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Investigating the effects of different amounts of A200 hydrogel and vermicompost on wheat crop under deficit irrigation

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Abstract

The intensification of drought and water stress caused by climate change is a major factor in yield and productivity reduction in the agricultural sector in arid and semi-arid environments. Agricultural lands are often sorely affected by water tension caused by scarce and low precipitation. This research evaluated the effect of different amounts of water, vermicompost and hydrogel used to save the soil water content on wheat grain and biomass yield. Hence, an experiment was conducted at the research farm of Kashmar higher education institute to evaluate the effects of different amounts of hydrogel and vermicompost on wheat biomass and grain yield. Experimental treatments were included: four levels of A_{200} hydrogel (i.e. 0(S_0), 0.1(S_1), 0.2 (S_2) and 0.3 (S_3) wt. %) plus four levels of vermicompost (0(V_0), 7(V_1), 10(V_2) and 15(V_3) tons per hectare) and three levels of irrigation water (60(W_1), 80(W_2) and 100(W_3) percent of wheat water requirement). The experiment was carried out in a randomized completely block design (RCBD) in a factorial arrangement as a pot experiment in 144 pots. The results showed that the highest amount of biomass and grain yield was obtained in $S_3V_3W_3$ treatment amounting of 81.7 and 35 grams per pot, respectively. Also, the lowest biomass and grain yield was achieved in $S_0V_0W_1$ treatment at the rate of 35 and 10.2 gram per pot, respectively. Furthermore, grain and biomass yield were significantly affected ($P \leq 0.05$) by different amounts of hydrogel and vermicompost under varying irrigation water levels. However, application of hydrogel and vermicompost compounds was not significant on the wheat yields. Overall, the best economic value for achieving the highest amount of grain yield was observed in (S_2, 0.2%) of A_{200} hydrogel and (V_2, 10 ton/ha) of Vermicompost. Similarly, the highest amount of biomass was obtained in the (S_3, 0.3%) treatment of A_{200} hydrogels and 15 ton/ha (V_3) of vermicompost. Based on the results, the application of moisture absorbents can be effective in increasing wheat yield in water deficit conditions in the arid and semi-arid environment.

Introduction

Half of global wheat production occurs in irrigated cropping regions that face increasing water shortages. Wheat (Triticum aestivum L.) crop supplies a fifth of food calories and protein to the world's population. It is the most widely cultivated crop in the globe, cultivated on 217 million ha annually (Erenstein et al., 2022). Today, the cultivated area of irrigated and rainfed wheat in Iran is approximately 2 and 4 million hectares, respectively. Iranian people consume 12.5 million tons of wheat annually and the per capita consumption of wheat is c 141 kg (Shokati et al., 2023). The lack of surface water sources for irrigating the rapidly expanding wheat cultivation area has triggered a massive exploitation of groundwater resources; as a consequence, water levels have decreased and environmental problems have developed. Agriculture is thus faced with the challenge of ensuring global food security by increasing yields, while minimizing environmental problems. Therefore, water saving agricultural techniques must be applied to prevent further overexploitation of groundwater resources and increase the yields of essential crops (Mao et al., 2017).

Water scarcity is becoming the important determinant problem in agricultural crop production in arid and semi-arid areas (Rivero et al., 2007; Pourgholam-Amiji et al., 2020). Soil amendments have been widely used for crops and ornamental plants to mitigate the damage caused by water shortage in arid and semi-arid areas (Bhardwaj et al., 2007). It is indisputable that both synthetic polymer and natural soil amendments can provide beneficial effects on crop growth in terms of germination, root growth and nutrient uptake by improving soil physical, chemical and biological properties (Xu et al., 2015). To sustain or increase the productivity of wheat system, it is important that soil status must be perfect the level of organic matter in soil should be enough and overall, the soil must be without any constraints. Some of the secretions of worms and associated microbes act as growth promoter along with other nutrients. It has attracted the attention not only of scientists but also of farmers worldwide. Since, it is a natural organic product which is eco-friendly, it does not leave any adverse effects either in the soil or in the environment (Kumar et al., 2017). Compost is one of organic product for the soil moisture retention by increasing the soil porosity and aeration, which positively affect beneficial soil microorganisms. Other practical and commercially available products to help retain soil moisture are available, especially soil amendments containing cross-linked copolymers (Pedroza Sandoval et al., 2017). Certain metabolites produced by earthworms may also be responsible to stimulate the plant growth. Vermicompost also helps in preventing plant diseases (Rao, 2001). The mucus associated with the cast being hygroscopic absorbs water and improve water holding capacity (Kumar et al., 2017). One of the special advantages of vermicompost over other organic fertilizers is, existing large amount of humus in it and its humus-making process speed (Claudio, 2009). Vermicompost application has been known to improve physical, chemical and biological properties of soil (Kansotia et al., 2016). By using vermicompost and accession of humus to the soil, clays and silts are generally compounded with humus and adhesive materials and make up small units of soil. These small units cling to each other by adding organic materials to the soil make aggregate and shape soil structure. Aggregates clinging, causes to improve moisture retention capacity, water penetration, drainage and climate exchange in the soil and its intensity is reduced (Bagheri and Afrasiab, 2013).

Super absorbent polymers are extensively studied cross-linked macromolecules with segments of hydrophilic groups which are capable of absorbing and retaining large volumes of water (Fernández et al., 2005). Hydraulic super absorbent polymers have a quite different structure from vermicompost that found special place in new agriculture in order to reinforce nutritional and moisture status of the plant. In fact, the main objective of polymers in soil is to increase water retention (Bagheri and Afrasiab, 2013). These materials can reduce the effects of water stress on the plant and lead to increased yield in arid and semiarid regions.

