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Research Article

Comparatives performance of *Aloe vera* and *Aloe ferox* species under pH along with desiccation stresses

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Abstract

An experiment in pot was conducted summer-2008-2009, the *Aloe* medicinal plants were treated under the various ecological conditions viz. soil pH and moisture stress. Two species of *Aloe, Aloe barbadensis* and *Aloe ferox* were submitted to different soil pH reaction along with various irrigation (upto various crop coefficients K_c) stress treatment in factorial randomized block design to evaluate the response of the growth and yield attributes with the composition of liquid and dry gel. Results revealed that *Aloe ferox* species showed better response than *Aloe vera* in terms of growth and yield production under these stresses. Composition of *A.ferox* gel, quality and quantity wise also better than gel of *A.vera*. But study concluded that both plant species required higher soil pH (7.5) and moderate moisture condition (0.3 to 0.4 crop coefficient k_c) during cultivation practices for vegetative growth and better quality yield production.

Keywords: *Aloe ferox, Aloe vera*, Aloin, Gel composition, Mineral composition

Introduction

Only four out of the more than 400 known species of *Aloe* are believed to have nutritional qualities. *Aloe vera* and *Aloe ferox* are regarded as the most beneficial for human health and thus are the most studied and cultivated for herbal and commercial purposes[1]. *Aloe* has been used by cultures throughout the India as remedy for a multitude of condition, including dermatologic problems (particularly burns, immune stimulatory and wounds), intestinal difficulties and other disorders[2]. Today's *Aloe* continues to be used as a medicinal[3] and as an additive in food, beverages and cosmetics. Much of beneficial activity observed in *Aloe* may be attributed to various chemically; biologically-active compounds and ingredients are found in leaf of the plants. Concentration of dry gel, composition of gel, aloin yield and growth attributes of *Aloe* plants are in considerable amount varied with species, climate, and exposure to sunlight, harvesting method and soil environment[4]. Temperature, rainfall leaf age and salinity of soil affect the composition of dry and liquid gel within a species[5]. Chemical compositions of gel are also varying from *Aloe vera* and *Aloe ferox*[6]. Therefore, need to study the effect on composition and concentration of gel and aloin under various soil stress environment during cultivation practices. Thus in this investigation, studied the production of gel and aloin under various soil pH along with desiccation level in two species of *Aloe*.

Material and Methods

Pot experiment was conducted at Polly house of college of Agriculture, Jabalpur during 2007-2009. Two species of *Aloe, Aloe vera* and *Aloe ferox* were planted in 30 x 32 cm pot filled with sandy soil. Six month old plants were treated under various soil stress environment of pH along with desiccation in randomized block design.

Soil pH was maintained with NaOH / HCl monitoring every three days for various pH levels viz., 6.0, 6.5, 7.0 and 7.5 (optimum). In desiccation stress, the moisture level of soil was maintained every alternate days with water irrigation for different crop coefficient (k_c) viz., 0.20 (optimum), 0.30, 0.40 and 0.50. Required irrigation for maintaining moisture level up to crop coefficient was calculated by using following equation[7]

$$\text{Required water (ml/ 2days)} = \frac{\text{Evapo-transpiration (loss of water ml/cm/day) X crop}}{\text{Soil water holding capacity}}$$

There were 32 treatments of combinations of moisture and salinity stress in soil with 3 replications as follows:

