک بر بهره‌وری آب، محتوای نسبی آب (RWC)، نشت الکترولیت (EL)، رنگدانه های فتوسنتزی، عملکرد و اجزای عملکرد گندم انجام شد. کم آبیاری باعث افزایش WP و EL و کاهش عملکرد، اجزای عملکرد، RWC و رنگدانه‌های فتوسنتزی شد، در حالی که مواد نگهدارنده آب خاک این صفات را بهبود بخشیدند. میانگین عملکرد در تیمار کود آلی و نصب پلاستیک در عمق ۴۰ سانتی متری به ترتیب ۹/۵۵ و ۸/۷۶ تن در هکتار بود. بیشترین مقدار بهره‌وری آب (۱/۸۹ کیلوگرم در متر مکعب) در تیمار کود آلی مشاهده شد. کاربرد کود

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گاوی و نصب غشای پلاستیکی بر برخی از خصوصیات گندم بین دو شرایط آبی تفاوت معنی‌داری نداشت. به طور کلی، استفاده از کود آلی و غشاهای نایلونی تحت شرایط کم آبیاری، خصوصیات گندم و بهره‌وری آب را بهبود بخشید. اما برای رسیدن به یک نتیجه جامع، ارزیابی این تیمارها در چندین سال متوالی با شرایط مختلف خاک و آب ضروری است.

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