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Impact of Irrigation Rates and Potassium Silicate Fertilizer on Seed Production and Quality of Fahl Egyptian Clover and Soil Properties under Saline Conditions

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Abstract: Water stress is one of the main problems of agriculture in arid and semi arid areas. Lack of water influence on most plant physiological processes. Two field experiments were carried out at Sahl El-Hossinia Agricultural Research Station, El-Sharkia Governorate, Egypt, during 2012/13 and 2013/14 winter growing seasons to study the impact of irrigation rates and potassium silicate fertilizer doses on seed yield and quality of Egyptian clover variety (Fahl) and soil properties. The experiment was laid out in a split plot design with four replications. Three irrigation rates, viz 3000 m^3, 3600 m^3, 42000 m^3 assigned to main plots; the sub-plots were devoted to three potassium silicate doses (2, 4 and 6 ml L^{-1}) was added spray ground at two intervals, i.e. 45 and 75 days from sowing, potassium silicate (concentration K_2O = 12%).The local variety (Fahl) was used. The results show that irrigation rate at 4200 m^3 with 2 ml L^{-1} potassium silicate gave greater values of field characters (plant height, number of branches plant $^{-1}$, number of heads plant $^{-1}$, number of seeds head^{-1}, straw and seed yield). At laboratory test, 1000-seed weight, germination %, seedling vigor index 1 and 2, shoot and radical length, fresh and dry seedling weight gave greater values at 4200 m^3 with 2 ml L^{-1} potassium silicate application. While, the protein in seeds was increased when irrigation rate was decreased (3000 m^3) with 2 ml L^{-1} potassium silicate application, carbohydrate increased at 4200 m^3 with 4 ml L^{-1} potassium silicate application and Fe, Zn and Cu in seed were increased when, irrigation rate was decreased (3000 m^3) with 4 and 6 ml L^{-1} potassium silicate. Results showed that application of different potassium silicate and irrigation water rates had a positive effect on soil pH in both seasons. Irrigation applied with 4200 m^3 resulted in decreased soil salinity in both seasons, compared with other rates applied.

Key words: Mono-cut clover · Irrigation rates · Potassium silicate doses · Soil properties · Seed production

INTRODUCTION

Egyptian clover (*Trifolium alexandrium* L.) is one the most important forage legume crops in some world countries particularly those have long winter season with moderate cool temperature. Magy and Meleha [1] reported that forage crops like Egyptian clover requires a continuous supply of readily available soil moisture, in order to maintain vigorous growth. Egyptian clover has been introduced with special emphasis to the agriculture sector as untraditional forage crops the importance of the crop is the high forage productivity and quality during winter and spring season [2].

Water stress is one of the main problems in arid and semi arid areas. Lack of water influences most plant physiological processes, such as photosynthesis, photosynthetic material transmission to seeds, cellular development, coalescence and transmission of nutrients in plants [3]. Hefni [4] reported that the plant fresh and dry weight and plant height were significantly increased in the 1st and 2nd cuttings due to frequent irrigation every 14 days relative to the 28 days intervals. Abd El-Latif and Maatouk [5] found that crop irrigation at intervals of 10 or 20 days produced higher plant production than wider irrigation intervals. The increase in protein yield may be mainly attributed to the increase of dry forage yield [6]. Hussein and El-Dewiny [7] revealed that water stress affected the mineral uptake in fenugreek plants. It is clearly shown that both missing of irrigation lowered the concentration of N, P, K and micronutrients in fenugreek

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plants. Zhao *et al.* [8] that drought affected plant height due to hormonal imbalance (cytokinin, abscisic acid) that affected growth due to changes in cell wall extensibility. Ouda *et al.* [9] showed that up to 20% of full irrigation could be saved with yield reduction reached 7%.

In Egypt, salinity is also one of the major environmental problems which affects agricultural land. Salt accumulation in soils from natural processes and irrigation adversely affects seed germination, seedling growth, as well as related metabolic processes of plants. Soil salinity designates a condition in which the soluble salt content of the soil reaches a level harmful to crops through the reduced osmotic potential of the soil solution and the toxicity of specific ions [1].