T_1 = *Aloe vera* + pH 6.0+ k_c 0.2	T_{17} = *Aloe ferox*+ pH 6.0+ k_c0.2
T_2 = *Aloe vera* + pH 6.0+ k_c 0.3	T_{18} = *Aloe ferox* + pH 6.0+ k_c0.3
T_3 = *Aloe vera* + pH 6.0+ k_c 0.4	T_{19} = *Aloe ferox*+ pH 6.0+ k_c0.4
T_4 = *Aloe vera* + pH 6.0+ k_c0.5	T_{20} = *Aloe ferox*+ pH 6.0+ k_c0.5
T_5 = *Aloe vera* + pH 6.5+ kc0.2	T_{21} = *Aloe ferox* + pH 6.5+ k_c0.2
T_6 = *Aloe vera* + pH 6.5+ kc0.3	T_{22} = *Aloe ferox* + pH 6.5+k_c0.3
T_7 = *Aloe vera* + pH 6.5+ k_c0.4	T_{23} = *Aloe ferox* + pH 6.5+ k_c0.4
T_8 = *Aloe vera* + pH 6.5+ k_c0.5	T_{24} = *Aloe ferox* + pH 6.5+k_c0.5
T_9 = *Aloe vera* + pH 7.0+ k_c0.2	T_{25} = *Aloe ferox* + pH 7.0+ k_c0.2
T_{10} = *Aloe vera* + pH 7.0+ k_c0.3	T_{26} = *Aloe ferox* + pH 7.0+ k_c0.3
T_{11} = *Aloe vera* + pH7.0+ k_c0.4	T_{27} = *Aloe ferox* + pH7.0+ k_c0.4
T_{12} = *Aloe vera* + pH 7.0+ k_c0.5	T_{28} = *Aloe ferox* + pH 7.0+k_c0.5
T_{13} = *Aloe vera* + pH 7.5+ k_c0.2	T_{29} = *Aloe ferox* + pH 7.5+ k_c0.2
T_{14} = *Aloe vera* + pH76.5+ k_c0.3	T_{30} = *Aloe ferox* + pH76.5+k_c0.3
T_{15} = *Aloe vera* + pH 7.5+ k_c0.4	T_{31} = *Aloe ferox* + pH 7.5+k_c0.4
T_{16} = *Aloe vera* + pH 7.5+ k_c0.5	T_{32}= *Aloe ferox* + pH 7.5+k_c0.5

After experiment, the healthy and succulent 3 leaves of per plant was screened, stripped off the stem, and washed with running tap water. The fresh leaf length, leaf thickness and leaf weight were recorded.

Harvested leaves were manually filtered in laboratory and prepared *Aloe* gel using method[8]. The *Aloe* leaves taken in prewashed container with 50% Isopropyl Alcohol (IPA). The surface of leaves was made free from dirt and bacteria with aqueous calcium hypo chlorite solution containing 50 ppm free chlorine and 50% Isopropyl Alcohol (IPA). The tips and butts were cut off to drain out yellowish bitter phenolic sap (aloin). Aloin was quantitatively determined by using a Shimadzu LC-10A reverse phase HPLC system equipped with Shodex C18 column and Shimadzu PDA detector (SPD-10A).

The rinds of leaves were than be removed and mucilaginous, thick, semisolid material collected which was gel fillet. Gel fillet weight was recorded for each leaf. Gel fillet liquefied and homogenized at 1500 times g than finally filtered through whatman No. 4 filter paper to separate interstitial fiber and applying vacuum until all liquid was removed thus gives *Aloe* gel solution. Gel liquid was weighed. Gel liquid was calculated using the following equation.

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$$\text{Gel liquid yield (\%)} = \frac{\text{Weight of gel liquid X 100}}{\text{Weight of gel fillet (g)}}$$

After prepared the gel liquid, Aloe gel solid (gel powder) was prepared through freeze-drying technique[9]. The *Aloe* solid yield was calculated using the equation as follow

$$\textit{Aloe}\text{ gel Solid yield (\%)} = \frac{\text{Weight of total solid (g) obtained from gel X 100}}{\text{Weight of gel}}$$

Total carbohydrate % determined by phenol sulphuric acid method. Nitrogen content and Protein content (%) in gel is estimated by Kjeldhal method Phosphorus content was determined by UV-spectrophotometer method. Potassium, calcium and sodium were estimated by Flame photometer. Other nutritionally mineral content viz: magnesium iron was determined by atomic absorption spectrophotometer using diacid digestion in mg /L gel.

