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EVALUATION OF ALOE VERA INTERCROPPING ON QUANTITATIVE AND QUALITATIVE CHARACTERISTICS OF ROSELLE

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Abstract

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This study was designed to investigate the effect of Roselle and Aloe Vera intercropping on Quantitative and Qualitative yields of Mixture Components in farm of Agricultural research Institute in Chahnime in a randomized complete block design with three replications per crop year, 2013-2014. Experimental treatments include sole crop Roselle, sole crop Aloe Vera, 50% Roselle + 50% Aloe Vera, 75% Roselle + 25% Aloe Vera, and 25% Roselle + 75% Aloe Vera. The results showed that Roselle intercropping with Aloe Vera affected all attributes of Aloe Vera. The maximum economic yield of *Roselle* was obtained in the treatment combination of 25% Roselle + 75% Aloe Vera with a mean of 3.9 t/ha. In general, the results obtained in mixed cultures of Roselle and Aloe Vera plants with a ratio of 25% Roselle + 75% Aloe Vera, it is recommended to use it to obtain the highest economic performance of the evaluated plants.

Key words: sole crop; chlorophyll concentration; stem diameter

Introduction

The Sistan Basin is an inland endorheic basin encompassing large parts of southwestern Afghanistan and southeastern Iran, one of the driest regions in the world and an area subjected to prolonged droughts. Sistan region is located in the East of Iran and the weather is very hot and dry. This area has an average annual evaporation is 5000 mm and 50 mm of rainfall. Aloe Vera is an herb that is well done Sistan conditions area. But the intense summer light brown and eventually burns the plant will be valuable and artificial canopy to prevent radiation damage of summer is not severe economic. Inspired by the advantages of intercropping and without hoods can this plant be grown in the harsh conditions of Sistan to cultivation Roselle mixes practical and be compensated for resulting losses. Roselle plant in the summer due to its large canopy and shade the appropriate setting not only can be *Aloe vera* to maintain but also to the loss of direct sun and yield per unit area will increase. The purpose of this study was to evaluate the intercropping of Roselle and Aloe Vera was performed for the first time in the Sistan region.

According to the environmental problems of current agricultural systems as well as reduction of the agricultural land, application of new methods in order to minimize these negative effects (Kokubun and Watanabe, 1982) and to increase the efficiency of land use (Mahapatra, 2011; Mazaheri et al., 2006; Seran and Brintha, 2010) are often considered in agricultural development programs. One of the most proper management methods in crop production that leads to improvement of efficiency in resource use is the intercropping system. Intercropping consists of simultaneous cropping of two or more plant species in a specific place and time (Vandermeer, 1989; Anil et al., 1669). On the other hand, in the developed countries, the Health Organization has recommended the use of medicinal plants due to their health, efficacy and standardization (Boudreau and Beland, 2006). Aloe Vera is an herb that grows well in Sistan area. Nevertheless, due to intense summer light, this precious plant turns brown and ultimately, it burns, and providing a synthetic canopy to prevent it against radiation damage is not economical. Therefore, it is possible to take advantage of Roselle intercropping which doesn't need any canopy. Due to its vast canopy and

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proper shading, Roselle plant can not only prevent Aloe Vera from direct sunlight, but it also will increase its production per unit area in the summer. In this regard, the evaluation of Roselle and Aloe Vera intercropping in Sistan region was performed for the first time in this research.

Materials and Methods

The experiment (2012) was carried out in the Agricultural Research Institute of Zabol University in Chahnimeh, Zahak, located in 35 km southeast of the city of Zabol in the geographical location 61' 41'' east latitude and 30' 54'' north and 481 m height from sea level. Based on the Coupon classification, its climate is dry and very hot especially in summers. According to the Zahak weather station, the average long-term rainfall is 30 to 63 mm, mean annual temperature is 23°C and the annual rate of evaporation is 4500-5000 mm. Experimental soil was sandy loam. Results of soil chemical analysis indicated that the soil had an electrical conductivity of extract saturation of 4.7 mmos.cm^{-1}. Roselle seeds and shoots of Aloe Vera were provided in the Chahnimeh Institute of Zabol University.