Potassium is an important nutrient and plays an essential role in water relation, osmotic adjustment, stomata movement and finally plant resistance to drought. Decrease in K+ concentration was reported in many plant species under deficient conditions [10]. Aown *et al.* [11] found that potassium plays a key role in improving the plant tolerance to stress conditions. For many physiological processes such as activation of enzymes, photosynthesis, maintenance of turgescence, translocation of photosynthates. Potassium addition was positively correlated with nutrient content (N, P and K) of bean plants under salt stress conditions and the superiority for potassium silicate; this may be due to the role of potassium in water regulation, intake and increase water use efficiency [12]. Potassium silicate is a source of highly soluble potassium and silicon. It is used in agricultural production systems primarily as a silica amendment and has the added benefit of supplying small amounts of potassium. Potassium silicate contains no volatile organic compounds and applications will not result in the release of any hazardous or environmentally persistent byproducts [13]. Silicon nutrition has several beneficial effect on plant growth largely due to its unique physiological role [14].The shoot dry matter increased about three fold and root dry matter about two fold due to Si application. Formation of new roots was also observed in cotton plants as Si was added to the nutrient solution, when earlier roots were rotted due to uncertain cases [15]. Increase Si application rate reduced grains discoloration from 46% in the control to 29% at the highest Si rate (960 kg Si ha^{-1}), it was also found this difference corresponds to a 64% reduction in grain discoloration. Si, physiological promotes ammonium assimilation and restrains the increase in soluble N compound, including amino acid and amide, which are instrumental for the propagation of hyphae [14].

Seed vigor is not a single measurable property like germination, but a concept describing several seed performance associated characteristics [16]. It can encompass potential seed performance both in the field and in storage [17]. Germination testing is designed to provide information about the planting value of a seed lot and remains the principle and internationally accepted criterion for seed viability. Irrigation schedule had significant effect on 1000-seed weight [18]. A germination test result less than an accepted standard (e.g. 90%)indicated that the quality of the seed lot is suspect and that there may be future problems with field emergence or ability to be stored [17]. Loss of vigor often precedes loss of germination [19, 20]. Environmental factors such as temperature, light, pH and soil moisture affect seed germination [21].

Thus, the objective of this research was to study the impact of different irrigation rates and potassium silicate fertilizer doses on seed yield and quality of Egyptian clover variety (Fahl) and soil properties.

MATERIALS AND METHODS

The experiments were carried out at Sahl El-Hussinia Agricultural Research Station, El-Sharkia Governorate, Egypt, during 2012/13 and 2013/14 winter seasons to study the impact of irrigation rates and potassium silicate doses fertilization on seed yield and quality of mono-cut Egyptian clover (*Trifolium alexandrinum*, variety Fahl) and soil properties. The location lies between 32° / 00 to 32° / 15, N latitude and 30° / 50 to 31° / 15 E longitude. The soil samples were air dried, crushed and finely ground then sieved through a 2 mm sieve and kept for analysis according to the methods described by Piper [22]. Soil chemical properties of the cultivated soils and also some available macro- micronutrients were determined according to the methods described by Jackson [23], Cottenie *et al.* [24] and page *et al.* [25]. The obtained data were recoded in Table (1).

The experiments were irrigated from El-Salam Canal water which characterized by the mean chemical composition recorded in Table (2). Samples of irrigation water were taken in December, February, March and April. These analyses were carried out according to Cottenie *et al*. [24]. Applied irrigation water was controlled by the irrigation water quantity by the water meter fixed on the irrigation pipe.

Table 1: Some physical and chemical properties of the studied soil (average two seasons)

Coarse sand (%)	Fine sand (%)	Silt (%)	Clay (%)	Texture	O.M. (%)	$CaCO_3$ (%)
4.00	34.04	12.74	49.22	Clay	0.45	6.74

		Soluble cations (meq l^{-1})				Soluble anions (meq l^{-1})		
pH (1:2:5)	EC (dS/m)	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO^{-}_{3}	Cl^{-}	$SO^{=}_{4}$
8.12	13.77	15.68	21.88	99.18	0.96	9.59	92.96	35.15

Available macronutrients (mg kg^{-1})			Available micronutrients (mg kg^{-1})		
N	P	K	Fe	Mn	Zn
30	3.10	188	1.42	2.12	0.74

Table 2: Chemical analysis of irrigation water from El-Salam Canal during two seasons of Fahl Egyptian clover planting

