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Effect of moisture stress level on yield and water productivity of common bean (*Phaseolus vulgaris* L.) at Melkasa, Central Rift Valley of Ethiopia

Efecto del nivel de estrés hídrico sobre el rendimiento y la productividad del agua del frijol común (*Phaseolus vulgaris* L.) en Melkasa, Valle Central del Rift de Etiopía

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Article Data

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Abstract

A field experiment was conducted in Ethiopia to investigate the impact of different irrigation water levels on common bean yield and water productivity under limited water resources. The experiment involved 7 moisture levels ranging from 100 to 35 % of crop evapotranspiration. The results showed that grain yield decreased as water stress increased, with the highest grain yield of 3004 kg ha^{-1} achieved at 100 % ETc and the highest water productivity of 1.16 kg m^{-3} at 35 % ETc. Dry biomass, harvest index, and 1000 seed weight were also affected by water stress. However, the grain yield obtained with 75 % ETc did not differ significantly from the yields obtained with 85 or 100 % ETc. Similarly, the weight of 1000 seeds and pods per plant did not significantly differ between 75, 85, and 100 % ETc. The water productivity observed at 75 % ETc was significantly higher than at 85 and 100% ETc. Therefore, the study suggests that the common bean variety SER-119 can be irrigated at 75 % ETc to increase water productivity without a significant reduction in yield and yield components in a water-stressed environment.

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Resumen

En Etiopía se llevó a cabo un experimento de campo para investigar el impacto de diferentes niveles de agua de riego sobre el rendimiento de la judía común y la productividad del agua en condiciones de recursos hídricos limitados. El experimento incluyó 7 niveles de humedad que oscilaban entre el 100 y el 35% de la evapotranspiración del cultivo. Los resultados mostraron que la producción de grano disminuía a medida que aumentaba el estrés hídrico, alcanzándose la mayor producción de grano de 3004 kg ha^{-1} con un 100 % de ETc y la mayor productividad del agua de 1.16 kg m^{-3} con un 35 % de ETc. La biomasa seca, el índice de cosecha y el peso de 1000 semillas también se vieron afectados por el estrés hídrico. Sin embargo, el rendimiento de grano obtenido con 75 % ETc no difirió significativamente de los rendimientos obtenidos con 85 o 100 % ETc. Del mismo modo, el peso de 1000 semillas y vainas por planta no difirió significativamente entre 75, 85 y 100 % ETc. La productividad del agua observada al 75 % ETc fue significativamente mayor que al 85 y 100 % ETc. Por lo tanto, el estudio sugiere que la variedad de judía común SER-119 puede regarse al 75 % de ETc para aumentar la productividad del agua sin una reducción significativa del rendimiento y de sus componentes en un entorno con estrés hídrico.

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Palabras clave:

Frijol común,
estrés hídrico,
productividad hídrica,
componentes del rendimiento.

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Introduction

Water shortage is one of the greatest challenges of the twenty-first century. Increasing population, agriculture reduction of water quality, and inappropriate government policies are the important reasons for water scarcity[1].

Irrigation demands or consumes about 70 % of the total developed water supply of the world. Many people believe that current irrigation systems are so inefficient that most, if indeed not all of the future needs for water by all sectors could be met by increasing the efficiency of irrigation and transferring the water saved in irrigation to the domestic, industrial, and environmental sectors[2,3]. The cultivated land in Ethiopia is mostly rain-fed agriculture and subsequently, the variability of rainfall during the cropping season affects crop production and productivity[4].

Rising temperatures increase the rate of evaporation from land and surface water resources; this has caused reductions in river run-off in arid and semi-arid areas. Water scarcity does not only occur in arid and semi-arid areas but also occurs in areas that receive ample rainfall and/or have abundant freshwater resources[5,6].

In Ethiopia, irrigation development is increasingly implemented more than ever to supplement rain-fed agriculture and to increase agricultural productivity in addition to diversifying the production of food and raw materials for agro-industry as well as to ensure agriculture plays a pivot in driving the economic development of the country. Legume crops are an important component of many agricultural systems and are a major contributor to global food systems. Common bean (*Phaseolus vulgaris* L.) is planted worldwide on approximately 26 million hectares[7] and it is the most widely grown legume crop in Ethiopia. It is an important source of food, income, and soil fertility management[8]. It is largely cultivated by smallholder farmers as a cash crop in the Rift Valley area, and in the southeastern and southwestern parts of the country, as a sole crop or intercropped with non-legumes, such as maize, sorghum, enset, and coffee[9].

