Middle East Journal of Agriculture Research, 3(2): 221-226, 2014
ISSN 2077-4605

Influences of Salt Stress and Foliar Fertilizers on Growth, Chlorophyll and Carotenoids of Jojoba Plants

Hussein, M.M., Mehanna, H.M., Safi - Naz S. Zaki and Nagwan F. Abdel Hady

Water Relations and Irrigation Dept., Agric. Div., National Research Centre, Dokki, Cairo, Egypt

ABSTRACT

The response of growth and photosynthetic pigments of jojoba plants due to potassium sulphate (KS) and ammonium phosphate (AP) and salt stress was studied in a pot experiment which was conducted in the greenhouse of the National Research Centre, Dokki, Cairo, Egypt in the 2012 and 2013 summer season. The treatments of salinity were: irrigation by diluted seawater, 6000 and 3000 ppm and tap water (290 ppm) as a control, and fertilizers treatments were spraying of AP and KS in the rate of 1g/L more than distilled water as a control. Results revealed that increasing of salt concentration led to decrease the dry mass of stem, leaves, top and whole jojoba plant dry weight. Root dry mass which seemed to be without effect. Irrigation jojoba plants with water contains 6000 ppm decreased stem, leaves, top and whole plant dry weight by 4.9, 13.5, 0.3 and 1.6% compare with those irrigated by tap water. Top to root ratio decreased considerably with the increase of salts in the diluted seawater. Spraying plants by potassium fertilizer increased vegetative characters i.e. dry weight of root, stem, top and whole plant. Salt stress decreased chl.a, chl.b, total chlorophyll and chl.a+chl.b:carotenoids as the concentration of salts increased. The reverse was true in carotenoids concentrations, however, chl.b increased with moderate salt stress and tended to decrease with high salt levels but still more than the control. Application of AP showed the highest concentration of chl.a, chl.b and chl.a+chl.b as well as total carotenoids. On the opposite side, KS showed the lowest chl.a value and distilled water showed the lowest valus of chl.b and carotenoids. The highest ratios (Chl.a:chl.b and chl.a+chl.b:carotenoids) were obtained by distilled water spraying and the values resulted from spraying KS came in between.

Key words: Jojoba-((*Simondsia chinensis (Link) Shnider*)-Salt stress-Potassium-Foliar fertilizer-Growth-Chlorophyll-Carotenoids.

Introduction

As result of increment of the population in Egypt (84.7 million in July, 2013), the need to energy resources increased. Egypt suffers today from the increasing of food gap due to the limited water resources and the high competition between food crops of the cropping system in the agricultural seasons.

Accumulation of salts in soil has a negative effect on the production of a wide variety of crops. For various reasons the area of salt affected soils will rapidly expand in the near future. As the world population continues to grow, the availability of renewable freshwater resources for agriculture will decrease, and simultaneously the area of irrigated land will increase in the attempt to satisfy the need for more food (FAO, 2010).

Salt stress results in a reduction in biomass production, a decrease in shoot length, induction of senescence response or earlier plant death. Studies over the last years have revealed a number of important strategies to improve salt tolerance. One strategy is the controlled influx of Na^+ into the root cells (Jaarsma *et al.*, 2013).

Supplying optimal quantities of mineral nutrients to growing crop plants is one way to improve crop yields. Nutrients need to be used rationally in order to avoid a negative ecological impact and undesirable effects on the sustainability of agricultural production systems (Sawan *et al.*, 2008).

Potassium (K) is one of the most important influence crop metabolism, growth, development and yield. The K application is very important in high-yield plant production because indeterminate growth habit of cotton plants (Oosterhuis, 1994 and Zhuo *et al.*, 2001). K play an important role in osmotic adjustment and maintaining cell turgor. The vacuole and the cytosol are the two major pools of K in plant cells.(Walker *et al.*, 1996). The K supply is thus associated with other minerals nutrients and is essential for the detoxification of active oxygen under stress (Marschner and Cakmak, 1989). K also, essential to the performance of multiple enzymes function and it regulates the metabolite pattern of higher plants, ultimately changing metabolite concentrations (Mengel, 2001).

Therefore, the objective of this work was to evaluate the effect of foliar fertilization in enhancing salt stress tolerant for jojoba plants which are irrigated by diluted seawater.

Material and Methods

The evaluation of growth and photosynthetic pigments of jojoba plants to potassium sulphate and ammonium phosphate and salt stress was studied in a pot experiment which was conducted in the greenhouse of

Corresponding Author: Hussein, M.M., Water Relations and Irrigation Dept., Agric. Div., National Research Centre, Dokki, Cairo, Egypt.

the National Research Centre, Dokki, Cairo, Egypt in the 2012 and 2013 summer season. The treatments were as follows:

Salinity:

Irrigation by diluted seawater, 3000 and 6000 ppm, and tap water (290 ppm) as a control treatment.

