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Effects of Deficit Irrigation and Mulching on Seed Yield and Water Use of Onion (*Allium cepa L.*)

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Authors' contributions

This study was conducted in collaboration between all authors. Authors SKB and DKR designed the study and managed the literature searches. Author SKB wrote the first draft of the manuscript and performed statistical analyses. Authors KKS, AJM, KFIM and MAA managed the experimental process of the study. All authors read and approved the final manuscript.

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ABSTRACT

The effects of deficit irrigation and mulch on seed yield, water use and water productivity of onion was studied through a field experiment during 2012 - 2013 and 2013 - 2014 winter season at the experimental field of Bangladesh Agricultural Research Institute, Gazipur, Bangladesh. Eight treatments comprising of four levels of irrigation regimes (40, 60, 80, and 100% soil moisture deficit (SMD)) and two levels of mulching (no-mulch and rice straw) were tried in randomized complete block design with three replications. Both irrigation and mulch exerted significant effects on the yield and yield contributing parameters of onion. On average, the seed yield ranged from 1061 to 1595 kg ha^{-1}, with minimum in treatment of 40% DSM without mulch and maximum in full irrigated (100% DSM) mulch treatment, respectively. The seed yields of the treatments irrigated up to 80% DSM were not statistically (p= .05) different from those that were fully irrigated (100% DSM). Analyses of results showed that irrigating onion up to 40% DSM reduced seed yield by about 30%. Applying water up to 60% of DSM caused a yield reduction of about 19%. However, irrigating onion

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up to 80% of DSM reduced seed yield by less than 4%. Results also revealed that water use of onion crop were largely influenced by the depths of water applied rather than mulching. On average, total water use ranged from 177 to 262 mm with minimum in mulch treatment of 40% DSM and maximum in full irrigated treatment. Total water used by the mulch treatments was only 5.08% lower than that of the non-mulched treatments. While difference in total water applied between mulched and non-mulched treatments was 7.2%. Water productivity was found to be the highest (0.71 kg m^{-3}) in the mulched treatment (80% DSM) with total water use of 220 mm. This treatment also produced near to the highest yield with 22% saving of irrigation water meaning that irrigating up to 80% DSM with mulch may be the best practice for seed production of onion.

Keywords: Onion seed; deficit irrigation; water productivity; straw mulch.

1. INTRODUCTION

Onion is the second most-valuable vegetable crop in the world, next to tomato. It also holds a predominant place among spices/vegetables in Bangladesh. Currently, onion is considered as an important cash crop for the farmers in Bangladesh; and hence the crop is produced in different parts of the country for local consumption. The crop is grown on an area of 127,420 ha which yielded about 1,052,000 metric tons as a winter crop for fresh consumption [1]. The production increased manifold during last decade due to the extension of area of production and introduction of improved management practices. But the entire production cannot meet the demand which is about 15 metric ton per year. The national average yield remains poor with 4.08 t ha^{-1} in 2001/2002 and 8.70 t ha^{-1} in 2012/2013 [1] as compared to world average yield of 17.92 t ha^{-1}. This big gap in yield is due non mastery of technical production procedures and on the other hand to the poor quality of seeds used. Low productivity of onion in Bangladesh could be attributed to limited availability of quality seed and lack of appropriate hybrid varieties [2,3] and water management practices. Improved seed contributes substantially to enhance crop yield as high as 30% [4]. The total production of onion seed in Bangladesh is about 150 metric tons per year, but the requirement is more than 300 metric tons [5]. The price of onion seed remains high in the season of onion cultivation. Seed is the basic and essential input for any crop production. According to Thompson [6], high quality seed is a critical input on which all other inputs will depend for their full effectiveness. Steady supply of good quality seeds is a pre-requisite for the successful accomplishment of high production of acceptable onions as fresh bulbs or as dehydrated forms either for local consumption or for export.

The demand for increased seed production arises from several factors like demand to meet the needs of ever increasing onion consumption; the development of irrigation schemes with good supply of water encouraging farmers to diversify their production system; the shift of some farmers to intensive commercial onion seed production and the increased demand for vegetable with increasing urbanization [7]. The average productivity of onion seed is only 500 kg ha^{-1} against its potential of 1200-1500 kg ha^{-1}. This prevailing yield gap is due to the lack of convenient management practices which can be addressed giving emphasis on appropriate irrigation and water management practices.