Biri et al. (2016) conducted a field experiment during the main cropping season of 2013 with an objective to study the effect of different levels of nitrogen and vermicompost application on Striga infestation, growth and yield of sorghum at Fedis agricultural research center, eastern Ethiopia. The treatments consisted of three rates of nitrogen (0, 46, 92 kg/ha) in the form of urea and five rates of vermicompost (0, 0.5, 1, 1.5, 2 t/ha) in the form of organic fertilizer. The results of this study revealed that application of vermicompost significantly increased soil organic carbon, total nitrogen, available phosphorus, and exchangeable potassium contents. Nitrogen and vermicompost interacted to significantly ($P < 0.01$) influence the number of Striga per hectare.

Yang et al. (2017), performed a field-based pot experiment with maize plants was conducted to examine the effect of combined folic acid (FA) and super-absorbent polymer (SAP) on leaf gas exchange, water use efficiency, and grain yield under soil water deficit. SAP (45 kg hm^{-2}) was applied to the topsoil at sowing. Plants were well-watered (80% field capacity), but subjected to water deficit (50% field capacity) from tassel stage to grain-fill. FA solution (2 g L^{-1}) was sprayed onto plant leaves at 2 and 9 days after imposing water deficit. Under water deficit, SAP and FA application did not affect evapotranspiration, but increased leaf abscisic acid and decreased leaf transpiration rate with a little change in photosynthesis, thus improving instantaneous water use efficiency. Applying SAP and FA under water deficit also increased grain yield by 19% and grain water use efficiency by 24%, largely attributed to an increase in kernel number. In contrast, under well-watered condition the two chemicals increased stomatal conductance, leaf transpiration, photosynthesis and chlorophyll content, but did not change kernel number and were relatively less effective in respect to water use efficiency compared to water-stressed condition. This study showed that application of foliar FA and soil SAP had little effect on evapotranspiration but maintained high photosynthesis and kernel number, and improved water use efficiency under soil water deficit.

Hao et al., (2015) demonstrated that proper selection of drought tolerant hybrids can increase corn yield and WUE under water-limited conditions. Mahajan et al., (2015) suggested that breeding for traits of high yield potential and improved weed-suppressive ability for dry direct-seeded rice would lead to strengthened integrated crop management strategies.

Kohansal et al. (2014), to determine whether technology has a positive or negative effect on production variation. To achieve this aim, a stochastic frontier production function with a heteroske-dastic error structure has been used. A 10-year panel dataset from 8 provinces (Azarbayjan-e-sharghi, azarbayjan-e-gharbi, Ardebil, Kurdestan, Kermanshah, Lorestan, Zanjan, Eilam) in northwest of Iran was used to estimate different functional specifications. The results indicated that Potash fertilizer and technological change have positive and significant impact on wheat production risk; as well land and labour have a positive effect on wheat production risk but these coefficients are not statically significant. Plus, using phosphate and nitrogen fertilizer and seed have negative and significant impact on wheat production risk.

Carew et al. (2009) used Just-pope production function to examine the relationship among fertilizer inputs, soil quality, biodiversity indicators, cultivars qualified for Plant Breeders' Rights (PBR), and climatic conditions on the mean and variance of spring wheat yields in Monitabo Canada, and the main result showed nitrogen fertilizer, temporal diversity, and PBR wheat cultivars were associated with increased yield variance.

Gardebroek et al. (2010) compared the production technology and production risk of organic and conventional arable farms in the Netherlands. Just–Pope production functions have been estimated for Dutch organic and conventional farms. The result showed that organic farms face more output variation than conventional farms. Manure and fertilizers are risk-increasing inputs on organic farms and risk-reducing inputs on conventional farms. Labour is risk increasing on both farm types; capital and land are risk-reducing inputs.

Saseendran et al. (2014), Crop water production functions (CWPFs) are often expressed as crop yield vs. consumptive water use or irrigation water applied. CWPFs are helpful for optimizing management of limited water resources, but are site-specific and vary from year to year, especially when yield is expressed as a function of irrigation water applied. Designing limited irrigation practices requires deriving CWPFs from long-term field data to account for variation in precipitation and other climatic variables at a location. However, long-term field experimental data are seldom available. We developed location-specific (soil and climate) long-term averaged CWPFs for corn (Zea mays L.) using the Root Zone Water Quality Model (RZWQM$_2$) and 20 years (1992–2011) of historical weather data from three counties of Colorado. Mean CWPFs as functions of crop evapotranspiration (ET), ET due to irrigation (ETa–d), irrigation (I), and plant water supply (PWS = effective rainfall + plant available water in the soil profile at planting + applied irrigation) were developed for three soil types at each location. Normalization of the developed CWPF across soils and climates was also developed. A Cobb–Douglas type response function was used to explain the mean yield responses to applied irrigations and extend the CWPFs for drip, sprinkler and surface irrigation methods, respectively, assuming irrigation application efficiencies of 95, 85 and 55%, respectively. The CWPFs developed for corn, and other crops, are being used in an optimizer program for decision support in limited irrigation water management in Colorado.

The Kashmar city has a moderate desert climate with an average annual rainfall of 210 mm. Agricultural production in Kashmar is affected by the shortage of water resources and the occurrence of successive droughts. One of the effective solutions to deal with drought and lack of water resources is deficit irrigation and a solution to increase the water holding capacity in the soil. Therefore, the present experiment was conducted with the aim of the effect of different amounts of water along with soil moisture absorbents (natural and artificial) on wheat grain yield and biomass.