Foliar fertilizer:

Spraying of potassium sulphate (KS) and ammonium phosphate (AP) in the rate of 1g/L more than distilled water (DW) as a control.

The experiment included 9 treatments which represented the combination of three salt stress treatment and three foliar fertilizer treatments.

Seeds of jojoba (*Simondsia chinensis* (Link) Shnider) were sown in 1st of June 2012. Calcium super phosphate (15.5% P_2O_5) potassium sulphate (48.5% K_2O) were added before sowing, sulphate Ammonium was added in two equal portions, the 1st two weeks after sowing and the 2nd four weeks later. Irrigation by diluted seawater started after four weeks, where one irrigation by mixed water followed by fresh water alternatively. Foliar fertilizers were sprayed twice, the first was done at one month from sowing and the second was added one month later.

Chlorophyl (chl) a, chl.b and total carotenoids were calculated according to the methods mentioned by von Witistien, *et al.* (1957).

All collected data were subjected to the proper statistical analysis described by Snedecor and Cochran, (1992).

Results and Discussion

- *Salt stress:*
- *Growth:*

Increasing salt concentration led to decrease the dry mass of stem, leaves, top and whole jojoba plant dry weight. Root dry mass which seemed to be without effect. Irrigation jojoba plants with water contains 4000 ppm decreased stem, leaves, top and whole plant dry weight by 4.9, 13.5, 0.3 and 1.6% compare with those irrigated by tap water. Top to root ratio decreased considerably with the increase of salts in the diluted seawater. Nelson *et al.* (1993) found that the wet treatment produce 43 and 75 % more growth in height then the medium and dry treatment. Ossas-Anderson *et al.* (2013) noticed that plants grown under control condition exhibited the highest growth characters while the more severe stress conditions gave the lower growth.

Table 1: Effect of salt stress on different plan parts of jojoba plants.

Salinity	Dry weight (g) of					Top/root ratio
	Root	Stem	Leaves	Top	Whole plant	
Tap water	13.99	35.94	27.41	58.07	72.06	4.15
3000	13.81	34.39	26.91	61.30	75.11	4.44
6000	13.03	34.16	23.71	57.90	70.93	4.44
LSD at 5%	N.S.	N.S.	N.S.	1.94	2.17	---

Hussain *et al.* (2011) revealed that minimum values of plant height, number of leavers or number of branches/plant were obtained with the highest concentration of brackish water (9 dS/m). Faykm *et al*. (2010) found that salinity level of 2000 ppm in sweater gave the highest significant average number of shoots while increasing salt concentration decreased it. Similar results were obtained with shoot length, leaf number and fresh weight of jojoba plants. On the other hand, Thomas (1982) concluded that jojoba plants tolerate 4 dS/M (2440 ppm) salt in the irrigation water. Yarmanos (1979) reported that jojoba plants can tolerate salts in brackish water up 8 dS/m (4880 ppm).

Chlorophyll and carotenoids:

It is clearly shown from Table (2) that salt stress decreased chl.a, chl.b, total chlorophyll and chl.a+chl.b:carotenoids as the concentration of salts increased. The reverse was true in carotenoids concentrations however, chlb increased with moderate salt stress and tended to decrease with high salt levels but still more than the control.

Middle East J. Agric. Res., 3(2): 221-226, 2014

Table 2: Effect of salt stress on chlorophyll and cxarotenoids of jojoba plants.

Salinity	Chl.a	Chl.b	Carotenoids	Chl.a+chl.b	Chl.a:chl.b	Chl.a+chl.b: carotenoids
Tap water	3.69	1.40	4.46	5.12	2.69	1.30
3000	3.57	2.08	3.42	5.65	1.75	1.64
6000	3.57	1.75	2.89	5.31	2.10	1.81
L.S.D. at 5%	N.S.	N.S.	0.93	N.S.	---	---

Mitra and Banergee (2010) found that the depression in total chlorophyll from 63.39 to 73.33 % and carotenoids from 27.87 to 36.84 % on *Heritiera fomes* with the increase in salinity from 2000 to 20000 ppm and concluded that chlorophyll and carotenoids exihibeted negative correlation with salinity. Rodriguez, *et al.* (2006) subjected rice plants to salt stress and concluded that chlorophyll content did not affected with the moderate salinity but chlorophyll concentrations nearly doubled upon exposure to high salt. Ayala-Astorga and Alcaraz-Melendez (2010) indicated that chlorophyll *a*, chlorophyll *b*, β-carotene, and violaxanthin significantly decreased with exposure to higher sodium chloride concentrations at 15 and 30 days in both species In work done with the halophyte *Atriplex centralasiatica* with sodium chloride concentrations ranging from 0 to 400 mM, the content of chlorophyll *a* + *b* and β-carotene remained unchanged at increased sodium chloride concentrations (Qiu *et al.*, 2003). Stoeva and Kaymakanova (2008) observed with beans that chlorophyll *a*, chlorophyll *b*, and carotenoids decreased with increasing salinity (100 mM NaCl).