		Period			
Properties	Seasons	December	February	March	April
pH (1:2.5)	1st	8.02	7.99	7.93	8.03
	2nd	8.00	7.95	7.97	8.01
EC (dS m^{-1})	1st	1.22	1.14	1.37	1.49
	2nd	1.36	1.25	1.45	1.70
NO_3(mgL^{-1})	1st	17.69	20.85	22.36	24.97
	2nd	18.53	21.47	24.10	23.19
NH_4(mgL^{-1})	1st	9.14	10.25	12.95	11.33
	2nd	5.31	11.43	9.46	10.85
P (mgL^{-1})	1st	2.98	4.88	4.94	3.59
	2nd	3.10	4.93	4.63	3.76
K (mgL^{-1})	1st	6.78	6.89	7.06	4.84
	2nd	4.99	5.05	5.61	5.00
Fe (mgL^{-1})	1st	1.67	1.96	1.55	1.42
	2nd	1.22	1.63	1.88	1.20
Mn (mgL^{-1})	1st	2.66	2.70	2.67	2.72
	2nd	2.68	2.84	2.80	2.77
Zn (mgL^{-1})	1st	0.063	0.079	0.072	0.069
	2nd	0.075	0.084	0.010	0.098

The experiment was laid out in a split plot design with four replications. The local variety (Fahl) was used. Three irrigation rates were assigned to main plots (the water amount to reach field capacity (control) 3000 m^3 fed^{-1}, I_1), field capacity +20% leaching requirements (3600 m^3 fed^{-1}, I_2), field capacity + 40% leaching requirements (4200 m^3 fed^{-1}, I_3). The sub-plots were devoted to three potassium silicate doses (2, 4 and 6 ml L^{-1}), potassium silicate contained (12% K_2O) and added spray on ground at two times 45 and 75 days from sowing. The sub plot area equals 12 m^2 (3 x 4 m). Seeds were broadcasted at the rate of 16 kg fed^{-1}. Super phosphate (15.5 % P_2O_5) was applied at rate of 150 kg fed^{-1} during soil tillage. Nitrogen fertilizer received 15 Kg N/fed in the form of ammonium nitrate (33.5% N), before the second irrigation. Sowing date was 20th and 25th November in the first and second season, respectively. Optimum cultural practices were followed as recommended throughout the growing season. The experimental plots were divided into two equal parts; the first was for estimating yield and its component, while the second was left to the stage of flowering and seed formation. An area of 2 m^2 was harvested at random from each plot was clipped and weighed for straw and seed.

At harvest, a sample of ten plants from each experimental plot was taken at random and the following measurements were recorded:

Plant height (cm), number of branches $plant^{-1}$, number of heads $plant^{-1}$, number of seeds head, seed yield kg fed^{-1} (feddan = 4200 m^2) and straw yield (ton fed^{-1}).

Laboratory Test: At Seed Technology Research Department, Field Crops Research Institute, Agricultural Research Center, Giza, Egypt. Seed samples were collected from each experimental plot and the following characters determined were:

1000- Seed weight (g): Three counts of 1000 seeds were randomly chosen from each treatment to calculate the average 1000-seed weight.

Vigor Test: Germination percentage: was determined according to ISTA [26].

Germination percentage = n / N X 100

Where, n is the number of germinated seeds, N is the number of total seeds.

Shoot and Radical Length: Ten seedlings were randomly selected and measured shoot and radical length, fresh weight and dry weight of seedling.

Fresh Weight and Dry Weight of Seedling: The seedlings were put into paper packet separately and placed into the preheated oven; weight was taken at 70°C.

Seedling vigor index: It was determined according to the formula given by Reddy and Khan [27].

Seedling vigor index (1) = germination percentage X seedling length

Seedling vigor index (2) = germination percentage X seedling dry weight

Protein Percentage of Fresh Plant Samples and Seeds: Nitrogen percentage was determined in seeds using microkjeldhal methods and crude protein percentage was estimated by multiplying N% by 6.25 [28].

Carbohydrate Percentage of Seeds: Carbohydrate was determined in seeds according to AOAC [28].

The atomic absorption spectrophotometer was used to determine Fe, Zn, Mn in fresh plant samples and seeds and Cu in seed concentration according to Cottenie *et al*. [23]. The content (%) of phosphorus in fresh plant samples and potassium in fresh plant samples and seeds were determined by using the procedure described by A.O.A.C. [28].

Data were statistically analyzed according to Snedecor and Cochran [29]. Bartlett's test was done to test the homogeneity of error variances. The test was insignificant for all traits, thus combined analysis was carried out for all studied traits in both seasons.

RESULTS AND DISCUSSION

Data on the seed yield and yield-related traits under different irrigation rates and potassium silicate doses are presented in Table (3). Irrigation regimes had a significant effect on growth traits, yield and yield components of clover crop and maximum values were obtained with irrigation at 100% ET_0 (wet regime) [30]. Based on the results, it was revealed that the highest values were 79.11 cm, 5.78, 7.78, 30.67, 1.51 ton fed^{-1} and 354.00 kg fed^{-1} for plant height, number of branches $plant^{-1}$, number of heads $plant^{-1}$, number of seeds $head^{-1}$, straw and seed yield under 4200 m^3 (I_3) with 2 ml L^{-1} silicate potassium application, respectively. The highest seed yield achieved in normal nutrition and environmental conditions [31-34].