Results and discussion

Growth and yield parameter was presented in Table 1. The data revealed that maximum leaf length (64.33 cm) recorded in T30 of *A. ferox* species receiving higher soil pH (7.5) and moderate moisture (k_c =0.3) exhibited 50.20 % superiority than *A.vera* at same stress condition and significantly better than rest of the treatments. The next top treatments were T_{31} (60.43), T_{32} (57.30), T_{27} (54.40) and T_{26} (51.10) statistically at par to each other. *A. ferox* at higher pH (7.5) along with moderate soil desiccation (k_c =0.3) produced highest leaf width (43.27 cm) while *A.vera* at same soil condition resulted 43.83cm leaf width. Thus *A. ferox* performed significantly superior by 24.23% than *A.vera*. Higher soil pH (>7.0) along with moisture level moderate to little higher (k_c 0.3 to 0.4) of both *A.vera* and *A. ferox* recorded better results viz T_{30} (43.27), T_{31} (38.97), T_{14} (34.83), T_{15} (33.97) and T_{32} (32.63) than rest of the treatments. Maximum leaf weight (507.13g) recorded at *A.ferox* of higher pH along with k_c = 0.4 moisture level treatment that was significantly superior to the *A.vera* and rest of the soil stress combinations. The next top odder treatments viz: T_{30} (478.03), T_{27} (455.40), T_{15} (449.50g), T_{14} (416.57g) and T_{26} (406.53). Treatment T_{30}, T_{27} and T_{15} were non significant to each other but statistically better than other soil stress combination of both plant species. At same soil environment (pH 7.5 + k_c 0.4) *A. ferox* produced 12.82 % maximum leaf weight than *A.vera*. All growth parameter showed that *A. ferox* performed better than *A.vera* under soil pH along with desiccation stresses. Both plant performed better growth results under higher soil pH (7.0 to 7.5) and moderate moisture level (k_c 0.3 to 0.4)[10] growth of *Aloe* plants under higher soil salinity along with moderate moisture irrigation. Aloe plants are a xerophytes plants thus it have tendency to tolerate high soil pH and withstand stress of dry condition very well but to get good crop and vegetative growth irrigation must be given.

Maximum gel yield (75.77%) was recorded in T_{31} but Aloe gel solid (1.18%) was in T_{30} at *A. ferox* plant. *A. vera* produced maximum gel (64.25%) in T_{15} and Aloe gel solid (0.75%) in T14. Both plants show at higher (at k_c 0.4) irrigation produced maximum gel liquid due to the presence of higher water content in their leaves. But on remove the water from liquid gel through freeze drying technique, produced Aloe gel solid almost equal and better at moderate (at k_c =0.3) irrigation treatment. Thus dry gel content did not increase with higher irrigation stress in soil during cultivation practices of Aloe plants but liquid gel and leaf weight was increases. At same pH along with desiccation combination *A. ferox* exhibited superiority than *A.vera* by 17.93 % in gel liquid and 57.33% in *Aloe* gel solid. Maximum Aloin content yield (61.47%) was recorded in T_{29} of A. ferox at higher soil pH along with lower irrigation to the rest of the treatment. The next treatment of *A. ferox* viz: T_{30} (57.47%), T_{25} (55.07%), T_{31} (51.73%) and T_{26} (50.68%) which receiving higher pH>7.0 along with lower to moderate moisture condition (k_c =0.2 to 0.3) were produced better Aloin content than rest of treatments. *A.vera* at treatment T_{14} performed maximum results in terms of Aloin content (30.47%) this was followed by T_{13} (28.70%), T_{10} (27.67%), T_9 (26.50%) and T_{15} (24.50%). This showed that *A.ferox* produced grater yield of gel and Aloin content than *A.vera*. Femenia and Grindlay[5-6] reported similar results on chemical comparison of *A.ferox* and *A.vera* plants leaf. Results revealed that higher soil pH and moderate water irrigation was required for good gel and aloin yield production. Twafik[11] reported similar better yield of Aloe plants under higher salinity conditions and Genet[12] reported similar water requirement up to crop coefficient (k_c) 0.2 to 0.4 for vegetative growth and good yield of *Aloe* plants.