Foliar Fertilizers:

Growth:

Data in Table (3): showed the effect of potassium foliar fertilizer on growth of jojaba plants, the growth vegetative parts i.e. plant height number of branches and fresh weight of root, stem, top and whole plant and root, stem, top and whole plant dry weight. Potassium application increased the vegetative character and dry mater of plants.

Table 3: Effect of foliar fertilizers on dry mass of different plant parts of jojoba.

Fertilizers	Dry weight of root, g	Dry weight of stem, g	Dry weight of leaves, g	Dry weight of top, g	Dry weight of whole plant, g	Top/root ratio
DW	12.74	25.06	22.21	47.30	60.04	3.71
KS	12.51	30.15	25.88	56.03	68.54	4.48
AP	15.58	45.29	29.94	79.24	84.82	5.09
L.S.D. at 5%	N.S.	18.2	N.S.	N.S.	N.S.	---

Spraying of potassium sulphate (KS), Ammonium phosphate (AP) in the rate of 1g/L , and Distilled water (DW) as a control.

Salt stressed root growth is restricted by osmotic effects and toxic effects and toxic effects of ions, which resulted in lower nutrients uptake and inhibits the salt translocation of mineral nutrients, especially K. At a result of the similarities in physiochemical properties between Na+ and K+, Na+ could compete with K for or building sites in key metabolic processes (Shabala and Cuin, 2008). It is also essential to the performance of multiple plant enzymes function.

Dry, matter yield, total chlorophyll concentration, K, Zn and P uptake per plant, number of opened bolls per plant, boll weight, seed index, lint index, seed cotton, yield per plant, seed cotton and lint yield ha^{-1} and earliness of harvest increased with the application of K (Sawan, *et al.*, 2008). K foliar fertilizer resulted in high K plant tissue concentration (Jefon and Lester, 2011).

Chlorophyll and carotenoids:

Application of ammonium phosphate showed the highest concentration of chl.a, chl.b and chl.a+chl.bas well as total carotenoids. On the opposite side, AP showed the lowest values. The highest ratios were by distilled water spraying and the values resulted from spraying potassium sulphate came in between (Table, 4).

Zhau, *et al.* (2001) concluded that decreased photosynthetic rate of deficient-K leaves of cotton plants was mainly associated with dramatically low chl.a content and poor chloroplast ultrastructure. Abo Zinada (2009) K application did not affect chlorophyll content.

Table 4: Effect of fertilizers on dry mass of chlorophyll and cxarotenoids of jojoba plants.

Fertilizers	Chl.a	Chl.b	Carotenoids	Chl.a+chl.b	Chl.a:chl.b	Chl.a+chl.b: carotenoids
D.W.	2.86	1.25	2.72	4.11	2.29	1.50
KS	3.50	1.69	3.11	5.19	2.07	1.67
AP	4.48	2.29	4.94	6.77	1.96	1.35
LSD at 5%	0.77	0.42	0.91	1.88	….	…

Spraying of potassium sulphate (KS), Ammonium phosphate (AP) in the rate of 1g/L , and Distilled water (DW) as a control.

Salt stress X potassium:

Growth:

The interactive effect of salinity and foliar fertilizers on growth of jojoba plants was illustrated in Table (5). This data showed the improving effects of foliar fertilizer of potassium phosphate on growth parameters i.e. stem, leaves and whole plants dry weight. Root only decreased by AP under different salt stress treatment. On stem, the fertilizer more affected under fresh water irrigation however, for the whole plant the fertilizer was more under salinity treatments. Generally, the improved in these parameter as a result of ammonium phosphate exceeded those resulted from potassium sulphate spraying (1 g/l).

Table 5: Effect of foliar fertilizers and salt stress on dry mass of jojoba.