In Ethiopia, the average yield of common bean production reported at the national level remains far below the potential yield to be attained. Like other plants, the development and productivity of beans are adversely affected by biotic and abiotic stress factors[10]. Moisture stress (MS), which results from periodic dry spells during the growing season, is among the limiting factors for common bean production worldwide[11]. Although Water stress affects crop growth and productivity in many ways, most of the responses harm production. Decreasing of water level in common bean minimizes cell turgor, which, in turn, reduces leaf expansion, induces stomata closure, and reduces plant physiological processes, ultimately compromising grain production. Several crops and genotypes have developed different degrees of drought tolerance, drought resistance, or compensatory growth to deal with periods of stress such as the early maturing technique which is useful in adapting to stresses, particularly midseason stress. The highest crop productivity is achieved for high-yielding varieties with optimal water supply and high soil fertility levels, but under conditions of limited water supply, crops will adapt to water stress and can produce well with less water[12]. Moderate to high MS can reduce yield and yield components of common bean-like: biomass, seed weight, number of pods, harvest index (HI), and seed yield[13]. High-yielding of common beans can be obtained under sufficient irrigation conditions. Nevertheless, limited irrigation can considerably overcome the harmful effect of drought stress on field performance[14].

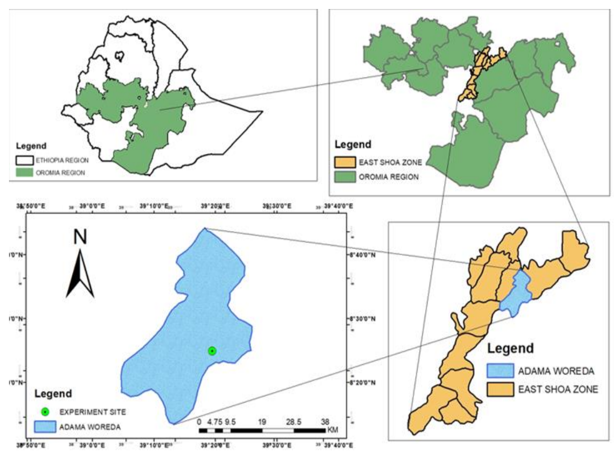
It is believed that an increase in water productivity (WP) is the key approach to mitigate water shortage and reduce environmental problems in arid and semiarid regions. In dry areas, water, not land, is the most limiting resource for improving agricultural production. Maximization of yield per unit of water (WP), and not yield per unit of land (land productivity), is, therefore, a better strategy for dry farming systems[15]. Irrigation water management techniques like deficit irrigation can contribute to the increase of grain yield and WP of common beans under water stress conditions since common bean crops can respond to soil MS depending on the severity of water stress[7]. The purpose of this study was to identify the optimum soil MS levels without a significant decrease in a final yield by improving the WP of common bean crop production.

Materials and methods

Description of the experimental sites. The field experiment was conducted at Melkassa Agricultural Research Center; MARC. The area lies at about 107 km from Addis Ababa in East Shoa zone, 17 km Southeast of Adama town at 8°24′56″N - 8°25′26″N latitude, 39°20′51″E - 39°22′63″ E longitude, and the average altitude of 1550 m (masl). The site is located in the central rift valley of Ethiopia in Awash River Basin (Figure 1). Loam and clay loam soil textures were the dominant soils of the area.

Experimental design and procedure. The experimental field was plowed with tractors. Then the land was leveled by land levelers to create a suitable slope for the experiment. After the land was leveled, ridge preparation was made with the ridge makers spaced at 60 cm using tractors. The experimental area was divided into 3 blocks having free space between each plot and replication. Each block was subdivided into 7 experimental units (EU). Once the layout was prepared, the main canal outside the experimental field and field channels were constructed to convey irrigation water. Water diverted from the Awash River was used as a source of irrigation water for the experimental study.

Figure 1 Map of study area



The study was conducted using the furrow irrigation water application method and it includes six MS levels, viz., 85, 75, 65, 55, 45, and 35 % crop evapotranspiration (ETc) and control irrigation of 100 % ETc. A total of 7 treatments. Control irrigation implies the amount of irrigation water applied by the computed crop water requirement with the aid of the CROPWAT program to refill the soil to its field capacity. The experiment was laid out in a randomized complete block design (RCBD) with 3 replications resulting in 21 plots. Blocking was done across the slope following the gradient of the experimental site. The bunds around individual plots were firm enough to control water movement between plots. Once the layout was prepared, the minimum canal outside the experimental field and field channels were constructed to convey irrigation water.