Deficit irrigation (DI) is an optimization strategy in which irrigation is applied during drought senstitive growth stages of a crop. Outside these periods, irrigation is limited or even unnecessary if rainfall provides a minimum supply of water. Water restriction is limited to drought-tolerant phenological stages, often the vegetative stages and the late ripening period. Total irrigation application is therefore not proportional to irrigation requirements throughout the crop cycle. While this inevitably results in plant drought stress and consequently in production loss, DI maximizes irrigation water productivity, which is the main limiting factor [8]. In other words, DI aims at stabilizing yields and at obtaining maximum crop water productivity rather than maximum yields [9]. Mulching is also one of the water management practices for increasing water productivity. Any material spread on the surface of soil to protect it from solar radiation or evaporation is called mulch. Different types of materials like wheat straw, rice straw, plastic film, grass, wood, sand etc. are used as mulches. They moderate soil temperature and increase water infiltration during intensive rain [10].

Under limited water supply conditions or even where water is not a problem, farmers usually tend to increase irrigation interval, which creates water stress resulting in low yields and poor quality of onion seed. Though there is a tendency of farmer's to apply excess water when it is available, but the major proportion of irrigation water is lost by surface evaporation, deep percolation and other loses, resulting in lower irrigation efficiencies [11]. It is prudent to make efficient use of water and bring more area under irrigation through available water resources. This can be achieved by introducing improved cultural and water management practices. Deficit irrigation with mulching is seen as one of the options for minimizing irrigation water requirement and for increasing water use efficiency at field level in order to release more water for other users beside agriculture. Deficit irrigation is the practice of irrigating crops deliberately below their water requirements. Such practice is aimed at minimizing water applied to the crop so as to maximize crop yield per water applied, even though there might be consequences of yield reduction. According to Rhu et al. [12] and Kashi et al. [13], mulch not only conserves soil moisture, but also increases soil temperature, reduce weed problems and simulate higher crop yields by more efficient utilization of soil moisture. Many research works have been carried out to study the consequences of deficit irrigation on onion bulb production [14-19]. Almost no work has been done in Bangladesh to study the effect of deficit irrigation along with mulch on onion seed production. The present study therefore was planned to evaluate the effect of mulch and deficit irrigation on the yield and quality of onion seed and to assess the economic feasibility in relation to mulch used for production of onion seed.

2. MATERIALS AND METHODS

2.1 Experimental Site

Field experiment was conducted at the experimental field of Irrigation and Water Management Division of Bangladesh Agricultural Research Institute (BARI), Gazipur during the winter season of 2012-2013 and 2013-2014. In the first year the crop was grown in sandy clay loam soil with field capacity, wilting point and bulk density, 27.2%, 13.14% and 1.46 g cm^{-3}, respectively. But in the following year, the experiment was conducted in a different field having clay loam soil. The field capacity, wilting point and bulk density of this soil were 29.48%, 14.78% and 1.40 g cm^{-3}, respectively. Onion variety "BARI Piaz-1" was used to study the effect of deficit irrigation and mulch on onion seed production.

2.2 Experimental Design and Crop Management

The experiment consisted of four levels of irrigation regimes (40, 60, 80, and 100% soil moisture deficit (SMD)) and two levels of mulching (no-mulch and rice straw). Thus the treatment combinations were as follows:

- T_1 = Irrigation up to 100% of deficit soil moisture (DSM)
- T_2 = Irrigation up to 100% of DSM + straw mulch
- T_3 = Irrigation up to 80% of DSM
- T_4 = Irrigation up to 80% of DSM + straw mulch
- T_5 = Irrigation up to 60% of DSM
- T_6 = Irrigation up to 60% of DSM + straw mulch
- T_7 = Irrigation up to 40% of DSM
- T_8 = Irrigation up to 40% of DSM + straw mulch

All treatments received irrigation at vegetative, bolting, flowering and seed formation stages. The experiments were laid on the field with treatments assigned to plots in a randomized complete block design (RCBD) replicated thrice, with the blocks lying across the general slope of the field. The blocks were separated by a distance of 2.0 m, while the plots in each block were separated by a distance of 1.0 m which serves as buffer to minimize lateral movement of water from one plot to another. The unit plot size was 3 m x 1.5 m. Recommended dose of fertilizer (150-100-180 kg ha^{-1} N-P-K) in the form of urea, triple super phosphate and muriate of potash were applied. In addition to N-P-K, gypsum, zinc and borax were also applied at 20-3.7-1.7 kg ha^{-1}. Nitrogen was applied in three equal splits, the first along with phosphorus and potash at the time of soil preparation while the remaining half was applied during vegetative and flowering stages. Well-decomposed cowdung (10 t ha^{-1}) was also incorporated into soil 3 days before planting of onion bulb. Bulb to seed method was used for this experiment, so onion bulbs were planted on 17 November, 2012 in the first year and 16 November 2013 in the second year in 25 cm apart rows maintaining plant to plant distance of