Salinity ppm	Fertilizers	Dry weight of root, g	Dry weight of stem, g	Dry weight of leaves, g	Dry weight of top, g	Dry weight of whole plant, g	Top/root ratio
T.W	D.W.	13.27	23.81	23.78	47.59	60.86	3.59
	KS	12.26	30.44	26.18	56.62	68.88	4.62
	AP	16.44	53.56	32.28	85.84	86.44	5.22
3000	D.W.	13.21	26.16	24.66	50.82	64.03	3.85
	KS	12.54	28.64	25.24	53.88	66.42	4.30
	AP	15.69	48.38	30.83	79.21	94.90	5.05
6000	D.W.	11.74	25.20	18.19	43.39	55.13	3.70
	KS	12.74	31.36	26.23	57.59	70.05	4.52
	AP	14.62	45.92	26.70	72.62	84.35	4.97
LSD at 5%		N.S.	N.S	9.18	27.2	66.8	....

Irrigation with brackish water, in which Mg, Ca and Na are higher than in good quality water lead to an increase in K release and desorption (Bar-Tal, *et al.*, 1991). Potassium uptake by plant can be affected by high salinity and the concentration of Na in soil solution (Kafkafi, 1984). A hypothesis, that K application can reduce the deleterious effect of salinity on plant development has been proposed. However, contradictory of the effect of K fertilization under saline conditions on whole plant and have bean reported. This include a reduction of salinity damages in various crops when high concentration of K are present in the root media (Bar-Tal *et al.*, 1991). Kaya, *et al.*, (2001) demonstrated vegetative growth, relative water content and chlorophyll and water use of spinach were reduced significantly by salinity and the reverse wand s true by MKP treatment. Membrane permeability was impaired in plants grown under salinity and MKP treatment maintained the membrane by decreasing electrolyte leakage. Foliar K fertilizer improved the drought tolerance of plants and increased growth and yield components of wheat (Aown, *et al.*, 2012).

Chlorophyll and carotenoids:

Table 6: Effect of foliar fertilizers and salt stress o nchlorophyll and carotenoids of jojoba.

Salinity ppm	Fertilizers	Chl.a	Chl.b	Carotenoids	Chl.a+chl.b	Chl.a: chl.b	Chl.a+chl.b :carotenoids
6000	D.W.	3.08	1.20	2.58	4.28	2.56	1.66
	KS	3.48	1.12	3.36	4.66	3.11	1.37
	AP	4.52	1.89	7.45	6.41	2.39	0.86
3000	D.W.	2.99	1.52	3.18	4.51	1.97	1.42
	KS	3.13	1.90	3.04	5.03	1.65	1.66
	AP	4.60	2.81	4.05	7.41	1.64	1.83
TW	D.W.	2.51	1.04	2.41	3.55	2.41	1.47
	KS	3.88	2.04	2.94	5.92	1.90	2.01
	AP	4.31	2.16	3.32	6.47	2.00	1.95
LSD at 5%		N.S	0.74	1.58	N.S	…..	…….

Spraying of potassium sulphate (KS), Ammonium phosphate (AP) in the rate of 1g/L , and Distilled water (DW) as a control.

Ammonium phosphate and potassium sulphate had a positive effect on chlorophyll and carotenoids concentrations. This was true under different irrigation treatments. Total chlorophyll increased by 8.88, 11.53 and 66.76% when plants sprayed by potassium sulphate and by 49.77, 64.30 and 82.25 % when plants received ammonium phosphate via leaves, under irrigation by 6000, 3000 and fresh water, respectively, compare to plants sprayed by distilled water.

Miladinova, *et al.* (2013) noticed that Chl.a, chl.b and carotenoids concentrations were decreased by salinity in some Paulownia colons. Similar response were obtained in spinach (Di Martino, et al 2003), in bean (Stoeva, *et al.*, 2003) and on Egyptian clover (Hussein *et al.*, 2012). Zhao, et al (2006) that found within the range of 0-180 kg/h K2So4 the chlorophyll and amino acid increased in plants. It seems reasonable to suggest that the improvement of K-nutritional status of might be of great importance for the survival of crop plants under environmental stress conditions through its effect on chlorophyll and photosynthetic rate, such as drought, chilling, salinity and high light intensity (Cakmak, 2005). Geromi, *et al.* (2012) showed that with the increasing of potassium and sodium silicate fertilizers the content of chl.a, b and total chlorophyll were increased in *Oriza sativa L.* Hussein, *et al.* (2012) reported that MKP in the rate of 200 ppm increased significantly the content of chlorophyll a and total phenols of pepper plants. The interaction effect of foliar fertilizer of potassium and irrigation with saline water was significant which increase chl.a, chl.a+chl.b and chl.a: chl.b but was not significant in chl.b and carotenoids concentration. Kaya, *et al.* (2009) noticed that increased salinity decreased chl.a and chl.b content and application of MKP ameliorate the adverse effect of salt stress.

