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The effect of living mulch (Mung bean plant) and silica on integrated weed management in sorghum

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ABSTRACT
Silica can increase the resistance of plants against the abiotic stress like drought stress. Furthermore, living mulch can increase the quality of fodder sorghum and also positively control the growth of weeds. The study was conducted to evaluate the effect of the cumulative application of silica and living mulch on various growths attributes of Sorghum (Sorghum bicolor L.) under drought stress condition. The split plot factorial experiment based on randomized complete blocks design was used with three replications in two successive years (2017 and 2018) at the research farm of Islamic Azad University, Varamin Branch, Tehran, Iran. Three irrigation intervals viz 60, 120 and 180 mm evaporation from class A evaporation pan was applied as the main factor while silica levels i.e. 0 (not used), (Spreading silica with a ratio of 3×1000 L in three steps and silica irrigation fertilizer at a rate of 10 liters per hectare in three times) and living mulch (Vigna radiate L.) containing three levels (not used, use living mulch and control weeds and without mulch and complete weed interference) was used as a sub factor. Results of combined analysis of variance showed that indicated that the effect of irrigation period, application of living mulch and silica fertilizer were significant on total protein yield, total fresh and dry weight.The use of living mulch when the irrigation interval reached 60 mm evaporation from plan A could reduce 57% of the fresh weight of weeds respectively. Crude protein was significantly (P < 0.01) affected by irrigation levels, living mulch and silica.
Key words: living mulch, weed, drought stress, silica, CP&total yield

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INTRODUCTION

Sorghum is one of the important silage crops possessing an increasing popularity because of low water requirement in comparison with other fodder especially corn [11]. Environmental stresses as well as weeds are the causative agents that extensively impair crop yield. Drought stress decreases crop productivity more than any other environmental stress [14]. Weed infestation, results in severe reduction in crop yield as in the condition of pure corn culture, corn losses of 40–60% have been reported [27]. Application of silica (Si) has been reported that can reduce the deleterious impacts of environmental stresses [1]. The Si transferred from the roots to the shoot through vascular bundles and forms silica cells and silica bodies [18].

Although Si has not been recognized as an essential element for plant growth, it does exert beneficial effects for many plant species [16]. Actually, Si can alleviate the detrimental effects of various stresses such as drought, salinity, heat, cold, metal toxicity, nutrient imbalance, plant pathogens, and insects [23]. The beneficial effect of Si on plant water status has been extensively examined in various plant species, including sorghum [30], maize [4], and wheat [10]. Mixed cropping is a type of multiple cropping systems that has recommended to be used in many parts of the world for production of food or fibers because of its overall high productivity, effective control of pests and diseases, good ecological services and economic profitability [29]. Moradi *et al.* [20] emphasized that the mixed cropping lead to higher forage yield per unit land area in comparison with monocrop systems by optimizing environmental resources. The dry matter and CP yield of produced forage increased by intercropping as compared with the maize monoculture [9]. The objectives of this study was to investigate the effects of intercropping sorghum and *Vigna radiate* L. under drought stress along with the application of silica on yield, forage quality and CP.
Hypotheses:

(1) Mixed cropping sorghum with living mulch increases total yield.
(2) Mixed cropping sorghum with living mulch increases the protein content of the crop.

(3) Mixed cropping sorghum with living mulch will reduce dry and fresh weeds weight.
(4) It also provides the effect of silica to improve resistance to drought stress.

MATERIAL AND METHODS

A two-year field experiment was conducted at the experimental farm of Islamic Azad University, Varamin Branch, Tehran, Iran (Latitude 35.325241, longitude 51.647198) during the 2017 and 2018 growing seasons.The area has an arid to semi-arid climate with 38-year average annual precipitation of 251 mm, annual average temperature of 13.5 ∘C, annual average soil temperature of 14.5 ∘C, and total annual class "A" pan evaporation of 2207 mm (Fig 1 and 2).