20 cm. Straw mulch was placed 10 days after planting of onion bulbs at a rate of 10 t ha^{-1}. Weeding was done twice, at three and six weeks after planting, before the application of fertilizer. However, in the mulched plots, only the first round of weeding was carried out. The mulch materials were carefully removed and placed back after weeding. In the mulched plots, weeds were effectively suppressed after the first weeding, so that there was no need for a second weeding. The crop was protected from diseases and pests by spraying Rovral and Ridomil Gold @ 2g L^{-1} at a regular 15 days interval up to initiation of flowering.

2.3 Irrigation Application and Data Recording

Soil moisture was monitored gravimetrically before and after each irrigation events at 15 cm increment of depth up to 45 cm. The values were then averaged for the depth 0- 45 cm. Amount of water needed for each treatment was calculated as per treatment and hence desired amount of water was applied to each plot through a 2.5 cm rubber pipe connected to a field water tap of known discharge. The time required to apply the required amount of water was monitored using a stop watch. The crop was harvested on 29 March, 2013 and 31 March 2014 in the first and second year, respectively. Ten plants from each plot were selected randomly for collection of data on growth, yield and yield components such as plant height, leaves per plant, flower stalks per plant, scape length and diameter, umbel diameter, effective and abortive florets per umbel, number and weight of seeds per umbel, 1000-seed weight and seed yield. The seed heads were cut at 2-3 cm of stem attached. The cut seed heads were then dried in the sun. When the seed heads were completely dry, these were threshed and seeds were collected after cleaning. Standard germination test was also conducted. Three replicates of 100 seeds for every treatment were taken and placed over moistened Whatman No. 3 and No. 1 filter papers, in Petri-dishes. The germinated seeds were counted every day and the final germination was calculated as percentage.

2.4 Statistical Analysis

Data were analyzed statistically using MSTAT-C package program and the mean differences were evaluated by Least Significant Difference (LSD) according to [20].

3. RESULTS AND DISCUSSION

3.1 Effect of Irrigation and Mulch on Growth Components

Irrigation, in general, exerted significant positive impacts, in both study years, on some growth parameters like plant height, scape length and diameter, and umbel diameter (Table 1). Mulch also had significant effect on plant height, only for deficit irrigated treatments; full irrigated treatment was not influenced by mulch. Obviously full irrigated treatment had the highest plant height and highest deficit irrigation treatment produced the smallest plant. In general, plant height under all deficit irrigated treatments with mulch produced the taller plants than their respective deficit irrigation treatment without mulch. Though the number of leaves per plant were not significantly affected by irrigation regimes, increasing number of leaves per plant was recorded in higher regime irrigated treatments. The reduction in leaf growth was followed by more reduction in the umbel diameter.

3.2 Effect of Irrigation and Mulch on Seed Yield, Yield Components and Seed Quality of Onion

Deficit irrigation affects crop by reducing grain yield and all yield components (Table 2). The number of effective florets per umbel is a very important component contributing to final seed yield. Highly significant reduction in number and percentage of effective florets per umbel was observed with increasing the magnitude of deficit irrigation. Full irrigation and irrigation up to 80% DSM produced the identical number of effective florets per umbel, though full irrigated treatment produced the highest number of effective floret per umbel. While irrigation up to 40% DSM produced the umbe ls having lower diameter and consequently the lowest number of effective florets per umbel. Both the umbel diameter and effective florets per umbel increased with the increase in irrigation regime. The effect was reverse in case of abortive floret. The number of abortive florets per umbel was significantly increased with the lowering of irrigation regime. The increased number of abortive floret in deficit irrigation treatments was due to the fact that deficit irrigation negatively affects flower pollination by decreasing the amount of viable pollen grain, increasing the unattractiveness of flowers to pollinators, and decreasing the amount of nectar produced by flowers. Consequently crop seed set was reduced.