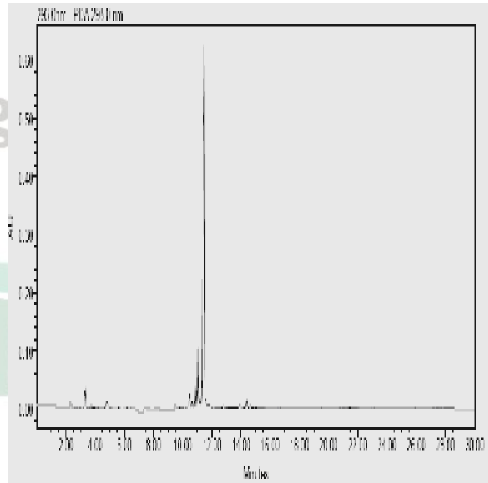

Fig A

Fig A Show HPLC chromatogram of Aloin Standard

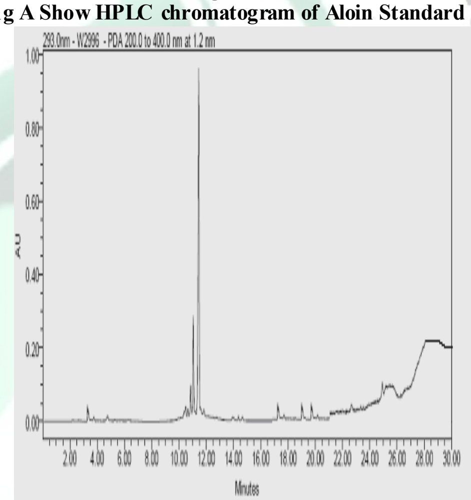

Fig B

Fig B Show HPLC chromatogram of Aloin Sample

Biochemical and mineral content of both plant species presented in Table 2. The data showed that carbohydrate, nitrogen and protein content in liquid gel recorded maximum in T_{30} (76.30%, 1.60% and 9.98% respectively) of *A. ferox* receiving higher soil pH along with moderate desiccation (k_c=0.3). This treatment was significantly superior to the *A. vera* at same soil stress combination and rest of all other treatments.

Polysaccharide composition was analyzed in dry Aloe gel. The data observed that mannose monosaccharide percent was found maximum than other monosaccahride in both *Aloe* plant species. Maximum mannose content was recorded in T_{15} (49.71%) of *A.vera* at higher soil pH along with moisture level of k_c= 0.4. This was significantly superior to the *A.ferox* at same soil condition by 31.54% and also to other treatments. Whereas glucose was found maximum in T_{30} (46.55%) of *A.ferox* at higher pH (7.5) along with moderate moisture condition (kc=0.3) while at same treatment condition *A.vera* produced 28.49% glucose. Yagi[13] showed similar results of *A.vera* dry gel solid

Table 1:

Growth and Yield parameter of *Aloe vera* and *Aloe ferox* under soil pH along with desiccation stresses

S.No	Treatments	Leaf length (cm)	Leaf width (cm)	Leaf weight (g)	Gel (%)	Aloe gel soild (%)	Aloin (%)
1	T1	4.63	5.20	102.37	10.91	0.29	19.13
2	T2	12.60	10.37	138.10	18.02	0.31	21.27
3	T3	14.13	11.50	181.97	14.44	0.22	17.37
4	T4	8.03	6.57	74.73	8.38	0.19	15.53
5	T5	15.27	13.47	124.13	25.72	0.34	19.50
6	T6	19.43	14.30	164.17	26.14	0.37	22.63
7	T7	15.77	12.80	219.87	14.44	0.27	18.37
8	T8	9.37	9.50	93.40	20.39	0.22	16.47
9	T9	25.20	18.66	252.97	27.96	0.44	26.50
10	T10	35.50	25.27	296.33	36.38	0.67	27.67
11	T11	32.30	27.43	355.33	58.03	0.58	20.57
12	T12	23.57	17.30	209.70	32.14	0.39	20.33
13	T13	29.00	20.40	288.90	34.41	0.47	28.70
14	T14	42.83	34.83	416.57	56.74	0.75	30.47
15	T15	39.50	33.97	449.50	64.25	0.64	24.73
16	T16	26.13	22.85	368.70	51.76	0.43	19.63
17	T17	20.30	11.57	172.20	24.64	0.45	38.43
18	T18	20.73	16.17	196.17	26.83	0.43	41.90
19	T19	31.47	17.00	225.40	25.64	0.38	34.87
20	T20	9.93	8.57	85.77	15.62	0.31	30.37
21	T21	28.37	14.90	145.13	31.07	0.49	40.43
22	T22	34.47	18.40	250.33	33.04	0.60	45.30
23	T23	35.93	17.67	273.40	32.71	0.54	38.23
24	T24	25.43	16.77	114.97	30.80	0.37	34.53
25	T25	37.77	21.43	319.17	37.36	0.68	55.07
26	T26	51.10	31.37	406.53	60.84	1.02	50.63
27	T27	54.40	28.50	455.40	65.44	0.88	49.20
28	T28	44.13	21.98	347.00	40.16	0.66	48.53
29	T29	40.30	25.23	385.70	38.36	0.75	61.47
30	T30	64.33	43.27	478.03	68.87	1.18	57.47
31	T31	60.43	38.97	507.13	75.77	0.92	51.73
32	T32	57.30	32.63	393.27	41.49	0.79	42.93
	CD (5%)	3.7458	3.3962	27.510	2.855 8	0.0449	1.8790