Iannucci [35] reported a yield reduction of berseem clover subjected to drought. In addition, Lazaridou *et al.* [36] stated that drought conditions resulted in a reduction of the above ground dry biomass, growth rate, leaf area and transpiration rate in berseem clover plants more than that under irrigation. The lowest values were 52.05 cm, 1.14, 3.61, 3.67, 1.00 ton fed^{-1} and 235.00 kg fed^{-1} for the same respective traits under 3000 m^3 (I_1) with 6 ml L^{-1} silicate potassium application. This result is supported with what was found by El-Babley [37] where reducing irrigation water amount by about 17% could reduce clover yield by about 9%. Subhan *et al*. [18] found that irrigation schedule also had significant effect on receme weight (g), number of seeds $head^{-1}$, thousand seed weight (g), biological yield (kg ha^{-1}) and seed yield (kg ha^{-1}). Dost [38] reported that (47%) reduction in seeds $head^{-1}$ with decreasing number of irrigations from 10 to 4; this might be due to abscission of flowers and head under moisture stress.

Applied potassium silicate seems to interact with other nutrients (N, P and K) and offers the potential to improve efficiency in terms of yield response [39]. Potassium is reported to improve plant resistance against drought stress and can alleviate water shortage in many legume crops [40-42]. Results in Table (4) showed that potassium silicate, irrigation rates and interaction between (I x K) had significant effects.1000-seed weight, germination %, seedling vigor index (1) and (2), shoot and radical length and fresh and dry seedling weight were significantly affected by the experimental treatments. Numerous reports indicate that silicon (Si) improve growth parameters of plants growing under water stress. Although silicon is not considered to be an essential nutrient for most terrestrial plants; it plays an important role in protecting plants from abiotic stresses [43-44].

Table 3: Seed yield and yield-related traits of Fahl Egyptian clover under different irrigation rates and potassium silicate doses (combined analysis across 2012/13 and 2013/14 growing seasons)

Irrigation water rates*	Potassium silicate doses**	Plant height (cm)	Number of branches plant^{-1}	Number of heads plant^{-1}	Number of seeds head^{-1}	Straw yield (ton fed^{-1})	Seed yield (kg fed^{-1})
I_1	K_1	63.11	2.83	4.83	6.67	1.16	284.33
	K_2	61.93	2.33	4.33	5.67	1.07	253.00
	K_3	52.05	1.14	3.61	3.67	1.00	235.00
	Mean	59.03	2.10	4.26	5.34	1.08	257.44
I_2	K_1	70.97	3.25	5.25	16.67	1.33	311.33
	K_2	65.25	3.08	5.08	12.33	1.28	300.33
	K_3	63.47	2.93	4.93	10.00	1.22	290.00
	Mean	66.56	3.09	5.09	13.00	1.28	300.55
I_3	K_1	79.11	5.78	7.78	30.67	1.51	354.00
	K_2	73.17	3.78	5.78	25.33	1.42	329.33
	K_3	72.00	3.69	5.69	21.33	1.37	316.67
	Mean	74.76	4.42	6.42	25.78	1.43	333.33
L.S.D 0.05	I	11.03	0.96	0.97	1.15	0.06	4.35
	K	7.22	0.78	0.78	1.10	0.05	5.71
	I x K	12.51	1.35	1.53	1.91	0.07	9.89

*I_1=3000 m^{3}fed^{-1}, I_2=3600 m^{3}fed^{-1}, I_3=4200 m^{3}fed^{-1} **K_1=2 ml L^{-1}, K_2=4 ml L^{-1}, K_3=6 ml L^{-1}

Table 4: Mean performance of vigor test of Fahl Egyptian clover under different irrigation rates and potassium silicate doses (combined analysis across 2012/13 and 2013/14 growing seasons)

