season in the area. Results obtained were in agreement with those reported by Doorenbos and Kassam (1979). They reported, $K_y < 1.0$ indicates that the decrease in yield is proportionally less with increase in water deficit, while yield decrease in proportionally greater when $K_y > 1.0$.

Table 8. Deficit irrigation effect on yield response factor of Onion

Treatments (T)	Yield (t/ha)	ET_a (mm)	$\frac{ETa}{ETm}$	$\frac{Ya}{Ym}$	$1-\frac{ETa}{ETm}$	$1-\frac{Ya}{Ym}$	K_y
T1	21.30	826.4	1.00	1.00	0.00	0.00	-
T2	19.14	702.4	0.85	0.90	0.15	0.10	0.68
T3	17.36	578.5	0.70	0.82	0.30	0.18	0.62
T4	15.18	413.2	0.50	0.71	0.50	0.29	0.57
T5	17.13	563.2	0.68	0.80	0.32	0.20	0.61
T6	12.86	320.1	0.39	0.60	0.61	0.40	0.65

$1-\frac{ETa}{ETm}$ *= Relative evapotranspiration deficit,* $1-\frac{Ya}{Ym}$ *= Relative yield reduction,* ET_a *= the net depth of irrigation applied for each deficit treatments (mm),* ET_m *= the net depth of irrigation water applied for the control treatment with full irrigation (mm),* K_y *= Yield response factor.*

Stressed treatments with irrigation application under T2, T3, T4, T5 and T6 showed a yield reduction of 10%, 18%, 29%, 20% and 40% respectively compared with the 100% ETc (T1) irrigation water application. This indicates a linear relationship between the decrease in relative water use and the decrease in relative yield (Figure 10). It also, clearly shows the effect of water deficit on crop yield. In other words, it describes the decrease in yield caused by the per unit decrease in water consumption. This relation is closely in line with Bhagyawant *et al.* (2015) who reported that there is a linear relationship between the decrease in relative water consumption and the decrease in relative yield.

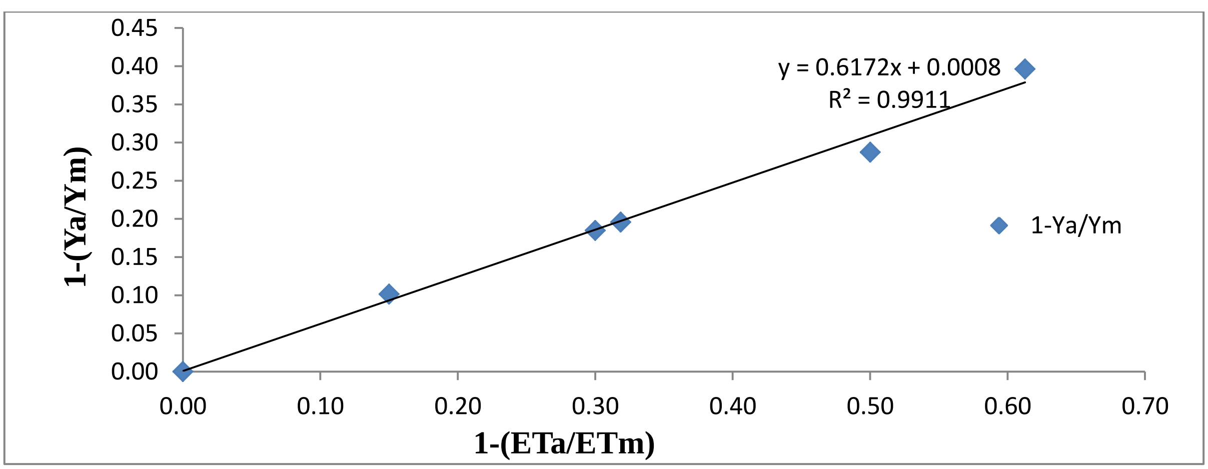

Figure 8. The relationship between relative yield reduction and relative evapotranspiration deficit for Onion.