The average monthly precipitation and temperature obtained from the Varamin Synoptic Meteorology Station, located at the experimental farm, are presented in Fig 1 and 2.

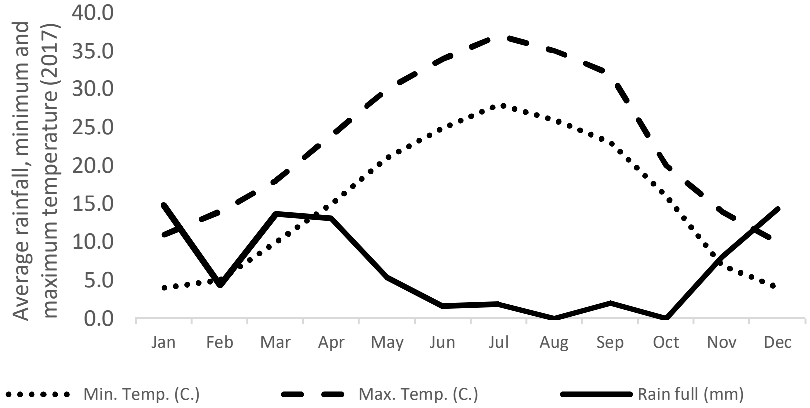


Fig 1. Average rainfall, minimum and maximum temperature on a standard week basis in the 2017 growing seasons

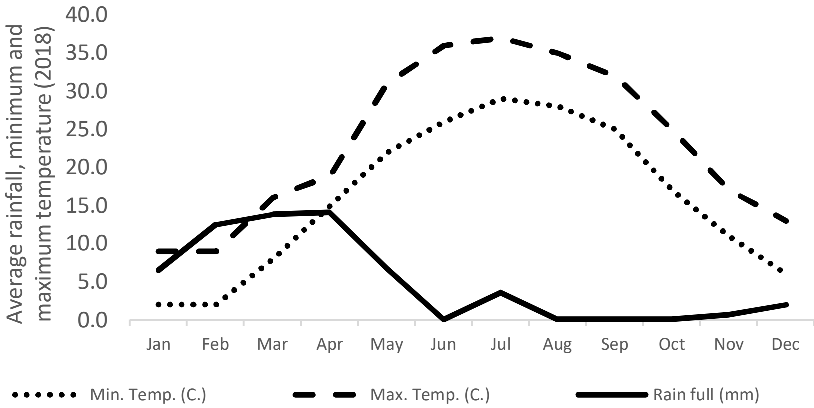


Fig 2. Average rainfall, minimum and maximum temperature on a standard week basis in the 2018 growing seasons

The experiment was arranged as a Randomized Complete Block Design (RCBD). Treatments according to Table. 1 were arranged in a three replicated split plot factorial design.

Table 1. Based on evaluated on trial treatments.

Table 1. Treatments			
Drf.	**Main factors**	**Sub factors**	
	Irrigation intervals (evaporation from class A evaporation pan)	**Potassium silicate K_2O -10%, SiO_2 - 20%**	**Living mulch mung bean (*Vigna radiate* L.)**
1	60 mm	Control (not used)	Control (not used)
2	120 mm	Fertilizer at a rate of 30 liters per hectare	Without living mulch and complete weed interference
3	180 mm	Spray 3×1000 L in three steps	Use living mulch

The experimental site was plowed by moldboard plow, harrowed and divided into three blocks, each contained 27 plots.Each subplot was 2.5 m wide and 5 m long and consisted of four rows of sorghum which were 0.6 m wide and 5 m long. A gap of 1.5 meters was considered between adjacent main plots and the distance between replications was 3 m Plots were seeded on the 10 th and 5 th of June in 2017 and 2018, respectively, at a row spacing of 60 cm and four rows of mung bean (*Vigna radiate* L.) were planted as living mulch. Prior to seeding, soil samples from each plot were taken from the top 30 cm of soil to test its background nutritional level. Selected chemical properties of soil are presented in (Table 2).