The amount of water applied to each treatment was determined based on the plot area and gross irrigation requirement. As soon as the water was introduced into the plot, the time required to apply the desired depth of water was calculated with the aid of a stop-watch. The irrigation scheduling was done based on the full irrigation treatment, and the rest of the treatment was taken as the assigned percentage of each treatment of full irrigation. The plots and replications had buffer zones of 2 and 3 m, respectively.

Common bean variety (SER-119) was used for the study. Plot size of 4 x 3.6 m consists of 7 ridges spaced at 60 cm. Each experimental treatment was fertilized with the recommended fertilizer application for common beans in the area, which was 27 kg ha^{-1} and 69 kg ha^{-1} of N and P_2O_5 respectively[16]. For yield and aboveground biomass, all Common beans excluding the outside rows and the end 10 cm of the plot both sides (3.8 x 2.4 m) areas were harvested. The grain moisture content was determined in the laboratory.

Data collection and measurement. The common above-ground dry biomass was determined by harvesting all plants from the net plot and weighting after sun drying to constant weight. The moisture content of the samples was estimated by drying the plants after taking fresh weight in an oven at a temperature of 70º C for 24 h. Finally, the result obtained from the net plot area was converted to a hectare base. Data on the yield of each experimental unit was collected by weighing the yield obtained after trashing and converted to hectares. Yield was adjusted to standard moisture of 12.5 % using the formula[17]. Thousand numbers of common bean grains were counted from each plot and weighed. The number of pods per plant was determined from the mean of 5 randomly selected common bean plants per plot. 10 randomly selected common bean pods from each plot were used to determine the mean seed per pod. HI was calculated as the ratio of grain yield to total aboveground dry biomass Yield multiplied by 100.

$$HI = \frac{GY}{AgBM} * 100\ \%$$

Where Gy is grain yield and AgBM is above ground dry biomass. The water productivity was calculated by the ratio of harvested yield per seasonal net amount of water used.

$$WP = \frac{\text{yield(Kg)}}{\text{Seasonal net amount of water(}m^3\text{)}}$$

Statistical analysis. Collected data were subjected to ANOVA using R software (version 4.0.0) and multiple linear regressions (MLR) were used to see the association of common bean yield, yield components, and WP.

Results

Soil Physico-chemical properties. The result of soil analysis showed that the soil texture of the experimental site was classified as loam soil from particle size analysis per root depth of 60 cm for common bean. The average pH value of the soil ranges from (7.25-7.52). The average soil pH of the study site was 7.34 (Table 1). The soil test results also displayed that the average available phosphorus (11.32 ppm) was in the medium ranges (9.25-20.15 ppm) According to USDA soil classification, soil with electrical conductivity of less than 2.0 dS m-1 at 25° C and pH less than 8.5 are classified as normal soil. The average value of organic matter (OM) content was found to be 1.67 % indicating that OM could be rated as moderate and that the field had an average structural condition with average structural stability. From the analysis of irrigation water in the study area, that pH value of 7.54 and ECw value of 0.372 dS m-1 were obtained (Table 1). Irrigation water quality of the experimental area was classified as medium salinity level.

Crop water requirement of common bean. Seasonal crop water requirement varies based on the treatment level. A common irrigation depth of 23.85 mm was applied for all treatments. The maximum and minimum seasonal crop water requirement obtained was

439.77 mm and 169.42 mm at 100 and 35 % ETc, respectively (Table 2).

Table 1 Soil chemical properties of the experimental site

Soil depth (cm)	pH	CEC (mEq/100)	EC (dS m^{-1})	TN (%)	%TOC	Av.P (ppm)	% OM
0-15	7.25	26.84	.18	.09	1.19	10.94	2.04
15-30	7.27	28.4	.21	.1	1.12	12.17	1.93
30-45	7.35	28.6	.23	.07	.85	13.44	1.47
45-60	7.52	25.06	.25	.05	.71	8.74	1.22
Average	7.34	27.23	.22	.08	.97	11.32	1.67
Irrigation Water chemical properties							
pH			7.54				
ECw (dS/m)			.372				

pH=pH of soil and water, EC=electrical conductivity of soil, ECw=electrical conductivity of water, OM=organic matter, TOC=Total organic carbon, TN= Total nitrogen, Av. P (ppm) =average phosphorous and CEC=cation exchange capacity