Test treatments included pure culture of Roselle, pure culture of Aloe Vera, 50% Roselle + 50% Aloe Vera, 75% Roselle + 25% Aloe Vera, and 25% Roselle +75% Aloe Vera. After clearing and preparation of land, each plot consisted of 4 rows of 3 m length and a fixed distance of 50 cm and 1 meter distance between repeaters. Planting took place both manually and simultaneously through hump planting of the Roselle seeds and Aloe Vera shoots. Studied traits of Roselle consist of plant height, stem diameter, chlorophyll density, and number of fruits, wet weight of fruits, dry weight of fruits, dry weight of leaf, number of side branches, dry weight of plant, biological yield, economical yield, and harvest index. The gathered data were compared in SAS Version 9.1 software and treatment means was calculated by Duncan test in 5% level.

Results and Discussion

Traits of Roselle plant

Dry weight

The results of variance analysis showed the effect of intercropping treatments on the dry weight of Roselle plant was significant (1%) (Table 1). Comparison of data means (Table 2) showed that the highest plant dry weight was observed in 50% Roselle + 50% Aloe Vera (53.84 t/ha) and the lowest rate of 84.36 ton/ ha was seen in pure Hibiscus Tea. Intercropping of 50% Roselle + 50% Aloe Vera increased plant dry weight rather than the control group, 75% Roselle + 25% Aloe Vera, 25% Roselle + 75% Aloe Vera, as 31.57%, 13.60%, and 1.19%, respectively.

Perhaps this increase can be attributed to its longer growing period, which is the result of proper concentration and taking advantage of light and nutritional sources. In analysis of intercropping of corn with broad bean, the maximum dry matter yield was obtained from the mixed culture with treatments of 100% corn and 100% broad bean (Dahmardeh et al., 2010). Shading decreased proportion of root dry weight of the aerial parts of the spear head plantain plant and corn significantly (Lambers and Posthumus, 1980). Substantial reduction in production of plant grains depends on environmental tensions such as shading. Due to reduced ambient passing light passing through the shading, the rate of absorbed photosynthetic light by the plant reduces and it produces less dry matters (Nasrollahzadeh et al., 2011). Production of dry weight is mostly reported in leaves and stem of urucorana Croton plant which is the result of shading (Alvarenga et al., 2003). Increasing crop density leads to earlier canopy closure and its shading over other plants, which is an important factor in reducing the light

Table 1
Analysis of variance for quantitative parameters of Roselle (*Hibiscus sabdariffa*)

		Means of Square									
S.O.V	df	HI*	BY*	EY*	SW*	NC*	CC*	SD*	PH*	CDW*	PDW*
Replication	2	0.0007^{ns}	19.01^{ns}	0.65^{ns}	1.72*	75.81^{ns}	4.06^{ns}	0.09^{ns}	991.9^{ns}	1.04^{ns}	39.8^{ns}
Intercropping system	3	0.009^{ns}	386.2**	2.93**	42.2**	44878.6**	10.8*	45.63**	528.6^{ns}	161.8**	187.3**
Error	6	0.0024	29.59	0.27	0.171	41.97	1.94	0.145	266.2	2.63	24.19
C.V(%)	-	19.8	8.68	14.12	7.08	3.56	13.41	2.05	6.9	9.99	10.33

*, **, ^{ns} significant at p<0.05, p<0.01 and Non significant, respectively

*PDW: Plant Dry Weight; *CDW: Capsule Dry Weight; *PH: Plant Height; *SD: Stem Diameter; *CC: Chlorophyll Concentration; *NC: Number of Capsule; *SW: 100 Seed Weight; *EY: Economical Yield; *BY: Biological Yield; *HI: Harvest Index

access to other ulting in reduced growth. Asymmetric competition for light and taller shrubs amount of light they receive.