Table 1. Effect of irrigation and mulching on the growth parameters of onion for seed production

*Treatment	Plant height (cm)	Leaves/ plant (no.)	Flower stalk/plant (no.)	Scape length (cm)	Scape dia. (mm)	Umbel dia. (mm)
2012-2013						
T_1	54.80	19.4	3.6	81.06	14.93	69.00
T_2	54.13	19.3	3.3	80.26	15.00	68.93
T_3	50.20	19.2	3.9	77.13	14.60	68.60
T_4	51.06	19.3	3.5	78.86	14.73	68.80
T_5	46.56	18.7	3.5	71.06	14.87	63.73
T_6	48.6b	18.2	3.3	74.73	14.40	64.20
T_7	44.33	17.3	3.2	68.00	14.00	59.93
T_8	45.26	17.6	3.1	69.60	14.13	60.33
$LSD_{0.05}$	6.14	4.3	0.7	0.75	1.65	6.96
2013-2014						
T_1	56.20	32.33	3.63	82.93	15.00	72.07
T_2	57.00	32.40	4.13	83.00	15.07	71.13
T_3	52.20	30.00	3.80	80.80	14.60	69.93
T_4	54.53	32.20	3.73	82.13	14.87	70.60
T_5	49.47	26.80	3.47	74.73	14.20	65.87
T_6	51.53	28.93	3.50	78.93	14.53	67.60
T_7	43.00	23.93	3.53	71.93	14.87	67.67
T_8	46.00	27.73	3.60	76.40	14.20	65.20
$LSD_{0.05}$	1.22	9.14	0.82	2.04	1.86	4.36

**T_1 = Irrigation up to 100% of deficit soil moisture (DSM), T_2 = Irrigation up to 100% of DSM + straw mulch, T_3 = Irrigation up to 80% of DSM, T_4 = Irrigation up to 80% of DSM + straw mulch, T_5 = Irrigation up to 60% of DSM, T_6 = Irrigation up to 60% of DSM + straw mulch, T_7 = Irrigation up to 40% of DSM, T_8 = Irrigation up to 40% of DSM + straw mulch*

Significant difference (p = .05) was observed on onion seed due to variation in irrigation regimes. The variation in yield ranged from 1040 to 1566 in the first year and yield from 1082 to 1623 kg ha^{-1} in the second year, with minimum in the treatment of 40% DSM without mulch (T_7) and maximum in full irrigated mulch treatment (T_2). The seed yields of the treatments irrigated up to 80% DSM were not statistically different from those that were fully irrigated (up to 100% DSM). The higher number of effective florets per umbel containing relatively higher number of seeds with heavier weights appeared to have contributed to the higher seed yield in the treatments with full irrigation. Application of mulch with deficit irrigation had pronounced positive effect on seed yield compared to mulch with full irrigated treatment. Similar findings were reported by Patil et al. [21] on seed onion and Laribi et al. [22] on caraway who reported that seed yield and its components (number of umbels per plant, number of umbellets per umbel and 1000 seed weight) are severely affected by water deficit.

Analyses of the percentage reduction in yields over the years showed that irrigating onion up to 40% of DSM reduced seed yield by 31.44 to 33.28% in non-mulch and 14.10 to 27.12 % in mulch condition. Irrigating onion at water application up to 60% of DSM caused a yield reduction of about 19.25% and 22.52% in non-mulch and 15.70% and 6.6% in mulch treatment, in the first and second year respectively. On average, compared to full irrigated treatment T_1, seed yield decreased by 32.36% in non-mulch condition and by 20.61% in mulch condition under 40% DSM water regime. Whereas under 60% DSM water regime, decrease in yield was 20.88% and 11.15% in mulch and non-mulch condition, respectively. Only about 4.60% decrease in yield was recorded when irrigation was applied up to 80% DSM. This suggests that water application under mulch condition may be reduced to 80% of water demand without causing a significant lost in seed yield of onion. Under all water regimes, reduction in seed yield was lower in mulch treatments than in non-mulch treatments. It was due to mulch helped to conserve soil moisture, reduce evaporation which resulted in good growth and seed yield of onion. High seed germination is an important characteristic of good seed. Seeds from all treatments exhibited no significant difference between their germination percentages (Table 2), though a variation was observed between different treatments. Usually a germination of 85% is to be desired for good quality seeds. Irrigating up to 100 and 80% of DSM produced the heavier seeds and had germination percentage above 85%. Germination percentage of seeds under 60 and 40% DSM irrigation regimes were slightly below the desired level. In general, higher irrigation regime treatments gave the higher percentage of germination than that of lower irrigation regime treatments. Mulch had no effect on germination percentage at higher irrigation regimes, but a positive effect was found at lower irrigation regimes.