Materials and methods

This experiment was performed at the research farm of Kashmar higher education institute at Kashmar city in Khorasan Razavi province, north-east of Iran. The experimental field is located at 35°16´ 01" N latitude, and 58° 28´ 24" E longitude at 1110 meters altitude. A location map of Kashmar city is presented in Fig. (1). In the study area of research farm, the mean annual temperature recorded at a nearby observatory was 35°C with June being the hottest month (*i.e.* mean maximum temperature of 45°C) and January was the coldest (*i.e.* mean minimum temperature of 7°C). The mean annual rainfall based on 32 years' record (1989-2022) was 210 mm.

Estimation of the ombrothermic curve of this city based on precipitation and long-term temperature (1989-2022) of the meteorological station of Kashmar indicates that it is considered to be dry months of Kashmar from late May to late January (Fig. 2). Therefore, the city of Kashmar has a lack precipitation of 8 months and experiences dry weather. Meteorological information of the area including monthly rainfall, monthly average of temperature, relative humidity (RH), and reference evapotranspiration (ET$_o$).

Fig. 1- Location of study area

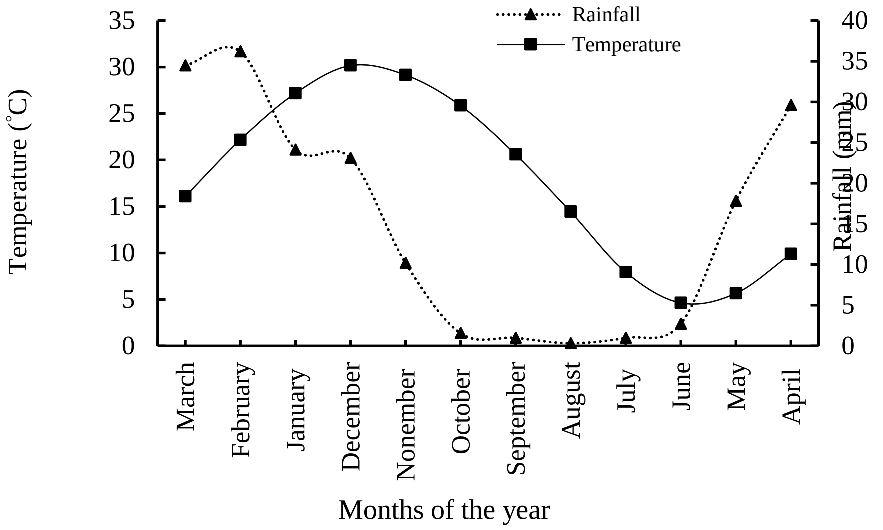

Fig. 2- Ombrothermic curve of Kashmar city based on long-term rainfall and temperature data of the area (1989-20222018)

Table 1- Experimental treatments

S	Different amounts of A_{200} Hydrogel	V	Different amounts of Vermi compost	W	Different amounts of Water Requirements
S_0	No A_{200} Hydrogel	V_0	No Vermi compost	W_1	60% water requirement
S_1	0.1 %wt of A_{200} Hydrogel	V_1	7 ton/ha Vermi compost	W_2	80% water requirement
S_2	0.2 %wt of A_{200} Hydrogel	V_2	10 ton/ha Vermi compost	W_3	100% water requirement
S_3	0.3 %wt of A_{200} Hydrogel	V_3	15 ton/ha Vermi compost		

In order to evaluate the effects of different amounts of hydrogel and vermicompost on biomass and grain yield of wheat, a field experiment was conducted at the research farm at Kashmar higher education institute in a factorial arrangement under completely randomization designs with three replications. The first factor consists of 16 different levels of artificial adsorbent (A_{200} hydrogel in four levels 0, 0.1, 0.2 and 0.3 weight percent, and vermicompost at four levels of 0, 7, 10 and 15 tons per hectare). The second factor consists of three levels of irrigation water (i.e. 60, 80 and 100% of the wheat water depth). The experiment was carried out in 144 black plastic pots (the height of 35 cm, upper diameter of 30 cm, and lower diameter of 25 cm). To illustrate the values of A_{200} hydrogel (S), vermicompost (V) and irrigation (W), the acronyms were used, as described in Table (1).

The irrigation water quality was good and classified in the C1S1 class. The irrigations were applied two weeks after planting. To fill the pots, 24 kg of homogenous soil was mixed with specified ratios of A_{200} hydrogel and vermicompost (the values given in Table 1). After preparing the pots, 15 wheat seeds of *Alvand* cultivar were cultivated in depth of 2cm from the top soil, in each pot. Soil moisture content of 10cm of soil depth and up to crop root zone were monitored periodically for irrigation scheduling *i.e.* deciding the date and quantity of irrigation water during the crop growth period. The date of irrigation was decided when the soil moisture of the root zone reached 50% of the total available water (TAW) *i.e* when half the moisture between the field capacity (FC) and permanent wilting point (PWP) gets depleted. The quantity of irrigation water for each treatment was calculated based on the soil moisture content before irrigation and root zone depth of the plant using the Eq. (1) (Azimi et., (2018).

$$SMD = (\theta_{FC} - \theta_i) \times D_{rz} \times f \qquad (1)$$

Where:

SMD is soil moisture deficit (mm), θ_{FC} is soil moisture content at field capacity (*vol,*

%), Θ_i is the amount of moisture corrected at irrigation time, (*vol*, %), D_{rz} is root effective depth, (mm), and *f* is coefficient of irrigation treatment (0.6, 0.8 and 1).