Table 2 Seasonal net irrigation water depth applied for each treatment

Date	Irrigation amount of each treatment (% ETc)						
	100	85	75	65	55	45	35
3/9/2022	23.85	23.85	23.85	23.85	23.85	23.85	23.85
3/17/2022	37.00	31.45	27.75	24.05	20.35	16.65	12.95
3/30/2022	34.03	28.93	25.52	22.12	18.72	15.31	11.91
4/6/2022	37.42	31.81	28.07	24.32	20.58	16.84	13.10
4/14/2022	41.30	35.11	30.98	26.85	22.72	18.59	14.46
4/19/2022	43.72	37.16	32.79	28.42	24.05	19.67	15.30
4/25/2022	68.63	58.34	51.47	44.61	37.75	30.88	24.02
5/6/2022	58.44	49.67	43.83	37.99	32.14	26.30	20.45
5/15/2022	47.69	40.54	35.77	31.00	26.23	21.46	16.69
5/23/2022	47.69	40.54	35.77	31.00	26.23	21.46	16.69
Total(mm)	439.77	377.38	335.79	294.20	252.61	211.01	169.42

ETc=crop evapotranspiration.

Thousand seed weight. For irrigation water level applied, a highly significant difference ($p<0.01$) was observed among treatments on mean thousand seed weight of common bean and ranges from 255 to 196.7 g (Table 3). Even though the maximum thousand seed weight was observed under 100 % crop water requirement (255 g), it was statistically similar with 85 % ETc (250 g) and 75 % ETc (240 g) Irrigation applications level of 65, 55, 45, and 35 % ETc has no significant differences on thousand seed weight among each other. However, the lowest thousand seed weight of 196.7 g was obtained from 35 % ETc (Table 3). Shortage of soil moisture, leading to underperformance of seeds and finally, 1000 seed weight decrease.

Number of pods per plant and seeds per pod. The result on the number of pods per plant showed that there is a very high significant difference ($P<0.001$) from one treatment to another. Number of pods per plant ranges from 13. 67 to 22.55 and 100 % ETc had the highest (22.55) followed by 85 % ETc which was not statistically different. On the other hand, 35 % ETc treatment had the lowest number of pods per plant (13.67). Treatment 75 and 65 % ETc did not show a significant difference (Table 3).

There was a significant ($P\leq0.05$) difference between treatments on the number of seeds per pod. Treatment with the significantly highest number of seeds per pod was 100 % ETc (6.50). While the lowest (5.34) number of seeds per pod from stressed treatment (35 % ETc) was recorded. The remaining treatment had a moderate number of seeds per pod and they were statistically similar (Table 3).

Table 3 Influence of moisture stress, between common bean yield, and yield components

Treatment (% ETc)	Thousand seed weight (g)	Pod Per plant	Seed per pod
100	255[a]	22.55[a]	6.500[a]
85	250[a]	21.22[ba]	6.360[a]
75	240[ba]	20.11[bc]	5.900[ba]
65	220[bc]	18.8[dc]	5.480[ba]
55	213.3[c]	17.55[de]	5.360[b]
45	200[c]	16.44[e]	5.350[b]
35	196.7[c]	13.67[f]	5.34[b]
$LSD_{(0.05)}$	25.7	2.19	.713
CV (%)	6.42	6.62	6.96

CV=Coefficient of variation, LSD=least significant difference

Table 4 Effect of moisture stress on yield, biomass, and harvest index and water productivity of common bean

Treatment (% ETc)	Grain yield (kg ha^{-1})	Biomass yield (kg ha^{-1})	Harvest index	WP (kg m^{-3})
100	3004.4[a]	6057.13[a]	.50[a]	.68[e]
85	2881.4[a]	6041.60[a]	.47[ba]	.75[e]
75	2796.1[ba]	6037.30[a]	.46[bac]	.83[d]
65	2565.8[bc]	5806.80[ba]	.44[bdc]	.87[d]
55	2426.9[dc]	5670.00[bc]	.43[edc]	.96[c]
45	2276.7[de]	5483.80[c]	.42[ed]	1.08[b]
35	1970.3[e]	5448.00[c]	.36[f]	1.16[a]
$LSD_{(0.05)}$	247.75	297.9	.04	.083
CV (%)	5.46	2.89	5.41	5.15