3.3 Soil Moisture Depletion Pattern, Water Use and Water Productivity

Variation of soil moisture was monitored throughout the growing seasons of 2012-2013 and 2013-2014 both in mulched and non-mulched plots. Fluctuation of soil moisture up to 45 cm depth is depicted in Figs. 1a and 1b to give some insight on the soil moisture depletion pattern in mulched and non-mulched plots. It is conspicuous that soil moisture depletion increased with lower irrigation regimes as growing season progress, irrespective of mulch and non-mulch treatments. However, soil moisture depletion slightly decreased with mulching in both the year. Due to reduction of incoming solar energy, less water was evaporated from the mulched plots compared to the non-mulched plots for all the irrigation treatments. Reduction of soil moisture depletion due to mulching was reported by many researchers for many other crops [23-26].

Since no rainfall occurred during the first growing season, total water used by the crop was equal to the applied irrigation water plus contribution by soil water. In the second growing season, 38 mm rainfall occurred of which 32 mm was considered as effective and hence included in total water use. There were little differences in water use between mulched and non-mulched treatments of same irrigation regime. On average, total water used by the mulched treatments was only 3.08% lower than that of the non-mulched treatments in the first year, but in the following

Table 2. Effect of irrigation and mulching on yield variables, yield and quality of onion seed

*Treatment	Effective florets/ umbel (No.)	Seed/ umbel (No.)	Wt of seed/ umbel (g)	1000-seed wt. (g)	Seed yield (kg/ha)	Yield reduction (%)	Germi-nation (%)
2012-2013							
T_1	247.86	916.60	2.92	3.14	1559		86.00
T_2	248.80	914.46	2.87	3.12	1566	-0.45	87.33
T_3	239.13	872.13	2.66	3.10	1473	5.52	87.67
T_4	250.86	911.13	2.91	3.15	1555	0.26	87.00
T_5	203.00	742.46	2.54	3.08	1259	19.24	81.33
T_6	212.86	771.26	2.39	3.03	1314	15.72	82.33
T_7	202.20	661.60	2.17	2.83	1040	33.28	78.00
T_8	208.80	673.33	2.25	2.91	1135	27.12	79.67
$LSD_{0.05}$	27.92	131.90	0.70	0.19	205	-	ns
2013-2014							
T_1	257.57	926	3.05	3.25	1579		96.00
T_2	260.50	931	2.90	3.27	1623	-2.79	97.67
T_3	249.07	907	3.11	3.24	1519	3.80	97.00
T_4	255.60	922	2.92	3.31	1601	-1.39	96.33
T_5	237.77	849	3.00	3.06	1223	22.55	90.33
T_6	242.33	880	2.64	3.11	1475	6.59	91.00
T_7	228.20	767	2.31	3.01	1082	31.44	87.67
T_8	233.83	839	2.60	3.10	1356	14.10	89.33
$LSD_{0.05}$	23.14	129.05	0.67	0.17	176.66	-	ns

T_1 = Irrigation up to 100% of deficit soil moisture (DSM), T_2 = Irrigation up to 100% of DSM + straw mulch, T_3 = Irrigation up to 80% of DSM, T_4 = Irrigation up to 80% of DSM + straw mulch, T_5 = Irrigation up to 60% of DSM, T_6 = Irrigation up to 60% of DSM + straw mulch, T_7 = Irrigation up to 40% of DSM, T_8 = Irrigation up to 40% of DSM + straw mulch; NS indicates "Not Significant" while a value in this row indicates significant difference at $p = .05$

Table 3. Component of water use and water productivity for onion seed production under different water regimes and mulching

*Treatment	Total water applied (mm)	Soil moisture contribution (mm)	Rainfall (mm)	Total water use (mm)	Water productivity (kg m^{-3})
2012 - 2013					
T_1	180	62	0	242	0.65
T_2	167	62	0	229	0.68
T_3	150	63	0	213	0.69
T_4	148	64	0	212	0.73
T_5	134	65	0	199	0.63
T_6	127	64	0	191	0.69
T_7	95	68	0	163	0.64
T_8	89	69	0	158	0.72
2013 - 2014					
T_1	200	51	32	283	0.56
T_2	179	46	32	257	0.63
T_3	159	53	32	244	0.62
T_4	146	49	32	227	0.70
T_5	132	57	32	221	0.55
T_6	127	55	32	214	0.69
T_7	115	67	32	214	0.51
T_8	96	68	32	196	0.69