For measurement of soil water content, the *PMS-714* moisture meter was used. Grain yield was measured as weight of harvested grain with 3% grain moisture in each pot and converted to kg ha^{-1} unit for each treatment. Biomass yield was determined by taking the weight of above ground plant parts including the grain. After harvesting and drying of wheat plants, harvest operations were performed on 22/May. For measurement the yield, the plants in each pot (10 wheat plants) were cut from the soil surface and recorded by digital scale as biomass.

The optimal production function was selected based on the statistical analysis. The production function coefficients were estimated using OLS and SPSS 16 software. The model coefficients for determining the grain yield, the coefficient of determination (R^2) and standard error for the comparison of production functions (Sankhayan, 1988).

Linear:

$$Y = a_0 + a_1 w + a_2 v + a_3 s \qquad (2)$$

Cobb-Douglas:

$$Y = a_0 w^{a1} v^{a2} s^{a3} \qquad (3)$$

$$\rightarrow \mathrm{Ln}\,(Y) = ln(a_0) + a_1 ln(w) + a_2 ln(v) + a_3 ln(s)$$

Quadratic:

$$Y = a_0 + a_1 w + a_2 w^2 + a_3 v + a_4 v^2 + a_5 s + a_6 s^2 + a_7 wv + a_8 ws + a_9 vs \qquad (5)$$

Transcendental:

$$Y = a_0 w^{a1} v^{a2} s^{a3} \exp\,(a_4 w + a_5 v + a_6 s) \qquad (6)$$

$$\rightarrow \mathrm{Ln}(Y) = ln(a_0) + a_1 ln(w) + a_2 ln(v) + a_3 ln(s) + a_4 w + a_5 v + a_6 s \qquad (7)$$

Results

Statistical Analysis

The results showed that wheat grain yield and biomass were significantly affected at ($P \leq 0.01$) level by different amounts of irrigation and hydrogel. Also, wheat grain and biomass yield were significantly affected at ($P \leq 0.05$) level by different amounts of vermicompost. The interaction effect of hydrogel with irrigation water levels on the biomass and grain yield was significant at 5% probability level. It was indicated that, increasing water amount resulted in a relatively higher yield, since water deficit was main yield-limiting factor. The effects of different amounts of irrigation water in interaction with hydrogel on biomass and grain yield was significant at the 5% probability level. Increasing the amount of A_{200} hydrogel caused increasing of biomass and grain yield. Also, the interaction effect of A200 hydrogel with vermicompost on the measured parameters was not significant. The results of variance analysis were presented in Table (2).

The result of Table (3) shows that, there is a significant difference between different amounts of irrigation water (60, 80 and 100% WR) on grain yield and biomass. The maximum and minimum grain yield was obtained at full irrigation (W3) and 60% of applied water (W_1) treatment at the rate of 27.97 and 14.16 g pot^{-1}, respectively. Similarly, the maximum and minimum of biomass was achieved in the highest applied water (W_3) treatment at the rate of 47.74 and 64.27 g pot^{-1}, respectively.

Table 2- Analysis of variance of different parameters

Variables	df	Biomass	Grain Yield
Hydrogel	3	1509.49^{**}	148.05^{**}
Vermicompost	3	586.34^{*}	97.93^{*}
Irrigation	2	10.57^{**}	6.05^{**}
Hydrogel × Vermicompost	9	3372.05^{ns}	2291.94^{ns}
Hydrogel × Irrigation	6	41.26^{*}	9.51^{*}
Vermicompost × Irrigation	6	41.03^{*}	4.05^{ns}
Hydrogel × Vermicompost × Irrigation	18	21.05^{ns}	3.49^{ns}
Error	96	1416.67	326.71

*,** and ^{ns} are significant at 5% probability level, significant at 1% probability level and no significant, respectively.

Table 3- Comparison of the average biomass and grain yield for different treatments

Factor	Level	Biomass (gr)	Grain Yield (gr)
Water requirement	60	47.71^c	14.16^c
	80	58.23^b	20.63^b
	100	64.27^a	27.97^a
A200 Hydrogel	0	48.47^d	18.54^c
	0.1	55.28^c	19.96^b
	0.2	59.58^b	22.28^a
	0.3	63.61^a	22.90^a
Vermicompost	0	51.25^d	18.76^c
	7	56.39^c	20.61^b
	10	58.75^b	21.75^a
	15	60.55^a	22.56^a

In each column and for each treatment, the values followed by at least one common character are not statistically different at 0.05 probability level.

According to table (3), there is not significant difference between 0.3 (S_3) and 0.2 (S_2) wt% of A200 hydrogel on grain yield and biomass. But there is a significant difference between 0.3 (S_3) and 0.2 (S_2) wt% of A200 hydrogel with 0.1 (S_1) and 0 (S_0) wt% on grain yield and biomass. The maximum and minimum grain yield was obtained at (S_3) and 0 wt% of applied hydrogel treatment at the rate of 22.9 and 18.54 g pot^{-1}, respectively. Similarly, the maximum and minimum of biomass was achieved in the highest and lowest hydrogel rates (S_3 and S_0) treatment at the rate of 63.61 and 48.47 g pot^{-1}, respectively.