Dry weight of capsules

The results of variance analysis (Table 3) show that the effect of intercropping treatments on the dry weight of herbal tea hibiscus was significant. The highest plant dry weight in control treatment (pure Roselle) 26.5 t. ha^{-1} and the lowest rate of 9.53 t. ha^{-1} was seen in 75% Roselle + 25% Aloe Vera (Table 4). Pure treatment of Roselle increased dry weight of capsule compared to 75% Roselle + 25% Aloe Vera 64.04% and 50% Roselle + 50% Aloe Vera (51.58)% compared to 25% Roselle + 75% Aloe Vera (39.43%). It appears that due to a lack of output competition, the dry weight of the capsule is increased in Roselle pure culture and finally, higher yield is produced. Hebert et al. (2001), in their research observed that different light regimes have various significant effects on dry weight. In shading treatment of the second sampling onward, they witnessed slower growth and finally, dry weight of the matter reduced due to this shading. Lambers and Posthumus (1980) also reported that shading had a significant effect on dry weight reduction of root rather than aerial organs in spear head plantain plant and corn. On the other hand, Hadi et al. (2006), in their research about the effects of shading on bean plant witnessed an increase in dry weight of the aerial organs as well as its leaf surface that was due to longevity of growth at shade, without any significant effect on grain weight. In addition, there are reports about higher dry weight production in leaves and stems of the plant, which is the result of shading (Alvarenga et al., 2003).

Economic yield

The results of the variance analysis table shows that the Roselle economic performance of intercropping treatments at 1% level was significant (Table 3), so that the greatest amount of economic performance was at the level of 25% Roselle + 75% Aloe Vera, with a mean of 3.9 t/ ha. The lowest rate of 2.83 t/ha was observed in pure culture of Hibiscus tea. Aloe Vera level of economic performance increased in comparison with the control (pure Roselle) 44.51% and compared with 75% Roselle + 25% Aloe Vera (28.82%) , and compared with 50% Roselle + 50% Aloe Vera (36.67%). It appears that due to less competition between species, the yield increases. In other words, the performance stability of the mixed culture of Roselle and Aloe Vera was more than pure culture of Roselle. Agegnehu et al. (2006) reported that in a mixture of barley and broad bean, intercropping has increased the total yield. Studies by Tsubo et al. (2005), referred to an increase in the yield of corn and beans intercropping. Research results of Geren et al. (2008) also showed that corn yield was higher in mixed form than in its pure culture.

In intercropping of onion, its yield increased with increasing spacing. (Bolandnezar et al., 2011). Also, Nayak and Murty (1980) showed that rice yield decreased in shading conditions. The test results of Rostami et al. (2009), showed the effect of different treatments of intercropping of beans and corn was significant on biological and economic performance of corn. In addition, since plants with Roselle cannot compete with light and other consumed resources, the Roselle yield is a function of its own density and canopy structure. Presence of more space between the rows of shrub planting which reduces intra-species competition can increase contracted LER, and finally, increase Roselle yield. Apparently, this increase in density has provided a competition for absorbing more water and nutrition among these plants. It has also provided some limitations for their access to light, so the ratio of photosynthetic matters to fruits has reduced and finally, the weight of fruits has lessened.