ETc= crop evapotranspiration, WP=water productivity

Grain yield. The analysis of variance indicated that soil MS had a very high significant ($p<0.001$) effect on the grain yield of common beans. The results revealed that the mean grain yield of common bean increased as the level of stress decreased. Unstressed treatment 100 % ETc produced the highest yield (3004 kg ha^{-1}) and was statistically related to treatment stressed by 15 and 25 % (Table 4). From the current study Lowest yield was observed from treatment stressed by 65 % ETc (1970.3 kg ha^{-1}) which is a 34.4 % yield reduction compared to non-stressed treatment. As a result, MS during different growth stages of common beans reduced grain yield largely due to the reduction in yield components, like several pods/plant, thousand seed weight, and seeds/pod. The results, obtained from this experiment showed that the reduction of irrigation water level by 25, 35, 45, 55, and 65 % from the full irrigation treatment reduced grain yield production per hectare by 6.93, 14.6, 19.22, 24.22 and 34.4 % respectively.

The relation between grain yield and MS level indicated that there was a polynomial relationship and the decline in grain yield was more prominent beyond the MS level of 75 % ETc (Figure 2). Similarly, the amount of irrigation depth had a non-linear relation with the grain yield (Figure 3).

Above-ground biomass yield. MS level had a highly significant influence ($p<0.01$) on common bean above-ground dry biomass production. Maximum above-ground dry biomass (6057.13 kg ha^{-1}) was obtained under non-stressed treatment (100 % ETc) followed by treatment stressed by 85 % (6041.6 kg ha-

[1]) and had the same statistical value with 75 % ETc (Table 4). The minimum above-ground biomass was recorded from 35 % ETc (5448 kg ha^{-1}). The decreased aboveground biomass in moisture-stressed treatments might be due to the reduction in photosynthesis in which the amount of water and chlorophyll is important.

Figure 2 Effect of moisture stress level on grain yield reduction

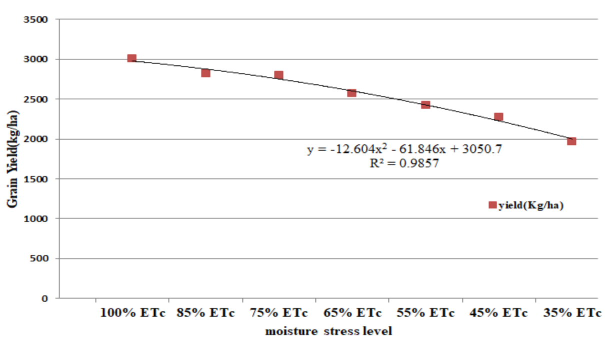


Figure 3 Relationship between grain yield and seasonal irrigation depth

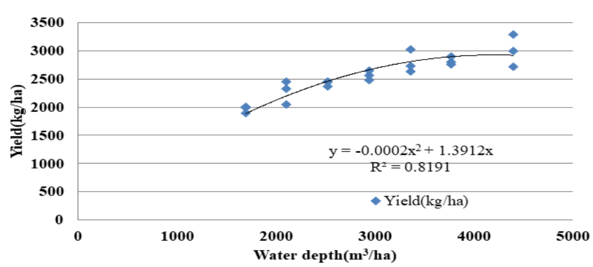
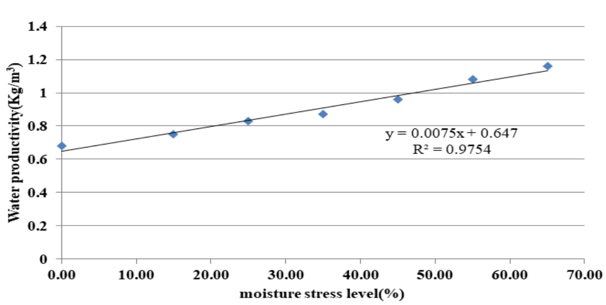


Figure 4 Effect of different levels of moisture stress on water productivity of common bean



Harvest index. Is the proportion of the percentage of grain yield to total ground dry biomass, from this finding, the HI was highly significantly influenced ($p<0.01$) by variation in MS level. The maximum HI (0.50) was obtained from the treatment that received optimal irrigation Table 4. However, this value was not statistically different from that treatment received 75 % and 85 % of its crop water requirements. The minimum HI (0.36) was obtained under 35 % ETc treatment.