Similar results were obtained for vermicompost, which there was not significant difference between 15 (V_3) and 10 (V_2) wt% of vermicompost on grain yield and biomass. But there is a significant difference between 15 (V_3) and 10 (V_2) t ha^{-1} with 7 (V_1) and 0 (S_0) t ha^{-1} of vermicompost on grain yield and biomass. The maximum and minimum grain yield was obtained at (V_3) and 0 t ha^{-1} of applied vermicompost treatment at the rate of 22.56 and 18.76 g pot^{-1}, respectively. Similarly, the maximum and minimum of biomass was achieved in the highest and lowest vermicompost amounts (V_3 and V_0) treatments at the rate of 60.55 and 51.25 g pot^{-1}, respectively.

The highest amount of biomass was observed at 100% of water requirement (W_3) in interaction with 0.3% weight of A_{200} hydrogel. The lowest amount of biomass was obtained at 60% of water requirement (W_1) in interaction with non-applied hydrogel treatment (S_0). Also, the highest amount of grain yield was related to 100% water requirement (W_3) and 0.3% weight of A_{200} hydrogel treatment which had no significant difference with 100% water requirement and 0.2% weight of A_{200} hydrogel treatment.

The interaction effect of vermicompost levels with the levels of irrigation water requirement was significant on the biomass at 5% probability level. Increasing amount of irrigation water depth and vermicompost caused to increased biomass. The highest amount of biomass was obtained at 100% water requirement (W_3) in interaction with 15 ton/ha vermicompost amount, which had a significant difference with (W_3) in interaction with 7 ton/ha vermicompost.

Table (4) shows the estimation of production function of water-hydrogel-vermicompost with simple linear functions, Cobb-Douglas, quadratic and transcendental. The determination coefficient values of each function were obtained amounting of 0.897, 0.06, 0.91 and 0.894, respectively. The results showed that the quadratic, linear and transcendental functions were fit well on the data. With Comparing the determination coefficients and standard error, it was found that the quadratic function was better than other functions. Also, comparison of coefficients shows that changes in irrigation water amounts was more effective on wheat grain yield than A_{200} hydrogel and vermicompost treatments. In addition, the effect of A_{200} hydrogel was greater than vermicompost on wheat yield.

Table 4- Wheat water-hydrogel- vermicompost production coefficients using simple linear functions, Cobb Douglas, quadratic, and transcendental

Variables	Linear	Cobb-Douglas	Quadratic	Transcendental
intercept	-5.443^{**}	1.027^{**}	3.023^{**}	1.027^{**}
SE	0.248	0.037	0.056	0.012
W	0.026^{**}	-	0.797^{**}	0.278^{**}
SE	0.001	-	0.024	0.009
V	0.039^{**}	-	0.209^{**}	0.073^{**}
SE	0.005	-	0.024	0.009
S	2.231^{**}	-	0.249^{**}	0.088^{**}
SE	0.222	-	0.024	0.009
Ln (W)	-	-0.01^{ns}		-0.014^{*}
SE	-	0.017		0.006
Ln (V)	-	-0.01^{ns}		-0.003^{ns}
SE	-	0.031		0.01
Ln (S)	-	-0.026^{ns}		-0.026^{ns}
SE	-	0.049		0.016
W^2	-	-	0.028^{**}	-
SE	-	-	0.033	-
V^2	-	-	-0.01^{**}	-
SE	-	-	0.026	-
S^2	-	-	-0.046^{**}	-
SE	-	-	0.029	-
WV	-	-	0.036^{**}	-
SE	-	-	0.024	-
WS	-	-	0.043^{**}	-
SE	-	-	0.024	-
VS	-	-	0.079^{**}	-
SE	-	-	0.024	-
R^2	0.897	0.006	0.910	0.894
SE	0.088	0.104	0.080	0.011

Discussion

According to results, decreasing of irrigation water had negative effect on wheat yields. By decreasing of irrigation water, biomass and grain yield were reduced. Also, by increasing of hydrogel and vermicompost, biomass and grain yield were increased compared to the lack of using it. This result consistent with the result of Fazeli Rostampour et al. (2011), Allahyari et al. (2013) and Darvishi et al. (2013). Mao et al. (2017) applied three precision planting patterns (single row, alternating single and twin rows and twin row) and three irrigation treatments (0 mm (I0), 90 mm (I90) and 180 mm (I180)). Compared with I0 and I90 irrigation treatments increased yield by 19.3%. They showed that in water scarce regions, 90 mm of irrigation has a greater potential to increase winter wheat production than 180 mm. A significant decrease in wheat yield under water deficit conditions suggests that the identification and development of drought mitigation strategies to not only improve yield in drought prone areas but to also bring the arid and desert regions of the world under cultivation is of prime importance (Nawaz et al., 2016). Tollenaar and Lee (2002) believed that the most drought stress effect on during grain filling was on grain weight that grain weight decreased by drought stress. Yield reduction by drought stress due to reduced number of grains per ear and grain weight in response to decreased leaf relative water content and increased cell membrane stability reported by Majidian and ghadiri (2002).

In different studies, the addition of small amounts of organic matter to the soil increases its capacity to retain water because of the positive correlation among the organic matter content, available water and yield (Julca-Otiniano et al., 2006). A positive effect of vermicompost application on yield attributes and yield of various crops had been reported by Vasanthi and Kumaraswamy (1999), Ranwa and Singh (1999). Dussere (1992) reported that vermicompost helps to improve and protect fertility of top soil and also helps to boost up productivity by 40% with 20 to 60% lower inputs, it also enhances the quality of end products and thereby creating significant impact on flexibility in marketing as well as increases the storage time. Vermicompost contain 30 to 50 percent substance which help in the stimulation of plant growth, particularly that of roots, also the nutrients present in vermicompost are readily available (Kumar et al., 2017). In addition, the application of compost increases the soil organic matter content and improves some of its physical characteristics, such as the amount of hydrostable aggregates, bulk density, and porosity, which promote the flow of air and water and plant root development (Tits et al., 2014). Kizilkaya et al. (2012) reported that vermicomposted organic wastes by supplying more nutrients for wheat than non-vermicomposted organic wastes can enhance wheat growth. Vermicomposted organic wastes may be a potential source of plant nutrients for sustainable crop production.