Table 2. Selected properties of the top soil (0–30 cm) at the experimental site.

Depth (cm)	Ds.m (Ec)	pH	Clay (%)	SALT (%)	SAND (%)	TEXTURE
0-30	3.8	7.3	53	22	25	Clay

P (ppm)	K (ppm)	N (ppm)	OC (%)	Fe (ppm)	Zn (ppm)	Mn (ppm)	Cu (ppm)
10	210	1.1	0.8	1.5	1.1	2.5	2.2

After planting, plots were irrigated equally to facilitate seed germination. The hand weeding in control treatment was done twice (20 and 45 days after crop emergence). Major weed species were common (*Chenopodium album* L.) and (*Amaranthus retroflexus* L.). Irrigation regimes were applied when plants were completely established and plots were irrigated anytime evaporation reached the considered amount for each irrigation level (60, 120, and 180 mm evaporation from the surface of the evaporation pan). To control and calculate the amount of water, drip irrigation was performed. The diameter of tape was 16 mm, emitter spacing 15 cm, and flow rate 2 lit. h^{-1}. Numbers of irrigations were 21, 13, and 8 for Ir60, Ir120, and Ir180, respectively (Table 3).

Table 3. Date of irrigation for each irrigation regime during the 2017 and 2018 growing seasons.

2017			2018		
10-Jun	10-Jun	10-Jun	05-Jun	05-Jun	05-Jun
16-Jun	16-Jun	16-Jun	10-Jun	10-Jun	10-Jun
23-Jun	27-Jun	01-Jul	16-Jun	20-Jun	26-Jun
29-Jun	07-Jul	16-Jul	22-Jun	29-Jun	11-Jul
05-Jul	18-Jul	31-Jul	27-Jun	08-Jul	25-Jul
10-Jul	29-Jul	15-Aug	03-Jul	17-Jul	09-Aug
15-Jul	11-Aug	30-Aug	09-Jul	27-Jul	23-Aug
20-Jul	23-Aug	14-Sep	16-Jul	06-Aug	07-Sep
26-Jul	01-Sep	29-Sep	22-Jul	17-Aug	22-Sep
02-Aug	11-Sep	-	27-Jul	27-Aug	-
08-Aug	21-Sep	-	02-Aug	06-Sep	-
14-Aug	04-Oct	-	08-Aug	16-Sep	-
21-Aug	-	-	14-Aug	-	-
29-Aug	-	-	20-Aug	-	-
05-Sep	-	-	26-Aug	-	-
13-Sep	-	-	01-Sep	-	-
21-Sep	-	-	07-Sep	-	-
28-Sep	-	-	13-Sep	-	-
07-Oct	-	-	18-Sep	-	-
-	-	-	25-Sep	-	-

Numbers of irrigations were 19, 12, and 9 for Ir60, Ir120, and Ir180, respectively. Each plot received an approximate amount of 0.85 m^3 of water in each irrigation and the end of each plot was blocked to control the volume of water. Each plat a total amount of 17 m3 of water at Ir60 irrigation regime while it was 11 and 8 m^3 at Ir120 and Ir180, respectively. The application time of silica fertilizer in two stages was 5 leaves and before the first flowering and the other stage 15 days after the first harvest. In the first year of the experiment (2017), the first and second forage cut took place on Aug 11 th, and Oct 8th, while it was Aug 5th and Oct 6th for the second year (2017), respectively. To measure the agronomic traits with respect to margins, 15 plants were randomly selected within each plot and plant height was measured. In order to measure the dry matter and the dry and wet function of living mulch in full flowering stage of sorghum 1 square meter in the middle of each plot were cut to 2 cm above the soil surface and separated by hand into sorghum in July (2017 and 2018) and reported in terms of tons per hectare. Plants were dried by oven at 75 ºC for 48 h and dry matter yield obtained. Total N of Sorghum in different cropping system was determined using the Kjeldahl's method and CP calculated by multiplying the N content by