contain maximum composition of mannose and *A.ferox* exhibited glucose manosccharides. Galactose content observed in small amount ranged from 1.19 to 5.81%. Maximum galactose recorded in 5.81 % in T_{31}. This was followed T_{27} (5.65%), T_{26} (5.29%), T_{30} (5.12%), T_{14} (5.01%) and T_{10} (4.91%). Boudreau[14] recorded similar ratio of mannose glucose and galactose in dry *Aloe* gel solid. Moreira[14] reported the similar repeating units of glucose and mannose in a ratio of 1:3 and minor amount of side chains of galactose in Aloe polysaccharide.

The mineral content, phosphorous was non significant among all other treatments. Potassium, Calcium, Zinc, Magnesium and iron content were found more in *A.ferox* than that of *A.vera* gel. T_{31} treatment recorded maximum potassium (7.05%), calcium (9.06%), Zn (0.96%) and magnesium (2.72 %) while T_{30} recorded maximum iron (0.56%) of dry *Aloe* gel. This treatment of *A.ferox* was significantly higher than the *A.vera*. But Sodium and copper content recorded maximum (3.71 and 0.098 % respectively) in treatment which receiving higher pH (7.5) along with moisture level kc equal to 0.4. Similarly the mineral concentrations of *A.vera* were compared to typical concentration measured in *A. ferox* in dry matter of gel.

The above study concluded that higher soil pH (>7.0) and moderate moisture condition (kc 0.3 to 0.4) was produced good quality and better yield of *Aloe* gel.

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Table 2. Biochemical and mineral content (% of dry gel) of *Aloe vera* and *Aloe ferox* under soil pH along with desiccation stresses