Grain yield of wheat crop varied from 51.25 to 60.55. A significant effect of A200 hydrogel application on wheat grain yield was observed. A similar effect was observed for maize production by Pedroza Sandoval et al. (2017). They showed that the production of fresh forage increased from 19.5 t ha^{-1} in the control to 77.6 and 81.6 t ha^{-1} when the hydrogel was applied at rates of 12.5 and 25 kg ha^{-1}, respectively. The application of the hydrogel increased the soil moisture content by 20.8% compared to the control, facilitating increased photosynthetic activity and other physiological variables and therefore resulting in increased biological yields. Kosterna et al. (2012) investigated the effect of different irrigation methods (no irrigation, irrigation by means of a drip tape) and method of AgroHydroGel application (control, AgroHydroGel applied to seedlings, AgroHydroGel applied to plants in the field, half of the AgroHydroGel applied to seedlings, the other half to plants in the field) on the yield level and quality of celeriac grown in the field. In the irrigated treatments, the highest yield was obtained in the plots where hydrogel was applied to plants in the field. Irrigation increased the total celeriac plant weight by 34% as compared to the non-irrigated plots. Simultaneously, irrigation and hydrogel application in a split proportion increased total sugar content as compared to the plants in which the hydrogel was only applied to the seedlings. Khadem et al. (2010) stated that 1000-seed weight, grain and biological yield increased by using animal manure and superabsorbent polymer together as maximum grain yield was obtained by using 65% animal manure and 35% superabsorbent polymer.

The positive effect of super absorbent polymers in increasing yield in the tomato (El-Hadi and Camelia, 2004), sunflower (Nazarli et al., 2010) and soybean (Yazdani et al, 2007) reported it and it was consistent with these findings. By applying super absorbent polymers, humidity fluctuations were reduced, irrigation intervals were increased and plant growth was increased. Yazdani et al. (2007) reported that using super absorbent polymers in drought stress and water shortage conditions can increase the yield of soybean and found that using adequate amount of super absorbent polymers not only under irrigation conditions but also under water stress can compensate its purchase costs and gain profit and increase yield. Also, the positive effect of super absorbent polymers in reducing the bad effects of drought stress was reported in corn (Islam et al. 2011) and sunflower (Nazarli et al. 2010). Pourpasha et al. in 2011 stated that A200 hydrogel has a positive effect on wheat yield and yield components.

Conclusions

The highest amount of biomass and grain yield were obtained in $S_3V_3W_3$ treatment at the rating of 81.7 and 35 grams in the pot, respectively. Also, lowest biomass and grain yield were obtained in $S_0V_0W_1$ treatment amounting of 35 and 10.2 gram in the pot, respectively. In general, it can be concluded that wheat biomass and grain yield was increased with application of A_{200} hydrogel and vermicompost. The highest grain yield can be achieved with application of 0.2% weighing of A_{200} hydrogel and 10 ton/ha of Vermicompost in interaction with W_2 treatment. However, comparison of coefficients reveald that changes in irrigation water depths was more effective on wheat grain yield than A_{200} hydrogel and vermicompost treatments. In addition, the effect of A_{200} hydrogel was greater than vermicompost on wheat yield. Nevertheless, the use of moisture absorbents in water shortage conditions, especially in arid and semi-arid regions, is recommended to obtain more agricultural productions.

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References

1- Allahyari, S., Golchin, A., Vaezi, A.R. 2013. Study on effect of super absorbent polymer application on yield and yield components of two chickpea cultivars under rainfed conditions. *Journal of Plant Production*, 20(1), 125-139. Doi: 20.1001.1.23222050.1392.20.1.8.1 (In Persian)

2- Azimi, S., Khoshravesh, M., Darzi Naftchali, A., Abedinpour, M. 2018. Effects of Hydrogel and Vermicompost on Water Use Efficiency of Wheat. *Journal of Water Research in Agriculture,* 32(1), 29-40. Doi: 10.22092/jwra.2018.116598 (In Persian)

3- Bagheri, H., Afrasiab, P. 2013. The effects of super-absorbent, vermicompost and different levels of irrigation water salinity on soil saturated hydraulic conductivity and porosity and bulk density. *International Research Journal of Applied and Basic Sciences*, 4(8), 2381-2388.

4- Bhardwaj, A.K., Shainberg, I., Goldstein, D., Warrington, D.N., Levy, G.J. 2007. Water retention and hydraulic conductivity of cross-linked polyacrylamides in sandy soils. *Soil Science Society of America Journal*, *71*(2), 406. Doi: 10.2136/sssaj2006.0138.

5- Biri, A., Kaba, S., Taddesse, F., Dechassa, N., Zewidie, A., Chavhan, A. 2016. Effect of Vermicompost and Nitrogen Application on Striga Incidence, Growth, and Yield of Sorghum [Sorghum bicolor (L.) Monech] in Fedis, eastern Ethiopia. *International J. of Life Sciences*, 4(3), 349-360.