6.25. Adequate plant protection measures and agronomic practices performed during the crop growth. To supply required nutritious, triple superphosphate fertilizer has been used between the first and the second disk interval (80 kg/ha). Accordingly, the required nitrogen has been supplied from the urea source (150 kg/ha). To precisely apply fertilizers, grooves were initially made in the irrigation furrows in each plot then the fertilizers was placed evenly inside the grooves, covered by soil and irrigated immediately. Data were analyzed using the analysis of variance (ANOVA) and general linear model (GLM) procedures of SAS 9.4. Effects were considered significant at P-values ≤0.05 in the F-test. LSD multiple range test was conducted for comparison of means. Since ANOVA indicated that there was no interaction between treatment and growing season, the values are reported as means of both growing seasons.

RESULTS AND DISCUSSION

Table 4. Analysis of variance for various studied traits of sorghum on dry weight sorghum, fresh weight sorghum, fresh weight living mulch, fresh weed weight, total dry weight and protein (CP) (%)

Source	DF	M.s.						
		Plant height	Dry weight sorghum	Fresh weight sorghum	Fresh weight living mulch	Fresh weed weight	Total dry weight	Protein (CP)
Year (Y)	1	4040.00**	7.402**	102.133n.s	6.821**	7.718**	12.171*	120.987**
Rep (Year)	4	270.58n	12.756**	99.171n.s	0.179n.s	0.108n.s	12.092**	0.352
Drought stress (D)	2	313347.513**	1527.565**	36807.293**	124.825**	38.191**	1811.692**	26.604
D (Y)	2	3.0617n.s	42.487**	33.229n.s	0.005n.s	0.114n.s	43.008**	4.858*
Eror a	8	427.049	3.715	38.271	0.386	0.612	3.407	1.394n.s
Living mulch (L)	2	33.208n.s	54.309**	1165.223**	835.768**	247.853**	179.789**	37.390**
L (Y)	2	4.913n.s	19.494**	2.919n.s	6.820356	1.984**	13.487*	1.080n.s
Silica (S)	2	8898.688**	156.057**	1571.541**	9.949**	10.662**	184.473**	54.554**
S (Y)	2	2.524n.s	43.370**	709.278**	0.033n.s	0.121n.s	43.661**	0.635n.s
D * L	4	120.463n.s	27.202**	410.091**	124.825**	15.783**	23.105**	12.180**
D * L * (Y)	4	1.135n.s	6.466n.s	2.775n.s	0.0058n.s	0.082n.s	6.69n.s	0.006n.s
D * S	4	2362.406**	27.278**	146.555*	1.1395**	1.414**	30.286**	8.244**
D * S * (Y)	4	1.246n.s	18.853**	192.571**	0.002n.s	0.099n.s	19.216**	1.228n.s
L * S	4	157.170n.s	0.763n.s	50.368n.s	9.949**	3.112**	3.508n.s	0.465n.s
L * S * (Y)	4	1.821n.s	1.188n.s	5.966n.s	0.033n.s	0.084n.s	1.065n.s	0.783n.s
D * L * S	8	43.877n.s	1.211n.s	21.159n.s	1.139**	0.398n.s	1.496n.s	0.974n.s
D * L * S * (Y)	8	2.793n.s	1.037n.s	6.053n.s	0.002n.s	0.049n.s	1.058n.s	0.265n.s
Total	96	117.1867	3.244	45.348	0.181	0.255	3.161	1.215
CV (%)		6.29	10.38	9.26	18.77	21.45	9.83	8.19

n.s. = Non-significant * = Significant at 5% level ** = significant at %1 level
Y= Year D= Drought – L= Living mulch - S= Silica

Results of combined analysis of variance indicated the significant impact between drought stress, silica and living mulch at 1% besides the impact of living mulch on sorghum height. The interaction effects between drought stress and living mulch were significant at 1% besides the height of bush. The interaction effect between the irrigation period and silica fertilizer were significant at 1%. Interaction effects between living mulch and silica fertilizer were significant at 1% on fresh weight living mulch and weed dry weight. Triple interaction effect of drought stress, living mulch, and silica fertilizer were significant at 1% on fresh weight living mulch (Table 4).