**T_1 = Irrigation up to 100% of deficit soil moisture (DSM); T_2 = Irrigation up to 100% of DSM + straw mulch; T_3 = Irrigation up to 80% of DSM; T_4 = Irrigation up to 80% of DSM + straw mulch; T_5 = Irrigation up to 60% of DSM; T_6 = Irrigation up to 60% of DSM + straw mulch; T_7 = Irrigation up to 40% of DSM; T_8 = Irrigation up to 40% of DSM + straw mulch*

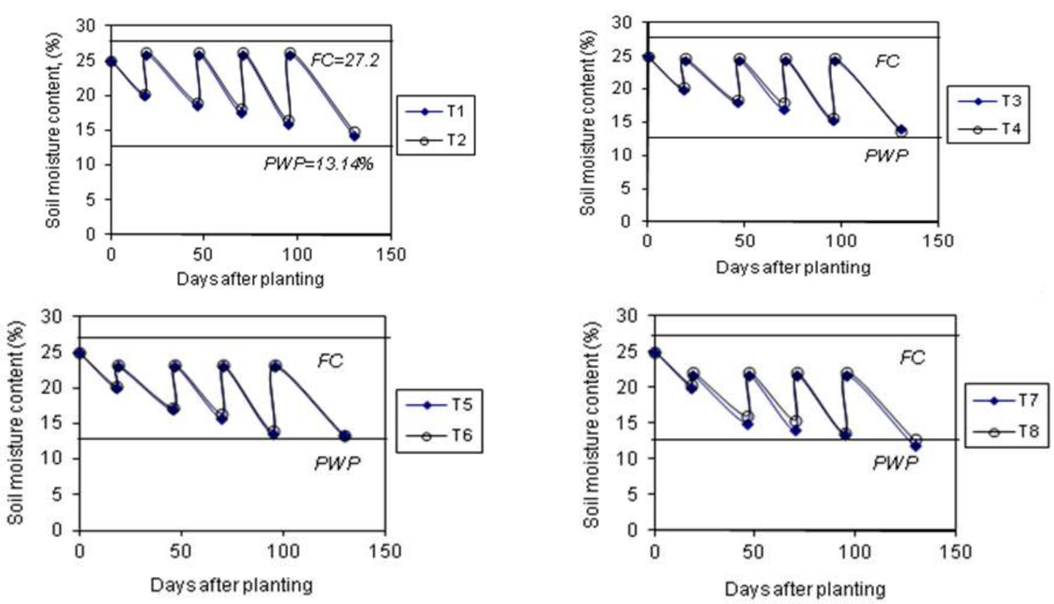

Fig. 1a. Soil water depletion patterns of different water regimes under mulch and non-mulch condition in 2012–2013 season (T_1 & T_2: Full irrigation, T_3 & T_4; Irrigation up to 80% DSM, T_5 & T_6: Irrigation up to 60% DSM and T_7 & T_8: Irrigation up to 40% DSM, under mulch and non-mulch condition, respectively)

year, difference in water used by mulch and non-mulch treatments was recorded as 8.45%. While, in the first year, difference in total water applied between mulched and non-mulched treatment was 4.82% and in the second year it was 9.86%. The variation in TWU and total water applied followed similar trend in both the year, but a difference in their magnitude between the two-study years might be due to difference in soil type, since experiment was conducted in two different soils in two study years. However, the difference between TWU and total water applied was off-set by the soil moisture contribution. There were significant differences in water use among different irrigation water regimes. Total water use ranged from 158 to 241 mm in the first growing season and from 196 to 283 mm in the second growing season with minimum in mulch treatment of 40% DSM and maximum in full irrigated treatment (Table 3). This result implies that water use by the crop was largely influenced by the amount of water application and minimally by mulching. The influence of amount of water application on crop water use was expected, since evapotranspiration is very much dependent on water supply and availability within the plant root zone. Though, it was also expected that the mulching will affect crop water use by reducing the evaporation component of the seasonal evapotranspiration. It could be explained by the fact that the moisture conserved from evaporation may have been used in the transpiration process; hence there was no significant difference in the water use by the mulched and non-mulched treatments of same irrigation regime. Evidence of higher crop water use associated with transpiration in the mulched treatments may be seen from the higher seed yields obtained under mulched treatments compared to the non-mulched treatments since seed yield of onion is very responsive to irrigation. The mulched treatments, in general, provided higher water productivity (WP) than those of the non-mulched treatments. Due to the higher seed yield and comparatively lower amount of water use, the WPs were higher in the mulched treatments. The WP ranged from 0.63 to 0.69 kg/m^3 under non-mulched condition and from 0.68 to 0.73 kg m^{-3} under mulch condition, while it ranged from 0.51 to 0.56 kg/m^3 under non-mulched condition and 0.63 to 0.70 kg m^{-3} under mulch condition in the first and second year, respectively. On average, the water productivity in terms of seed yield per unit water use was found to be the highest (0.715 kg m^{-3}) in the mulched treatment that received irrigation up to 80% DSM with total water use of 220 mm. This treatment also produced near to the highest yield with 22% saving of irrigation water. Therefore, in terms of yield and water saving, irrigating up to 80% DSM with mulch gave the best result for seed production of onion.