Irrigation water rates*	Potassium silicate doses**	1000-seed weight (g)	Germination (%)	Seedling vigor index (1)	Seedling vigor index (2)	Shoot Length (cm)	Radical length (cm)	Fresh seedling weight (g)	Dryseedling weight (g)
I_1	K_1	1.74	70.00	132.30	0.007	1.47	0.42	0.002	0.0009
	K_2	1.67	66.00	105.60	0.006	1.20	0.40	0.002	0.0007
	K_3	1.58	60.00	86.40	0.006	1.07	0.37	0.001	0.0006
	Mean	1.66	65.33	108.10	0.006	1.25	0.40	0.002	0.0007
I_2	K_1	1.90	83.00	207.50	0.332	2.00	0.50	0.006	0.0004
	K_2	1.85	81.00	194.00	0.243	1.90	0.48	0.005	0.0002
	K_3	1.80	80.00	160.00	0.080	1.60	0.45	0.003	0.0001
	Mean	1.85	81.33	187.17	0.218	1.83	0.48	0.005	0.0002
I_3	K_1	2.10	87.00	238.30	0.435	2.37	0.73	0.009	0.0005
	K_2	2.06	85.00	229.00	0.255	2.13	0.57	0.007	0.0003
	K_3	1.98	84.00	192.00	0.085	1.70	0.53	0.006	0.0002
	Mean	2.05	85.33	219.77	0.258	2.07	0.61	0.007	0.0003
L.S.D 0.05	I	0.03	1.30	2.24	0.009	0.102	0.037	0.003	0.0001
	K	0.01	0.59	2.22	0.005	0.082	0.067	0.001	0.0002
	I x K	1.09	1.28	1.36	0.009	0.077	0.034	0.005	0.0003

*I_1=3000 m^{3}fed^{-1}, I_2=3600 m^{3}fed^{-1}, I_3=4200 m^{3}fed^{-1} **K_1=2 ml L^{-1}, K_2=4 ml L^{-1}, K_3=6 ml L^{-1}

The highest values of 1000-seed weight were 2.10 g when 4200 m^3 (I_3) with 2 ml L^{-1} potassium silicate, while the lowest values were 1.58 g under 3000 m^3 (I_1) with 6 ml L^{-1} potassium silicate. Hatam [45] reported that the significant decrease in1000-seed weight occurs with decrease of irrigation from 9 to 2 numbers.

The germination % ranged between 60 to 87%. The highest values were 87% under 4200 m^3 irrigation water and treated with 2 ml potassium silicate L^{-1} foliar application, followed by 85 % and 84% under 4200 m^3 with 4 and 6 ml L^{-1} potassium silicate foliar application, respectively. When the irrigation rate was decreased to 3000 m^3 with a high dose of potassium silicate, the germination % was decreased and the values were 70%, 66% and 60%, respectively. Shen *et al.* [46] found that the effects of potassium silicate application led to increase in seed germination, physiological activity and the microbial community in the plant rhizosphere. On the other hand, the major factors that affect germination are water potential and salinity. Researches showed that osmotic and salt stress can delay, reduce or prevent germination [47]. Seed germination is initiated by water absorption followed by biochemical events in the seed [48].

Table 5: Protein and carbohydrate % and some microelements in seeds of Fahl Egyptian clover under different irrigation rates and potassium silicate doses (combined analysis across 2012/13 and 2013/14 growing season)

Irrigation water rates*	Potassium silicate doses**	Protein (%)	Carbohydrate (%)	Fe (ppm)	Zn(ppm)	Mn(ppm)	Cu(ppm)	K(%)
I_1	K_1	23.40	66.20	268.00	37.63	195.93	11.70	1.80
	K_2	21.06	67.40	277.00	39.40	180.93	11.50	2.10
	K_3	20.08	68.43	280.00	40.70	190.30	11.80	2.10
	Mean	21.51	67.34	275.00	39.24	189.05	11.67	1.95
I_2	K_1	20.30	70.40	258.00	33.70	192.33	10.10	2.30
	K_2	19.70	69.70	260.00	35.63	181.63	10.50	2.50
	K_3	18.60	69.40	265.00	37.40	193.20	11.58	2.65
	Mean	19.53	69.83	261.00	35.58	189.05	10.73	2.48
I_3	K_1	19.30	76.40	244.00	30.70	198.47	9.20	2.40
	K_2	18.70	74.40	252.00	33.80	195.30	9.10	2.60
	K_3	18.60	70.10	254.00	34.57	193.33	9.40	2.65
	Mean	18.87	73.63	250.00	33.02	195.70	9.23	2.55
L.S.D 0.05	I	0.09	0.18	2.65	0.03	0.54	0.03	0.11
	K	0.07	0.05	1.98	0.05	0.46	0.02	0.01
	I x K	0.12	0.11	3.44	0.09	0.81	0.03	0.23