Sorghum plant height

The most height of bush resulted from 60mm evaporation from pan A and drench application of silica (261.02 cm) whereas the lowest height of bush were obtained from 180mm evaporation from pan A without application of silica (89.44 cm) (Table 6).Accordance, Zhou *et al*., [33] Drought stress dramatically decreased growth parameters (biomass, root/shoot ratio, leaf area, chlorophyll concentration and photosynthetic rate), while silica application reduced the drought-induced decreases in those parameters. Leaf relative water content and transpiration rate were maintained at high levels compared to those in seedlings without silica. Helaly *et al*., [12] reported the improvement of plant resistance to drought, osmotic, and salt stresses after the addition of Si to the growth medium.

Dry and fresh yield of sorghum

The result of compare mean between drought stress and living mulch represented that the most dry weight of sorghum was obtained from 60mm evaporation from pan A without application of living mulch (24.64 ton/ha). On the other hand, the lowest yield was obtained from 180mm evaporation from pan A, weed control, and without living mulch application (11.31 ton/ha) (Table 5). Accordingly, Mahallati *et al*., [17] also highlighted the superiority of the mix cropping for maize-bean crop cultivation. Moreover, Chaichi *et al*. [6] found that forage production in sorghum-alfalfa crop cultivation was more stable and the highest forage was obtained from mixed fist 75% sorghum + 25% alfalfa. Similarly, Mix cropping cereals with legumes, which is one of the most common practices in the tropics, leads to decrease in nitrogen requirement, improves soil fertility and forage quality [26]. The result of compare mean between drought stress and silica fertilizer showed that the most dry weight (24.98 ton/ha) was obtained from 60mm evaporation from pan A and drench application of silica fertilizer, whereas, the lowest yield was obtained from 180mm evaporation from pan A without using silica fertilizer (Table 6). Accordingly, Hurtado *et al*., [13] reported that increase in silica leads to increase in total dry weight (TDW) in sorghum cultivars compared to control treatment. Moreover, Rizwan *et al*., [24] represented at the different impacts of Si application to improve plants' resistance to drought or salt stress including maintenance of nutrient balance, promotion of photosynthetic rate, increasing antioxidant capacity, and decomposition of toxic ions.