6- Carew, R., Smith, E.G., Grant, C. 2009. Factors influencing wheat yield and variability: Evidence from Manitoba, Canada. *Journal of Agricultural and Applied Economics,* 41(3), 625-639. Doi: 10.1017/S1074070800003114.

7- Claudio, P.J., Raphael Alves, B.F., Kamiila, L.R., Brunade, S.N., Priscila, M.B. 2009. Zn(ll) adsorption from synthetic solution and kaolin wastewater on vermicompost. *Science of the Total Environment*, 162, 804-811. Doi: 10.1016/j.jhazmat.2008.05.104.

8- Darvishi, A., Mehraban, A., Fanaee, H. 2013. Investigation on the effect of A 200 superabsorbent and water stress on yield and yield components of Hamoon cultivar in Sistan region. First National Agricultural and Sustainable Natural Resources Conference, Tehran, Higher Education Institute of Mehr Arvand.

9- Egli, D.B., Bruening, W.P. 2004. Water stress, photosynthesis, seed sucrose levels and seed growth in soybean. *Journal of Agricultural Science*, 142, 1-8. Doi: 10.1017/S0021859604004095.

10- El-Hadi, O.A., Camelia, Y.E. 2004. The conditioning effect of composts (natural) or/and acrylamide hydrogels (synthesized) on a sandy calcareous soil. Growth response, nutrients uptake and water and fertilizers use efficiency by tomato plants. *Journal of Applied Science Research*, 2(12), 1293-1297.

11- Erenstein, O., Jaleta, M., Mottaleb, K.A., Sonder, K., Donovan, J., Braun, HJ. 2022. Global Trends in Wheat Production, Consumption and Trade. In: Reynolds, M.P., Braun, HJ. (eds) Wheat Improvement. Springer, Cham. https://doi.org/10.1007/978-3-030-90673-3_4.

12- Fazeli Rostampour, M., Seghatollahi, M.J., Mousavi, S. 2011. Effect of water stress and polymer on yield and water use efficiency of corn in Birjand region. *Journal of environmental stresses in crop sciences*, 4(1), 12-19. Doi: 10.22077/escs.2011.95.

13- Fernández, E., López, D., López-Cabarcos, E., Mijangos, C. 2005. Viscoelastic and swelling properties of glucose oxidase loaded polyacrylamide hydrogels and the evaluation of their properties as glucose sensors. *Polymer*, 46(7), 2211-2217. Doi: 10.1016/j.polymer.2004.12.039.

14- Gardebroek, C., Chavez, M. D., Lansink, A. O. 2010. Analyzing production technology and risk in organic and conventional Dutch arable farming using panel data. *Journal of Agricultural Economics*, 61(1), 60-75. Doi: 10.1111/j.1477-9552.2009.00222.x

15- Hao, B., Xue, Q., Marek, T.H., Jessup, K.E., Becker, J., Hou, X., Howell, T. A. 2015. Water use and grain yield in drought-tolerant corn in the Texas High Plains. *Agronomy Journal*, 107(5), 1922-1930. Doi: 10.2134/agronj15.0133.

16- Islam, M. R., Xue, X., Mao, S., Zhao, X., Eneji, A.E., Xu, Y. 2011. Superabsorbent polymers (SAP) enhance efficient and eco-friendly production of corn (Zea mays L.) in drought affected areas of northern China. *African Journal of Biotechnology*, 10(24), 4887-4894.

17- Julca-Otiniano, A., Meneses-Florián, L., Blas-Sevillano, R., Bello-Amez, S. 2006. La material orgánica, importancia y experiencia de suusoenla agricultura. *Idesia*, 24(1), 49-61. Doi: 10.4067/S0718-34292006000100009.

18- Kansotia, B.C., Sharma, Y., Meena, R.S. 2016. Effect of vermicompost and inorganic fertilizers on soil properties and yield of Indian mustard (Brassica juncea L.). *Journal of Oilseed Brassica*, 1(1), 198-201. Doi:

19- Khadem, S.A., Galavi, M., Ramrodi, M., Mousavi, S.R., Rousta, M.J., Rezvani-moghadam, P. 2010. Effect of animal manure and superabsorbent polymer on corn leaf relative water content, cell membrane stability and leaf chlorophyll content under dry condition. *Australian Journal of Crop Science*, 4(8), 642-647.

20- Kizilkaya, R., Turkaym, F.S.H., Turkmen, C., Durmus, M. 2012. Vermicompost effects on wheat yield and nutrient contents in soil and plant. *Archives of Agronomy and Soil Science*, 58, 175-179. Doi: 10.1080/03650340.2012.696777.

21- Kohansal, M.R., Aliabadi, M.M.F. 2014. Impact of technological change on wheat production risk in Northwest of Iran. *International Journal of Agricultural Science and Technology*, Chicago.

22- Kosterna, E., Zaniewicz-Bajkowska, A., Rosa, R., Franczuk, J. 2012. The effect of AgroHydroGel and irrigation on celeriac yield and quality. *Folia Horticulturae*, 24(2), 123-129. Doi: 10.2478/v10245-012-0015-z.

23- Kumar, R., Kumawat, N., Sahu, Y.K. 2017. Role of bio fertilizers in agriculture. *Pop Kheti*, 5 (4), 63-66.

24- Mahajan, G., Ramesha, M.S., Chauhan, B.S. 2015. Genotypic differences for water-use efficiency and weed competitiveness in dry direct-seeded rice. *Agronomy Journal*, 107(4), 1573-1583. Doi: 10.2134/agronj14.0508.