*I_1=3000 m^3fed^{-1}, I_2=3600 m^3fed^{-1}, I_3=4200 m^3fed^{-1} **K_1=2 ml L^{-1}, K_2=4 ml L^{-1}, K_3=6 ml L^{-1}

The highest values for seedling vigor index 1and 2 were 238.30 and 0.435 when 4200 m^3 with 2 ml L^{-1} potassium silicate application while the lowest values were 86.40 and 0.006, respectively when the irrigation rate was decreased 3000 m^3 with a high dose of potassium silicate. For shoot and radical length, the highest values were 2.37 and 0.73 found in the 4200 m^3 with 2 ml L^{-1} potassium silicate. The highest values for fresh seedling were 0.009 g under the 4200 m^3 with 2 ml L^{-1} potassium silicate application followed by 0.007 and 0.006 under 4200 m^3 with 4 and 6 ml L^{-1} potassium silicate application. A low rate of irrigation with 2 ml L^{-1} potassium silicate gave increase of dry seedling weight; the values were 0.0009 g followed by 0.0007 and 0.0006 g under 3000 m^3 with the application of 4 and 6 ml L^{-1} potassium silicate.

Results in Table (5) showed that potassium silicate, irrigation rates and the interaction between (I x K) had significant effects. The characters of protein %, carbohydrate %, Fe, Zn, Mn and Cu were significantly affected by the experimental treatments. The nutritional composition of breseem is 2.9 % phosphorus, 18.3 % protein, 2.6 % calcium and 20 ppm carotenes and also rich source of vitamin A [49]. The $Si_{100\,K}^{+}$(Fc1) and $Si_{50\,K}^{+}$ (Fc 2) treatments gave high enough amounts of N-fixation, high dry matter production and greater nitrogen yield and conducted that the synergistic effect of silicon and potassium fertilization with adequate irrigation improves growth and nitrogen fixation in chickpea plants [50]. Jamriska [51] reported that the potassium and phosphorus had significant effect on yield and quality. The value of protein % ranged from 18.6 to 23.40 %. When low irrigation rate with low doses of potassium silicate the protein was increased, the highest value was 23.40 under 3000 m^3 with 2 ml L^{-1} potassium silicate application. Potassium (K) is very important for development and maintenance of white clover in pasture and which increases protein production [52]. The protein was decreased with a high dose of potassium silicate for all irrigation rates; the values were 18.70 and 18.60% for 4200 m^3, 19.70 and 18.60% for 3600 m^3 and 21.06 and 20.08%, respectively for 3000 m^3 under 4 and 6 ml L^{-1} potassium silicate. Simpson *et al.* [53] indicated that protein content of clover was reduced with higher K increasing depletion of moisture.

The high value of carbohydrate (76.40%) as affected by irrigation with 4200 m^3(I_3) and 2 ml L^{-1} potassium silicate application, while the lowest value was 66.20% for plot treated with 3000 m^3 irrigation water and 2 ml L^{-1} potassium silicate application.

For microelements, Fe and Zn were increased in values with low irrigation rate and a high dose of potassium silicate. The values were 252, 254 ppm and 33.80, 34.57 ppm for 4200 m^3 with 4, 6 ml L^{-1} potassium silicate, 260, 265ppm and 35.63, 37.40 ppm for 3600 $m^3$with 4, 6 ml L^{-1} potassium, 277, 280 ppm and 39.40, 40.70 ppm, respectively for 3000 m^3 with 4, 6 ml L^{-1} potassium silicate application. While the lowest values were 244 ppm, 30.70 ppm under 4200 m^3 with 2 ml L^{-1} potassium silicate, 258 ppm, 33.70 ppm under 3600 m^3 with 2 ml L^{-1} potassium silicate, 268 ppm, 37.63 ppm, respectively under 3000 m^3

Table 6: Macronutrients (N, P and K) and some microelements (Fe, Mn and Zn) of Fahl Egyptian clover under different irrigation rates and potassium silicate doses (combined analysis across 2012/13 and 2013/14 growing season)