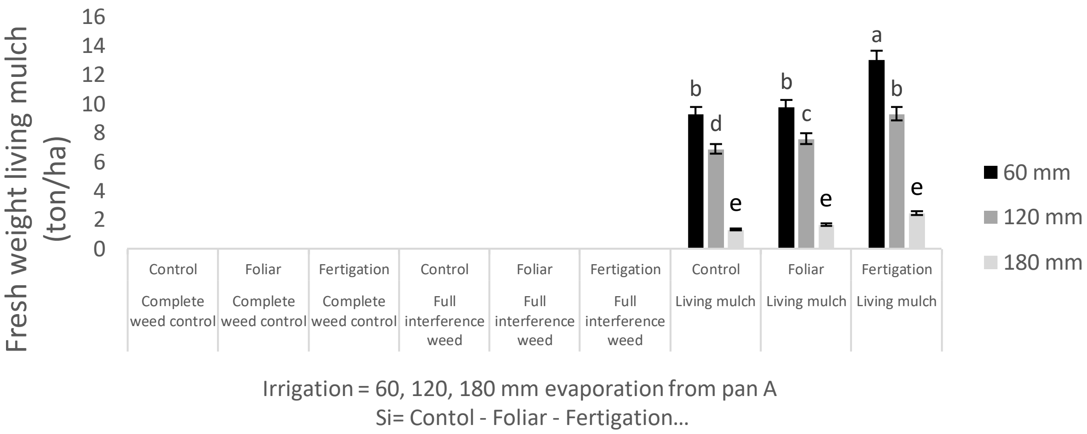
Fresh yield of sorghum

The most yield of fresh weight achieved from 60mm evaporation from pan A without application of living mulch (106.94 ton/ha) and lowest fresh weight achieved from 180mm evaporation from pan A along with complete mixture of weed (40.06 ton/ha) (Table 5). These results were in accordance with Ahmed *et al*., [1] that obtained the highest fresh forage yield of grasses by the mixture the in comparison with monocultures. Furthermore, Bhaskar *et al*., [5] reported that living mulch produced 8 to 79 tons ha−1 of fresh biomass corresponding to 1 to 12.7 tons ton/ha of dry matter. The result for the impact of drought stress mean and silica fertilizer on fresh weight of sorghum showed that the most fresh weight of sorghum (104.1 ton/ha) obtained from 60mm evaporation from pan A and application of silica fertilizer while the lowest weight (40.06 ton/ha) achieved from 180mm evaporation from pan A without application of silica fertilizer (Table. 5).Applications of Si fertilizers have been effective in enhancing the yield and quality of many agricultural crops, including both monocots such as rice, wheat, maize, barley, sorghum, and sugarcane, and soybean [15].

Fresh weight living mulch

The highest fresh weight of living mulch (13.00 ton/ha) was obtained from the irrigation 60 mm evaporation from plan A treatments and the use of silica in irrigation water and the lowest fresh weight (1.31ton/ha) was reported from the irrigation 180 mm evaporation from plan A and no silica consumption. (Fig. 3). Accordance, intercropping reduced weed population, boosted maize performance, enhanced land utilization and increased farmers' monitory advantage (Nikniaei *et al*., 2017; Hussain *et al*., 2013).

Fig 3. Interaction of drought stress in living mulch and silica fertilizer on Fresh weight living mulch

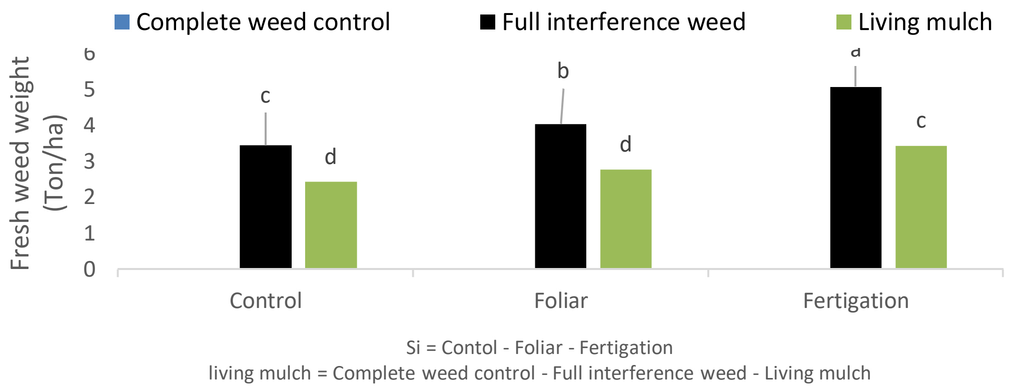


Different letters on bars corresponding to the same response variable, Interaction of drought stress in living mulch and silica fertilizer on Fresh weight living mulch according to LSD test (P < 0.05).