25- Majidian, M., Ghadiri, H. 2002. Effect of water stress and different levels of nitrogen fertilizer during different growth stage on grain yield, yield components, water use efficiency, and some physiological characteristics of corn (zea mays L.). *Iranian Agriculture Science*, 33(3), 521-533

26- Mao, X.M., Zhong, W.W., Wang, X.Y., Zhou, X.B. 2017. Effects of precision planting patterns and irrigation on winter wheat yields and water productivity. *Journal of Agricultural Science*, 155(9), 1-13. Doi: 10.1017/S0021859617000508.

27- Nawaz, F., Ashraf, M.Y., Ahmad, R., Waraich, E.A., Shabbir, R.N., Hussain, R.A. 2016. Selenium supply methods and time of application influence spring wheat (Triticum aestivum L.) yield under water deficit conditions. *Journal of Agricultural Science*, 155(4), 1-14. Doi: 10.1017/S0021859616000836.

28- Nazarli, H., Zardashti, M.R., Darvishzadeh, R., Najafi, S. 2010. The effect of water stress and polymer on water use eficiency, Yield and several morphological traits of sunflower under greenhouse condition. *Notulae Scientia Biologicae*, 2(4), 53-58. Doi: 10.15835/nsb.2.4.4823.

29- Pedroza Sandoval, A., Yáñez-Chávez, L.G., Sánchez-Cohen, I., Samaniego-Gaxiola, J.A., Trejo-Calzada, R. 2017. Hydrogel, biocompost and its effect on photosynthetic activity and production of forage maize (*Zea mays* L.) plants. *Acta Agronómica*, 66(1), 63-68. Doi: 10.15446/acag.v66n1.50868.

30- Pourgholam-Amiji, M., Liaghat, A., Ghameshlou, A., Khoshravesh, M., Waqas, M.M. 2020. Investigation of the yield and yield components of rice in shallow water table and saline. *Big Data in Agriculture*, 2(1): 36-40. Doi: 10.26480/bda.01.2020.36.40.

31- Pourpasha, M., Roshdi, M., Rezaee, M., Mashashi, K. 2011. Effect of different levels of nitrogen and superabsorbent polymer on yield and yield components of wheat. *Journal of Agricultural Research*, 3(12), 85-97. Doi: 10.22059/IJFCS.2017.223031.654237.

32- Ranwa, R.S., Singh, K.P. 1999. Effect of integrated nutrient management with vermicompost on productivity of wheat (Triticum aestivum L.). *Indian Journal of Agronomy,* 44 (3), 554-559.

33- Rao, K.R., Rao, P.A., Rao, K.T. 2001. Influence of fertilizers and manures on the population of coccinellid beetles and spiders in groundnut ecosystem. *Annals of Plant Protection Sciences*, (9), 43–46.

34- Rivero, R.M., Kojima, M., Gepstein, A., Sakakibara, H., Mittler, R., Gepstein, S., Blumwald, E. 2007. Delayed leaf senescence induces extreme drought tolerance in a flowering plant. *Proceedings of the National Academy of Sciences*, 104(49), 19631-19636. Doi: 10.1073/pnas.0709453104.

35- Sankhayan, P.L. 1988. Introduction to the economics of agricultural production. Prentice-Hall of India, Private Limited: New Delhi; 131 p.

36- Saseendran, S.A., Ahuja, L.R., Ma, L., Trout, T.J., McMaster, G.S., Nielsen, D.C., Fang, Q.X. 2014. Developing and normalizing average corn crop water production functions across years and locations using a system model. *Agricultural Water Management*, 157, 65-77. Doi: 10.1016/j.agwat.2014.09.002.

37- Shokati Amghani, M., Mojtahedi, M., Savari, M. 2023. An economic effect assessment of extension services of Agricultural Extension Model Sites for the irrigated wheat production in Iran. Sci Rep 13, 16947. Doi: 10.1038/s41598-023-44290-5.

38- Tits, M., Elsen, A., Bries, J., Vandendriessche, H. 2014. Short-term and long-term effects of vegetable, fruit and garden waste compost applications in an arable crop rotation in Flanders. *Plant Soil*, 376(1-2), 43-59. Doi: 10.1007/s11104-012-1318-0.

39- Tollenaar, M., Lee, E.A. 2002. Yield potential, yield stability, and stress tolerance in maize. *Field Crops Research*, 75, 161-169. Doi: 10.1016/S0378-4290(02)00024-2.

40- Vasanthi, D., Kumaraswamy, K. 1999. Efficacy of vermicompost to improve soil fertility and rice yield. *Journal of the Indian Society of Soil Science*, 47(2), 268-272.

41- Xu, S., Zhang, L., Mclaughlin, N.B., Mi, J., Chen, Q., Liu, J. 2015. Effect of synthetic and natural water absorbing soil amendment soil physical properties under potato production in a semi-arid region. *Soil and Tillage Research*, 148, 31–39. DOI 10.1016 /j.still.2014.10.002.

42- Yang, W., Li, P., Guo, S., Fan, B., Song, R., Zhang, J., Yu, J. 2017. Compensating effect of fulvic acid and super-absorbent polymer on leaf gas exchange and water use efficiency of maize under moderate water deficit conditions. *Plant Growth Regulation*, 83(3), 351-360. Doi: 10.1007/s10725-017-0297-9.

43- Yazdani, F., Aladadi, I., Akbari, G., Behbehani, M.R. 2007. Effect of different rates of superabsobent polymer (Tarawat A200) on soybean (Glycine max L.) yield and yield components. *Pajouhesh and Sazandegi*, 75, 167-1747 (in Persian).