Irrigation water rates*	Potassium silicate doses**	Macronutrients (%) N	P	K	Micronutrients ($mg\ kg^{-1}$) Fe	Mn	Zn
I_1	K_1	2.16	0.33	1.49	79.53	30.57	19.66
	K_2	2.24	0.38	1.52	83.52	33.57	21.27
	K_3	2.49	0.40	1.57	87.99	38.02	21.91
	Mean	2.30	0.37	1.53	83.68	34.05	20.95
I_2	K_1	2.38	0.36	1.86	84.24	35.02	21.17
	K_2	2.48	0.45	2.05	90.13	41.05	23.33
	K_3	2.60	0.49	2.14	94.37	44.34	25.42
	Mean	2.49	0.43	2.02	89.58	40.14	23.31
I_3	K_1	2.48	0.45	2.09	88.92	41.41	23.17
	K_2	2.65	0.48	2.16	93.82	43.22	24.85
	K_3	2.75	0.53	2.23	98.31	50.89	27.11
	Mean	2.63	0.49	2.16	93.68	45.17	25.04
L.S.D 0.05	I	0.03	0.02	NS	0.81	2.17	0.33
	K	0.03	0.02	0.03	1.29	1.80	0.30
	I x K	0.05	NS	0.05	NS	NS	0.52

*I_1=3000 m^3fed^{-1}, I_2=3600 m^3fed^{-1}, I_3=4200 m^3fed^{-1} **K_1=2 ml L^{-1}, K_2=4 ml L^{-1}, K_3=6 ml L^{-1}

with 2 ml L^{-1} potassium silicate. The values of Mn were decreased at a low irrigation rate and a high dose of potassium silicate the values were 193.33, 193.20 and 190.30 ppm under 4200 m^3, 3600 m^3 and 3000 m^3, respectively with 6 ml L^{-1} potassium silicate. While the values of Cu were increased with low irrigation rate and high doses of potassium silicate, the values were 9.40, 11.58 and 11.80 ppm under 4200 m^3, 3600 m^3 and 3000 m^3, respectively with 6 ml L^{-1} potassium silicate. Copper (Cu) content was in the 6-12 ppm ranged, which was adequate for plant nutrition [54]. The drought stress at all treatments of drought of Egyptian clover plant adversely affected plant's nutrients uptake [55].

The lowest value of potassium (K) was 1.80 % under 3000 m^3 with 2 ml L^{-1} potassium silicate application, while the highest value was 2.65 and 2.65% under 4200 m^3 and 3600 m^3 with 6 ml L^{-1} potassium silicate application (Table 5). The highest Si is not only involved in amelioration of growth and in maintaining of water status but it can also be considered an important element for symbiotic performance of chickpea plants [50].

The highest values were 2.75, 0.53 and 2.23% for N, P and K, respectively under 4200 m^2 with 6 ml L^{-1} potassium silicate application, while the lowest values were 2.16, 0.33 and 1.49 % of N, P and K, respectively under 3000 m^3 with 2 ml L^{-1} potassium silicate application (Table 6). 4200 m^3 with 6 ml L^{-1} potassium silicate gave highest values of Fe, Zn and Mn, the values were 98.31, 50.89 and 27.11 mg kg^{-1} for elements, respectively. Meanwhile, the lowest values were 79.53, 30.57 and 19.66 mg kg^{-1}, respectively under 3000 m^3 with 2 ml L^{-1} potassium silicate application.

Effect of Irrigation Water Rates and Potassium Silicate Doses on Saline Soil Properties after Fahl Egyptian Clover Harvest

Soil pH: Soil pH is considered the single most important chemical property of soil because it affects the availability of essential plant nutrients. Data presented in Table (7) showed that the application of different potassium silicate and irrigation water rates were of positive effect on soil pH in both seasons. The soil pH ranged between 8.07 and 7.96. The soil pH was slightly moderate alkalinity; these results are in agreement with Wahdan *et al.* [56]. Also, the potassium silicate and irrigation water rates had no significant effect on soil pH. The soil pH tends to decrease with increasing the rates of potassium silicate application. These results are in agreement with Fouda *et al.* [57]. Mahmoud [58] reported that the values of soil pH were decreased with the increase of added rate of K fertilizer. Linjun [59] found that the application of potassium silicate with loam soil had significantly lowest soil pH.

Table 7: Soil pH, EC and macro-micronutrients content in soil after Fahl Egyptian clover harvest (combined analysis across 2012/13 and 2013/14 growing season)