Fresh weed weight

The most yield of fresh weed weight achieved from 60mm evaporation from pan A with application of living mulch (5.49ton/ha) and lowest fresh weed weight achieved from 180mm evaporation from pan A along with complete mixture of weed (2.07ton/ha) (Table 5). Accordingly, Bhaskar *et al*., [5] reported where living mulches were vigorous and established quickly, weed cover was as low as 7%, without the use of herbicides, or inter row tillage. In a dry year, living mulch growth had a negative impact on cotton yield; however, in a year when soil moisture was not limiting, there was a positive relationship between cotton yield and living mulch biomass. The result for the impact of drought stress mean and silica fertilizer on fresh weed weight showed that the most fresh weed weight (3.71 ton/ha) obtained from 60mm evaporation from pan A and application of silica fertilizer while the lowest weight (0.91 ton/ha) achieved from 180mm evaporation from pan A without application of silica fertilizer (Table. 5). The highest fresh weed weight (5.07 ton/ha) was obtained from the use of silica in irrigation water with application of living mulch and the lowest fresh weed weight (2.43 ton/ha) was reported with application of living mulch and no silica consumption. (Fig.4). Accordingly, Brainard *et al*., [6] reported that after 3 years, the density of summer annual weeds was more than 10-fold greater in rye living mulch treatments compared with standard residual herbicides treatments. Intercropping faba bean and maize for silage in conventional production are possible and the forage quality is improved, with slightly higher protein content and higher in vitro organic matter digestibility [25].

Fig. 4 Interaction between living mulch and silica fertilizer on fresh weed weight



Different letters on bars corresponding to the same response variable, Interaction between living mulch and silica fertilizer on fresh weed weight according to LSD test (P < 0.05).

Total dry weight

The most yield of total dry weight achieved from 60mm evaporation from pan A with application of living mulch (25.62 ton/he) and lowest total dry weight achieved from 180mm evaporation from pan A along with complete mixture of weed (11.31 ton/ha) (Table 5). Accordingly, Zhang *et al*., [31] reported that the intercropping of alfalfa and corn-rye increased total forage and degradable nutrient yields. An increase in intercropping system nutrient could be attributed to the increase of forage dry mater yield rather than nutrient content. Moreover, The result for the impact of drought stress mean and silica fertilizer on total dry weight showed that the most total dry weight (26.37 ton/ha) obtained from 60mm evaporation from pan A and water application of silica fertilizer while the lowest weight (11.04 ton/ha) achieved from 180mm evaporation from pan A without application of silica fertilizer (Table 5). Accordingly, Ahmed *et al*., [1] reported that the data pertaining to response of sorghum cultivars under irrigated, non-irrigated, Si applied (Si200) and silica deficient (Si0) treatments accounted that shoot dry weight increases due to the application of silica. Moreover, Mushtaq *et al*., [21] reported that the silica application increased dry matter production of wheat at all soil water contents levels. Dry matter reduction in plants due to low water contents was significantly increased when Silica was applied, indicating increased tolerance of wheat plants to drought.

Protein percentage

In this regard, the comparison table of the mean interactions between irrigation and living mulch showed that living mulch culture in rows of planting along with the irrigation form 60 mm evaporation from plan A resulted in a maximum forage protein percentage with an average of 16.18% and irrigation from 180 mm evaporation from plan A and no use living mulch showed the lowest amount of protein in the forage 7.87% (Table 5). Accordingly, Zhang *et al*., [32] reported that the intercropping system of alfalfa and corn-rye provided higher forage production performance with net increases of 9.52% and 34.81% in dry mater yield, 42.13% and 16.74% in crude protein (CP) yield, 25.94% and 69.99% in degradable dry mater yield, and 16.96% and 5.50% in degradable CP yield than rotation and alfalfa sole cropping systems, respectively. The results of the comparison of the mean interactions of irrigation and silage fertilizer on the percentage of forage protein showed that the irrigation from 60 mm evaporation from plan A and application of silica in foliar with an average of 14.91% and the lowest amount of forage protein were obtained from 180 mm evaporation from plan A treatment and no use of silica fertilizer with a mean of 7.31% (Table 6) . Rizwan *et al*., [24] have been reported to A variety of beneficial effects of Si application could be ascribed to the alleviation of problematic water status in those studies by increasing the osmotic adjustment capacity, decreasing the transpiration rate, or increasing water uptake. The new reported about sorghum showed that Si could alleviate potassium (K) deficiency by improving plant water status [7]. Potassium is the most abundant cation in plants and plays a key role in osmotic processes that contribute to cellular turgor, photosynthesis, and transpiration [28] and potassium plays essential roles in protein synthesis, photosynthesis, stomatal movement, energy transfer, cation-anion balance and stress resistance [19].