In general, the results of this study reveals, increasing water deficit throughout the whole growing season caused decreasing of K_y values, but increasing water deficit during a specific growth stages (initial, development, mid and late stages) caused increasing of K_y values.

3.7 Economic Analysis

The partial budget analysis revealed that the highest net benefit of Birr 191368.09 per hectare with higher cost was recorded from T1 with marginal rate of return 290.91% which was followed by net benefit of Birr 173959.54 per hectare from T2 with marginal rate of return 246.21%. However, the highest net benefit of Birr 160365.03 per hectare with least cost production of about Birr 27155.37 per hectare was obtained from T3 with its marginal rate of return 271.02 %.This means that for every Birr 1.00 invested in T3, growers can expect to recover the Birr 1.00 and obtain an additional Birr 2.7102. The minimum acceptable marginal rate of return (MRR %) should be between 50% and 100% CIMMYT (1988). Thus, the current study indicated that marginal rate of return is higher than 100% (Table 11). This showed that all the treatments are economically important as per the MRR is greater than 100%. Hence, the most economically attractive for small scale farmers with low cost of production and higher net benefit was obtained by application of T3 under conventional furrow irrigation system. However, for resource full producers (investors) and in areas where water is not limiting factor for crop production, application of 100% (T1) is highly profitable with higher cost which is recommended as a second option.

Table 9. Economic analysis of Onion production under different deficit irrigation treatments

Treatments (T)	Irrigation Water Applied (m^3/ha)	Marketable Bulb Yield (t/ha)	Adjusted bulb yield (t/ha)	Total Return (Birr/ha)	Variable cost (Birr/ha)	Net Income (Birr/ha)	MRR (%)
T1	13775.0	21.30	19.17	230029.20	38661.11	191368.09	290.91
T2	11708.8	19.13	17.22	206636.40	32676.86	173959.54	246.21
T3	9642.5	17.36	15.63	187520.40	27155.37	160365.03	271.02
T4	6887.5	15.18	13.66	163890.00	19423.15	144466.85	471.43
T5	9388.7	17.13	15.41	184950.00	26462.59	158487.42	199.17
T6	5335.7	12.85	11.56	138747.60	15023.25	123724.35	-

MRR = Marginal Return Rate

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

This study was proposed to investigate the deficit irrigation effect on yield and water productivity of Onion under conventional furrow irrigation system. The field experiment consist of six treatments with different level of deficit irrigation water application throughout crop growth season and at different growth stages (T1 = 100% ETc, T2 = 85% ETc, T3 = 70% ETc, T4 = 50% ETc, T5 = 100% ETc Is 85% ETc Ds 70% ETc Ms 50% ETc Ls and T6 = 85% ETc Is 70% ETc Ds 50% ETc Ms 0% ETc Ls irrigation water application levels).The treatments were assigned in Randomized Complete Block Design with four replications.

As result revealed that, all DI treatments had highly significant effect ($p < 0.01$) on vegetative growth, yield, yield components and water use efficiency of Onion. Thus, total Onion bulb yield and WUE was varied under different deficit irrigation levels. The highest and the lowest bulb yield were recorded from T1 and T6 respectively. Similarly, the highest IWUE and CWUE were obtained from T6 while the lowest one recorded from T1. But, at T6, T4 and T5 high yield reduction was recorded which may not be attractive for producers. Therefore, it could be concluded that 70% ETc can solve the problem of water shortage and would ensure the opportunity of further irrigation development in the study area and similar agro-ecology.

4.2 Recommendations

Based on the study and the results obtained on yield, yield components and water productivity of Onion, the following important recommendations were made:

- In the study area water scarcity is the major limiting factor for crop production. So, it is possible to get better yield and water productivity of Onion when we apply 70% ETc irrigation water application throughout growing season under conventional furrow irrigation system.
- To achieve maximum Onion bulb yield in areas where water is not scarce, applying 100% ETc irrigation water application level throughout whole growing season under conventional furrow irrigation system is recommended.
- Since this experiment is a one season study in a single location, further research over locations and seasons is necessary to confirm the present results.

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