Stem diameter

Experimental results indicate that the effect of intercropping treatments on stem diameter and Roselle plant was significant at 1% level (Table 3). Comparison of data means showed that the highest stem diameter in the treatment of 25% Roselle

Table 2
Means of quantities characteristics of Roselle (*Hibiscus sabdariffa*) as influenced by intercropping Aloe *Vera*

Intercropping system	PDW* t/ha	CDW* t/ha	PH* cm	SD* mm	CC* %	NC*	SW* gr	EY* t/ha	BY* t/ha	HI* %
Pure Roselle	36.84b	26.5a	223.3a	15.6c	8.54b	107.5c	11.15a	2.83b	46.59b	0.060a
25%A+75%R	46.52ab	9.53c	226.6a	15.2c	10.57ab	136.0b	2.61d	3.63ab	69.49a	0.052a
50%A+50%R	53.84a	12.83b	248.8a	20.2b	9.47b	119.5c	3.95c	3.23ab	62.74a	0.051a
75%A+25%R	53.2a	16.0b	246.8a	23.3a	12.94a	364.5a	5.65b	3.9a	71.68a	0.054a
LSD 5%	9.8	3.24	32.6	0.76	2.78	12.94	0.82	1.04	10.87	0.031

*PDW: Plant Dry Weight; *CDW: Capsule Dry Weight; *PH: Plant Height; *SD: Stem Diameter; *CC: Chlorophyll Concentration; *NC: Number of Capsule; *SW: Seed Weight; *EY: Economical Yield; *BY: Biological Yield; *HI: Harvest Index
Any two means not sharing a common letter differ significantly from each other at 5% probability

+ 75% Aloe Vera (23.3 mm) and the lowest amount with the mean of 15.6 mm was observed in the control treatment (pure Hibiscus Tea) (Table 4). The treatment of 25% Roselle + 75% Aloe Vera can increase stem diameter compared to the control treatment (pure Roselle), 75% Roselle + 25% Aloe Vera, 50% Roselle + 50% Aloe Vera, 25% Roselle + 75% Aloe Vera, 16.33%, 34.87%, and 13.20%, respectively. It seems that the densities of Roselle inter- species and intra-species competitions have reduced its stem diameter in a pure culture.

Chlorophyll concentration

According to the results of variance analysis, the effect of intercropping treatments on chlorophyll concentration of Roselle at the probable level of 5% was significant (Table 3). Comparison of data means based on data given in Table (4) showed that the highest concentrations of chlorophyll were in the treatment of 25% Roselle + 75% with Aloe Vera (12.94%) and the lowest rate, 8.54%, was observed in the control treatment (Pure Roselle).

Intercropping of 25% Roselle + 75% Aloe Vera increases chlorophyll concentrations compared to control, 75% Roselle + 25% Aloe Vera, 50% Roselle + 50% Aloe Vera, 34.00%, 18.31%, and 26.82%, respectively. Perhaps this increase in Roselle chlorophyll can be attributed to its intercropping with Aloe Vera using nitrogen fixation along with mixed cultures of soil Nitrogen in this intercropping. It seems that due its high chlorophyll index, intercropping is more favorable thereby it can increase the efficiency of photosynthesis and improve nitrogen use efficiency (Wenxue et al., 2004). Unlike low volume of strauma, in leaves which are at shade grana which has allocated major part of chlorophill to itself is bigger. On the other hand, in these plants, variation in matter's allcation and leaf morphology in response to shading have maximized light absorption (Lambers et al., 1998). Some of the findings show that plants that favor shading can compensate shortage of light photons due to possessing lower light respiration (Ballare, 2004). Unlike low volume of strauma, in leaves which are at shade grana which has allocated major part of chlorophill to itself is bigger (Salisbury and Ross, 1992). Since chlorophyll content, photosynthetic rate and biomass are related to each other, greater amount of chlorophyll in higher densities can lead to increased photosynthesis, dry matter production, and higher yield.

Number of capsule

The results of variance analysis (Table 3) showed that the effect of intercropping treatments over the capsule number of Roselle was very significant. Maximum number of capsules in the treatment of 25% Roselle + 75% Aloe Vera, 364.5 pcs and the lowest rate of 107.5 pcs in control treatment (Pure Roselle) was observed (Table 4). The level of 25% Hibiscus Tea + 75% Aloe Vera increased the capsule numbers relative to the control (pure Aloe Vera) 70.51% and 75% Roselle +25% Aloe Vera (62.68%) compared to 50% tea Hibiscus + 50% Aloe Vera (67.21%). It seems this increasing density of plants have arose competition between plants so that this competition has reduced the number of cylinders in tea Hibiscus pure culture.