Water productivity. Applying 35 % of the full irrigation resulted in the highest WP 1.16 kg m^{-3} (Table 4). While the lowest was obtained from the treatment received full irrigation (0.68 kg m^{-3}). Treatment stressed by 25 % of its crop water requirement has a significant difference with irrigation application of 100 and 85 % ETc. The lower WP at 100 % ETc might be attributed to the higher irrigation water depth applied, much of which was lost through soil evaporation and deep percolation. Compared to 100 % ETc, the application of 75 % ETc treatment resulted in an improvement of WP by 22.1 % with a yield loss of 6.93 %. While 35 % ETc improved the WP of common beans by 70.6 % compared to 100 % ETc with a yield loss of 34.4 % (Table 5). From this it can be observed that increasing the area irrigated with the water saved would compensate for the yield loss due to deficit irrigation.

Increasing the area irrigated with the water saved could compensate for any yield loss because of the MS. 85, 75, 65, 55, 45, and 35 % ETc could compensate for the yield reduction occurred and resulted in additional yield (426.32, 710.24, 994.45, 1278.5, 1562.68, and 1847.1 kg ha^{-1}) than the control with the saved 14.19, 23.64, 33.10, 42.56, 52.02 and 61.48 % of water, respectively (Table 5).

Regression of yield and yield components. The MLR was conducted with JMP software version 16. The fitted multiple regression analysis showed that biomass yield, HI, WP, and 1000 seed weight had significantly ($p<0.01$) affected the common bean grain yield (Table 6). The data revealed that as the parameters, like seed weight, biomass yield, HI, and WP increased, grain yield production improved strongly.

Table 5 Influence of moisture stress level on yield reduction and water productivity

Treatment (% ETc)	Water Productivity Improvement (%)	Relative Water Saved (%)	Relative yield reduction (%)
100	-	-	-
85	10.3	14.19	4.1
75	22.1	23.64	6.93
65	27.9	33.10	14.59
55	41.2	42.56	19.22
45	58.9	52.02	24.22
35	70.6	61.48	34.4

Y = 0.467TSW + 71.58WP + 5745.57HI + 0.456BY– 2787.15(22)
(R-squared = 0.99) Where: Y is common bean yield (kg/ha), WP is water productivity (kg/m^3), HI is harvest index, BY is biomass yield (kg/ha) and R^2 is coefficient of determination.

Table 6 Regression analysis of common bean yield as affected by yield components

Predictor variables	Coefficient	Std Error	t Ratio	P value
Intercept	-2787.15	116.596	-23.90	<.0001
BY	.456	.0139	32.90	<.0001
HI	5745.57	66.809	86.00	<.0001
WP	71.572	26.565	2.69	.0160
TSW	.467	.156	3.00	.0085

BY=biomass yield, HI=harvest index, WP=water productivity, TSW=thousand seed weight

Discussion

The results of soil bulk density showed that it increases with soil depth since subsurface layers are more compacted and have less organic matter, less aggregation, and less root penetration compared to surface layers, therefore containing less pore space[18]. The average total organic carbon content of the testing soil is 0.97 % (Table 2) which is rated as moderate and gives average structural condition and stability to the soil[7]. Reported that drought stress, on average reduced common bean 100 seed weight by (13 %)[19]. A decrease in grain yield and mean weight of a hundred seeds along with accelerated maturity among these characteristics. Reported that the minimum thousand seed weight of wheat may be due to the lack of translocation of food processed in photosynthesis as insufficient amount of water in the root zone relative to other treatments[20,21]. Also revealed that thousand seed weight of maize crop increased as the amount of irrigation water increased[5,6]. The decrease in seed yield and related traits (seed number per head, 1000 seed weight, and head diameter) was more pronounced under water stress condition[22]. Treatment which received 65, 55, and 45 % of crop water requirement were statistically similar for seed per pod. This finding was consistent with[23,24] and who also identified the effect of MS on the number of seeds per pod and pod per plant[25], especially for beans stressed at flowering and pod-filling stages[23-25]. Reported that the reduction in the number of seed per pod and pod per plants leads to 29.8 % yield reduction in stressed treatment relative to non-stressed treatment[26]. In agreement with this, from a study conducted on chickpea, concluded that the higher reduction in the number of pods per plant and seeds per plant by at lower moisture regime could be because of the failure of some pods and seeds to develop due to severe water stress condition during the reproductive period[27].