Irrigation water rates*	Potassium silicate doses**	pH (1:2.5)	EC (dSm^{-1})	Available macronutrients (mg kg^{-1}) N	P	K	Available micronutrients (mg kg^{-1}) Fe	Mn	Zn
I_1	K_1	8.07	9.75	49.13	3.19	193.33	1.49	2.22	0.79
	K_2	8.05	8.84	51.79	3.90	198.00	1.54	2.28	0.81
	K_3	8.02	7.98	52.89	3.96	206.33	1.58	2.27	0.83
	Mean	8.05	8.86	51.27	3.68	199.22	1.54	2.26	0.81
I_2	K_1	8.05	8.81	51.66	3.34	210.67	1.52	2.33	0.85
	K_2	8.03	7.97	52.62	3.96	213.67	1.64	2.39	0.90
	K_3	8.01	7.50	55.63	4.06	216.33	1.69	2.44	0.94
	Mean	8.03	8.09	53.30	3.79	213.56	1.62	2.39	0.90
I_3	K_1	8.03	7.69	53.63	4.01	214.33	1.58	2.43	0.87
	K_2	8.01	7.38	55.84	4.10	220.00	1.72	2.49	0.96
	K_3	7.96	6.86	57.37	4.17	228.67	1.82	2.55	1.00
	Mean	8.00	7.31	55.61	4.09	221.00	1.71	2.49	0.94
L.S.D 0.05	I	ns	0.49	ns	0.03	1.68	0.04	0.03	0.03
	K	ns	0.36	1.46	0.02	2.07	0.04	0.03	ns
	I x K	ns	ns	ns	0.04	3.59	ns	ns	ns

*I_1=3000 m^3fed^{-1}, I_2=3600 m^3fed^{-1}, I_3=4200 m^3fed^{-1} **K_1=2 ml L^{-1}, K_2=4 ml L^{-1}, K_3=6 ml L^{-1}

EC (dSm^{-1}) Soil: The effect of different irrigation water rates on soil salinity was significant. The results showed that the irrigation applied with 4200 m^3 results in decreased soil salinity in both seasons, compared with other rates applied. The highest values of soil salinity were observed with decrease of irrigation water rate to 3000 m^3, while the slight soil salinity was observed when irrigated with 4200 m^3. El-Bordiny and El-Dewiny [60] mentioned that, decreased irrigation water rates seem effect on salt accumulation in soil. In addition, the salinity of soil solution is dependent on soil type, climate, water use and irrigation water characteristics. On the other hand, the effect of potassium silicate rates on soil salinity was significant. The highest rates of potassium sulphate led to decrease soil salinity. These results are in agreement with Michael *et al.* [61] who indicated that the potassium silicate has been proven a highly effective shale inhibitor with lower EC values versus other commonly used potassium additives. Also, the interaction between irrigation water rates and potassium silicate doses on soil salinity was not significant.

Available Macronutrients Content in Soil Study: Data in Table (7) showed the available macronutrients, i.e. N. P and K (mg kg^{-1}) in the studied soil as affected by silicate potassium and irrigation water in different rates. Data revealed that the soil treated with potassium silicate in different doses had a significant increase on N, P and K content in soil. The highest values of N, P and K are a reflection of increase of potassium silicate rate. Fouda *et al.* [57] reported that application of potassium silicate gave greater available N, P and K in saline soil. Potassium silicate application can increase the quantity of mobile phosphates in the soil [62]. Linjun [59] indicated that the available nitrogen, phosphorus and potassium were significantly different among soils after potassium silicate application.

Concerning the effect of different irrigation water rates on macronutrients, N (mg kg^{-1}) content in soil had no significant increase, while the P and K content in soil were significantly affected. The height irrigation water rate led to increasing N, P and K content in soil. These results are in agreement with Yuncal and Schmidhalter [10] who indicated that the drought stress conditions led to lowering the N, P and K available in soil. Alam [63] found that the decline in soil moisture results in a decrease in the diffusion rate of nutrients in the soil.

Available Micronutrients Content in Soil: The availability of most micronutrients to crop plants mainly depend upon the pH of the soil solution as well as the nature of binding sites on organic and inorganic particle surfaces [64]. Data presented in Table (7) show that the effect of different rates of irrigation water used was significant on Fe, Mn and Zn contents in soil. Also, the effect of potassium silicate on Fe and Mn contents in soil was significant, while the Zn had no significant effect.

The interaction between different rates of potassium silicate and irrigation water on Fe, Mn and Zn had no significant effect. The increase of potassium silicate and irrigation water rates led to increasing of Fe, Mn and Zn in soil studied. Shaban *et al*. [65] found that the availability of Fe, Mn and Zn in soil increased with increasing K application rate under the soil salinity.

Finally, results in literature show that Si can alleviate the adverse effects of salinity on Egyptian clover variety (Fahl). Potassium silicates with a low irrigation improved germination and seed yield and quality. However; they are often localized such that each case must be examined individually. For example, although the contents of micronutrients in the soil might be high, the plants can still suffer from nutrient deficiencies. Thus, the addition of a micronutrient to a soil would have little effect and, instead, foliar application would prove to be more useful.

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