100 Seed weight

Table results of variance analysis showed that intercropping treatments on seed weight per Roselle plant was 1% significant (Table 3). So that the maximum amount of seed weight (Table 4) in the control treatment (pure Roselle) was observed with an average of 11.15 g and the lowest rate of 2.61 g in 75% Roselle + 25% Aloe Vera. Control treatment (pure Roselle) increased seed weight more than the 75% Roselle + 25% Aloe Vera (57.64%) and 50% Roselle + 50% Aloe Vera (64.57%) compared to 25% Roselle +75% Aloe Vera (49.33%). This increase can be attributed to increased competition among intra- species plants.

Plant dry weight

Effect of intercropping treatments on Roselle dry weight at the 1% level was significant (Table 3). The greatest amount of plant dry weight was observed at level of 50% Roselle + 50% Aloe Vera, (53.84 g) and the lowest rate (36.84 g) was observed in pure Roselle (Table 4). Intercropping of 50% Roselle + 50% Aloe Vera increased plant dry weight more than the control group, 75% Roselle + 25% Aloe Vera, and 25% Roselle + 75% Aloe Vera, 31.57%, 13.59%, and 1.17%, respectively. It seems that with increasing Roselle density due to an increased interspecies competition has reduced its dry matter amount. Findings of Aref (2009) showed that in intercropping of potato and corn, any increase in corn density per unit area can reduce percentage of potato dry matter in the intercropping. Like RGR, CGR, and NAR increased with any increase of dry weight of the plant and leaf surface index (Morrison et al., 1990).

Biological yield

Based on the analysis of data variance, the effect of intercropping treatments on Roselle biological yield crop was at 1% level was significant (Table 3). Comparison of data means showed that different levels of intercropping are effective on increased or decreased levels of biological yield of the plant (Table 4). So that the maximum biological yield is related to 75% Roselle + 25% Aloe Vera treatment (71.68 t/ha) in which in comparison with other treatments of 25% Roselle + 75% Aloe Vera, 50% tea Hibiscus + 50% Aloe Vera, it doesn't show any statistically significant difference. This treatment increased biological function rather than control treatment (pure Roselle), 75% Roselle + 25% Aloe Vera, 75% Roselle + 25%

Aloe Vera, 50% Roselle + 50% Aloe Vera, 95.32%, 15.3%, and 71.9%, respectively. It seems that any increase in plants' density leads to competition between them so that this competition reduces biological yield. In mixed culture, there are numerous reports referring to increased biological yield in this competitive system. Sengul (2003) reported that in mixed culture of barley with vetch, barley biological yield increased.

Harvest Index

Experimental results indicated that the effect of intercropping treatments on Roselle plant harvest index at 1% level significant (Table 3). Comparison of data means showed that the highest rate was observed in treatment of 25% Roselle + 75% Aloe Vera (0.054%) and the lowest rate (0.05%) was seen in 50% Roselle + 50% Aloe Vera and pure Roselle which had no significant difference with 75% Roselle + 25% Aloe Vera treatment (Table 4). It seems that any increase in plant density leads to competition between plants so that this competition decreases harvest index.

Conclusion

In this field study, the results showed that when the Aloe Vera plant is intercropped with Roselle plants, the created shadow of Aloe Vera protects the Aloe Vera plant.

However, the effect of intercropping on all Roselle traits, except plant height, was significant and the maximum economical yield of Roselle was obtained in the mixed treatment of 25% Roselle + 75% Aloe Vera with a mean of 1.5 tons/ ha. In general, based on the results obtained in mixed cultures of Roselle plant and Aloe Vera, a treatment 25% Roselle + 75% Aloe Vera is recommended to achieve the highest economic yields of these plants.

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