Regarding the yield of common bean, many researchers[23,28,29] reported that grain yield and yield components were directly associated with the MS level, when the stress level increase, the grain yield became small. Likewise, from research conducted on maize[6] and wheat[20], it was reported that as MS level increased, the yield of the crop was declined, which agreed with this finding.

Moisture is an essential influence for shoot development of common bean crop and corresponds with the findings of[23,30]. Shoot biomass accumulation is considered an important trait to attain high seed yield in grain legumes. Concluded that he reasons for the increase in total dry matter production in plants under optimum irrigation was the extension of leaf area and its higher durability that provided enough physiological resources to take advantage of received light and therefore produce more dry matter[31]. Also reported that plant above ground dry weight was decreased as the increased of water stress levels[6].

HI decreased as irrigation water application level decreased (Table 4). Similar ideas showed that HI is reduced with stress, especially during the reproductive plant growth stage when stress may cause flower abortion and poor grain filling[32]. Found significant HI differences among genotypes of Kabuli chickpea under field conditions where late maturing genotypes resulted in lower HI[33]. The significant impact of the MS on common bean HI was in line with the finding of[31] on mungbean, which indicated that HI tends to be low when the crop is stressed at the grain filling stage. Moreover, reported that increasing irrigation from 25 to 100 % ETc increased the HI of maize be cause grain formation was highly and strongly affected by moisture content[6].

The different soil MS levels on common bean have shown a very highly significant ($p<0.001$) influence on WP. This finding was in agreement with a different author[35], investigated the maximum of onion WP was achieved at a water supply level that is lower than the control (maximum water), which gave the maximum bulb yield. Also reported that the minimum WP resulted for 100 % ETc may be due to higher irrigation water use, much of which was lost through soil evaporation and deep percolation[20,21]. However, in stressed treatments, irrigation water might be used for productive purposes in the crop effectively. The data revealed that WP is associated positively with stress levels (Figure 4).

As conclusion, the highest common bean grain yield, dry biomass yield, thousand seed weight, seed per pod, pod per plant, and HI were obtained from treatment receiving full irrigation (100 % ETc), However treatment application of 85 % of its full crop water requirements resulted in statistically similar average grain yield, biomass yield, HI, seed per pod and thousand seed weight with 100 % ETc. While, treatments stressed by 35, 45, 55, and 65 % had less yield and yield components than the rest treatment due to increasing stress level. Treatment stressed by 25 % resulted in relatively good grain yield compared to those treatments stressed from 35 to 65 %. Even though MS at any level decrease the yield and yield parameter of common bean, grain yield was not significantly affected until irrigation water reduced to 75 % ETc.

The reduction in irrigation water amount by 65 % leads to a reduction of grain yield by 34.4 %. Maximum and minimum grain yield of 3004.4 and 1970.3 kg ha^{-1} was obtained at 100 and 35 % ETc, respectively. Maximum above ground biomass of 6057.13 kg ha^{-1} was obtained at 100 % ETc and a minimum of 5448 kg ha^{-1} at 35 % ETc. Regarding WP treatment stressed by 25 % of its crop water requirement has significant difference with irrigation application of 85 and 100 % ETc, the application of 75 % ETc treatment resulted an improvement of WP by 22.10 % with yield loss of 6.93 %. Therefore, reducing irrigation water leads to improving WP with insignificant yield loss at 75 % ETc that leads to save 25 % of irrigation water for MS area. WP increased by 70.6 %, from 0.68 to 1.16 kg m^{-3} as irrigation water reduced from control to 35 % Etc. Additionally, practicing irrigation with MS level for farming community save irrigation water to cultivate additional farmland and/or for industrial, commercial or public purposes and increases frequency of cultivation for common bean production on loamy soil under limited water condition.

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Conflicts of interest

There is no conflict of interest among the authors.

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Ethical considerations

We hereby declare that this work was not submitted to other journal publishers for possible publication. We further state that there was no scientific irregularity in the results

Authors' contribution

Addisu Asefa, developed the proposal and conducted the research experiment, analysis the data, Wrote the conducted research, and *Abraham Woldemichael* and *Shimelies Asseffa* analyzed, read and approved the final manuscript.

Research limitations

All data generated and analyzed during this study are included in this manuscript.

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