S. No	Treat ments	Carbohy drate	N	Protein	P	K	Na	Ca	Zn	Cu	Mg	Fe	Galactose	Mannose	Glucose
		(%) of liquid gel			% of dry gel										
1	T1	9.34	0.11	0.69	0.0002	3.11	2.25	2.10	0.043	0.032	0.33	0.08	1.46	34.54	13.54
2	T2	11.40	0.15	0.94	0.0003	3.41	2.45	2.35	0.048	0.039	0.43	0.04	2.11	34.10	14.54
3	T3	12.57	0.08	0.50	0.0003	3.56	2.57	2.46	0.041	0.037	0.54	0.07	1.69	35.49	15.31
4	T4	8.35	0.05	0.31	0.0001	3.26	2.73	2.16	0.044	0.030	0.11	0.04	1.19	33.40	12.95
5	T5	12.67	0.33	2.06	0.0004	3.33	2.81	2.39	0.053	0.042	0.77	0.02	2.33	37.54	15.73
6	T6	14.41	0.36	2.42	0.0005	3.40	2.95	2.62	0.062	0.046	0.99	0.06	2.40	37.79	16.49
7	T7	13.30	0.30	1.72	0.0006	3.69	3.10	2.72	0.057	0.044	0.72	0.04	2.83	38.96	15.85
8	T8	10.43	0.26	1.65	0.0002	3.55	3.18	2.36	0.052	0.040	0.66	0.03	2.16	35.23	14.75
9	T9	13.34	0.42	2.62	0.0009	3.09	3.25	3.16	0.063	0.049	1.11	0.03	3.08	39.32	17.79
10	T10	16.78	0.51	3.19	0.0042	3.78	3.27	3.55	0.210	0.057	1.48	0.11	4.46	45.47	24.63
11	T11	15.34	0.46	2.88	0.0054	3.95	3.33	3.14	0.140	0.063	1.40	0.16	4.46	46.68	28.84
12	T12	13.64	0.38	2.38	0.0010	4.12	3.46	2.74	0.077	0.032	1.25	0.13	3.75	42.65	18.21
13	T13	18.48	0.74	4.61	0.0025	3.78	3.58	3.41	0.093	0.054	1.13	0.14	3.29	38.69	20.92
14	T14	22.56	0.93	5.81	0.1333	4.35	3.56	3.66	0.235	0.065	1.37	0.17	4.91	47.36	27.37
15	T15	20.40	0.82	5.15	0.0084	4.15	3.71	3.23	0.167	0.076	1.64	0.20	4.73	49.71	28.94
16	T16	17.62	0.55	3.42	0.0063	3.75	1.16	2.60	0.123	0.058	1.29	0.18	4.22	44.62	20.49
17	T17	33.27	0.73	4.54	0.0028	4.12	1.93	6.72	0.333	0.014	1.34	0.12	3.25	29.10	31.73
18	T18	38.62	0.88	5.52	0.0017	4.26	1.72	7.52	0.427	0.020	1.61	0.18	3.85	30.63	31.92
19	T19	31.42	0.86	5.38	0.0024	3.82	1.10	7.20	0.380	0.017	1.50	0.22	3.64	29.33	31.58
20	T20	28.44	0.64	3.98	0.0017	3.55	2.24	6.82	0.297	0.013	1.44	0.14	3.13	27.40	30.45
21	T21	43.23	1.03	6.44	0.0034	4.42	2.30	7.63	0.437	0.022	1.67	0.20	4.12	31.35	34.31
22	T22	48.25	1.11	6.96	0.0054	4.71	2.35	7.53	0.567	0.025	1.90	0.23	4.33	32.61	35.37
23	T23	44.38	1.21	7.58	0.0084	4.86	2.42	7.65	0.517	0.029	1.76	0.27	4.15	32.55	34.69
24	T24	40.37	0.93	5.82	0.0063	4.36	2.38	7.33	0.457	0.018	1.51	0.21	3.65	30.37	33.51
25	T25	63.36	1.26	7.88	0.0093	5.28	2.62	8.47	0.733	0.023	2.14	0.29	4.37	34.44	40.61
26	T26	73.39	1.41	8.79	0.1033	6.06	2.71	8.65	0.923	0.037	2.69	0.41	5.29	34.90	44.43
27	T27	69.60	1.46	9.17	0.1054	5.78	2.78	8.66	0.853	0.042	2.52	0.46	5.65	35.93	41.16
28	T28	54.39	1.18	7.38	0.0153	5.49	2.61	8.19	0.563	0.098	2.34	0.29	5.01	31.50	38.68
29	T29	68.32	1.30	8.15	0.1074	6.68	3.12	8.52	0.743	0.036	2.11	0.35	4.65	32.82	39.83
30	T30	76.30	1.60	9.98	0.1550	6.83	3.24	8.82	0.840	0.046	2.57	0.56	5.12	36.13	46.55
31	T31	71.57	1.51	9.42	0.1347	7.05	3.15	9.06	0.963	0.050	2.72	0.52	5.81	37.79	43.76
32	T32	56.37	1.34	8.38	0.1157	6.17	3.12	8.08	0.757	0.042	2.34	0.38	4.51	34.86	43.39
	CD (5%)	0.3856	0.0240	0.1799	--	0.1082	0.1324	0.2297	0.0292	0.0341	0.1728	0.0209	0.1679	0.7405	**0.8569**