Table 5. Effect of drought stress and living mulch on dry weight sorghum, fresh weight sorghum, fresh weight living mulch, fresh weed weight, total dry weight and protein (CP) (%)

Drought stress	Living mulch	Dry weight sorghum (Ton/ha)	Fresh weight sorghum (Ton/ha)	Fresh weight living mulch (Ton/ha)	Fresh weed weight (Ton/ha)	Total dry weight (Ton/ha)	Protein (CP) (%)
60 mm	Complete weed control	24.76a	106.94a	0	0	24.76a	11.79e
60 mm	Full interference weed	20.43c	88.28c	0	5.49a	20.43b	11.58e
60 mm	Living mulch	22.23b	93.22b	10.71a	3.48c	25.62a	14.55a
120 mm	Complete weed control	18.21d	81.94d	0	0	18.21c	13.58cd
120 mm	Full interference weed	16.89e	74.44e	0	4.98b	16.89d	13.23d
120 mm	Living mulch	18.04de	75.37e	7.92b	3.03d	20.48b	14.75a
180 mm	Complete weed control	11.37g	44.73f	0	0	11.36f	13.59c
180 mm	Full interference weed	11.31g	44.21f	0	2.07e	11.31f	14.05ab
180 mm	Living mulch	12.89f	44.69f	1.81c	2.13e	13.47e	13.94b

Value given in table is mean of four replicates; Values followed by same letter did not differ significantly from LSD test at 5% significance

Table 6. Effect of drought stress and silicaon dry weight sorghum, fresh weight sorghum, fresh weight living mulch, fresh weed weight, total dry weight and protein (CP) (%)

Drought stress	Silica	Plant height (Cm)	Dry weight Sorghum (Ton/ha)	fresh weight Sorghum (Ton/ha)	fresh weight living mulch (Ton/ha)	Fresh weed weight (Ton/ha)	Total dry weight (Ton/ha)	Protein (CP) (%)
60 mm	control	236.43c	21.31b	93.67b	3.09b	2.57c	22.31b	12.37cd
60 mm	foliar	244.92b	21.14b	90.77b	3.25b	2.69c	22.15b	12.56cd
60 mm	fertigation	261.02a	24.98a	104.01a	4.36a	3.71a	26.37a	13.01c
120 mm	control	145.80e	14.96e	71.79d	2.29c	2.41c	15.63e	12.1d
120 mm	foliar	188.7d	18.31d	76.06d	2.52c	2.46c	19.11d	14.11b
120 mm	fertigation	185.41d	19.87c	83.91c	3.09b	3.15b	20.85c	15.36a
180 mm	control	89.44g	10.92g	40.06f	0.43e	0.91e	11.04g	12.77cd
180 mm	foliar	100.38f	12.14f	45.23e	0.55de	1.65d	12.32f	13.91b
180 mm	fertigation	95.55fg	12.5f	48.34e	0.81d	1.65d	12.79f	14.91a

Value given in table is mean of four replicates; Values followed by same letter did not differ significantly from LSD test at 5% significance

CONCLUSION

Results finally indicated that the using of living much improved the dry and fresh weight of forage and also increased the quantity of crude protein. The most quantity of the crude protein obtained from the irrigation treatment of 60 mm evaporation from plan A along with application of living mulch (16.18%). Furthermore, the application of silica fertilizer not only increased the dry and fresh weigh, but also enhanced the height of sorghum and forage CP. In addition, application of living mulch directly controlled weed growth. Thus, application of living mulch in the row of cultured sorghum along with silica fertilizer enhanced the tolerance against abiotic stress and increased the quantity and quality of forage. However, further research is needed to efficiently improve the yield of forage within different areas.

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