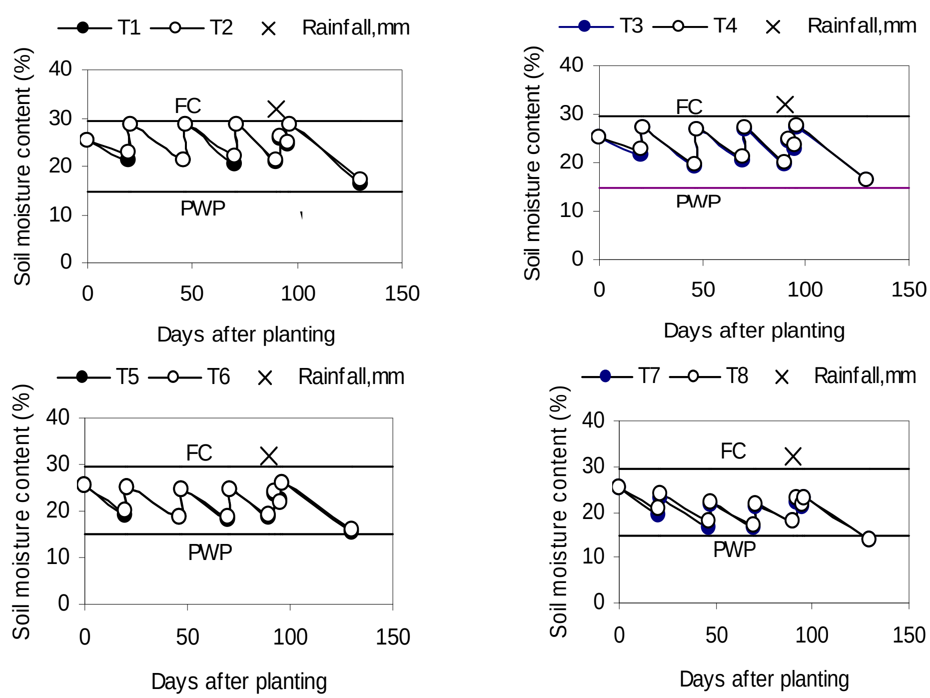

Fig. 1b. Soil water depletion patterns of different water regimes under mulch and non-mulch condition in 2013–2014 season (T_1 & T_2: Full irrigation, T_3 & T_4; Irrigation up to 80% DSM, T_5 & T_6: Irrigation up to 60% DSM and T_7 & T_8: Irrigation up to 40% DSM, under mulch and non-mulch condition, respectively)

4. CONCLUSIONS

Deficit irrigation and mulching with rice straw exerted a significant positive effects on seed yield, water use and crop water productivities of onion crop. Mulching with rice straw gave a yield increase of about 1.36–5.46% compared to non-mulched condition under higher irrigation regimes of 80 and 100% DSM. But a big difference (12-17%) in yield was found between mulched and non-mulched treatments under irrigation regimes of 40 and 60% DSM. Total water use of the onion crop was largely influenced by amount of water applied rather than mulching. Deficit irrigation with mulching gave better water productivity compared to non-mulched condition. The water productivity was found to be the highest (0.71 kg m^{-3}) in mulched treatment that received irrigation up to 80% DSM. Therefore, in terms of yield and water productivity, irrigating up to 80% DSM with straw mulch can be recommended for seed production of onion.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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