References

Abo Zinada, 2009. Potato response to potassium nitrogen fertilization under Gaza strip condition.. of Al-Azhar Univ. Giza, 11: 15-30.

Aown, M., S. Raza, M.F. Saleem, S.A. Anjium, T. Khaliq and M.A. Wahid, 2012. Foliar application of K fertilizer under water deficit conditions improved the growth and yield of wheat. The j of Animal and Plant Sci., 22(2): 431-437.

Ayala-Astorga, G.I. and L. Alcaraz-Meléndez, 2010. Salinity effects on protein content, lipid peroxidation, pigments, and proline in *Paulownia imperiali*s (Siebold & Zuccarini) and *Paulownia fortunei* (Seemann & Hemsley) grown *in vitro*.. Envir.l Biotech., 13 (5) Issue of September 15: 2010.

Bar-Tal, A., S. Feigenaum and D.l. Sparks, 1991. Potassium-salinity interactions in irrigated corn Irrigation Sci., 12: 27-25.

Cakmak, I., 2005. The role of potassium in alleviating dwterminal effects of abiotic stresses in plants. J. Plant Nutr. and soil Sci., 168(4): 521-531.

Di Martino, C., D. Sebastiano, R. Pizetto, F. Loreto and A. Fuggi, 2003. Free am acid and glycine betaine on leaf osmoregulation of spinach responding to salt stress. New Physiol., 158: 455-463.

FAO year book, 2010.

Faykm, M.A.., E.A. Shabaan, M.S. Zayed, A.A. El-Obeidy and R.A. Taha, 2010. Effect of salt stress on chemical and physiological contents of jojoba *(Simondsia chinensis (Link) Shnider*) using in vitro culture. World J. Agric. Sci., 6(4): 446-452.

Geromi, N., A. Fallah and M. Moghadam, 2012. Study of potassium and sodium silicate on the morphological and chlorophyll content of rice plant in pot experiment . Intr. J. of Agric. & Crop Sci., 4(10): 658-661.

Hassain, G., M.A. Rashir and M. Ahmid, 2011. Brakich water impact and growth of jojoba. J. Agric. Res., 49(4): 591-596.

Hussain, G., M. Bashir and M. Ahmed, 2011. Brackish water impact on growth of jojoba (*Simmondsia chinensis L*). J. Agric. Res., 49(4): 591-596.

Hussein, M.M., S.Y. El-Faham and A.K. Alva, 2012. Pepper plants growth, yield, photosynthetic pigments, and total phenols as affected by foliar application of potassium under different salinity irrigation water. Agricultural Sciences, 3(2): 241-248.

Jaarsma, R., R.S.M. de Vries, A.H. de Boer, 2013. Effect of Salt Stress on Growth, Na^+ Accumulation and Proline Metabolism in Potato (*Solanum tuberosum*) Cultivars. PLoS ONE 8(3): e60183. doi:10.1371/journal.pone.0060183.

Jefon, J.A. and G.L. Lester, 2011. Effect of foliar potassium fertilizer and source on cantelope yield and quality.Better Crops, 95(1): 13-15.

Kaf Kafi, U., 1984. Plant nutrition under salinity conditiond. In Shienberg,I. and Shalhever, J. (ed) Soil salinity under irrigation. Springer, Berlin.

Kaya, C., A. Tuna and I. Yokas, 2009. The role of hormones under salinity stress tasks for vegetation science. Salinity and Water stress, 44: 45-50.

Kaya, C., D. Higgs and H. Kirnak, 2001. The effect of high salinity and supplementary phosphorus and potassium on physiology and development of spinach. Bul.J. Plant physiol., 27(3/4): 47-59.

Marschner, H., I. Cakmak, 1989. High light enhances chlorosis and necrosis in leaves of zinc, potassium, and magnesium deficient bean (*Phaseolus vulgaris*) plants. J. of Plant Physiology, 134: 308-315.

Mengel, K., 2001. Principal of Plant Nutrition 5th ed.,Kluwer Acad. Publications, Dorderecht the Netherland, pp: 481-509.

Miladinova, K., K. Ivanova, T. Geogerva, M. Geneva and Y. Markoviska, 2013. The salinity effect on morphological and pigments content in three *Pulownia* colons. Pulgarian J. of Agric. Sci., 19(2): 52-56.

Mitra, A. and K. Banerge, 2010. Pigments of Heritiera fomes under different salinity conditions: prespective sea level rise. Mesopot. J. Mar. Sci., 25(1): 1-10

Nelson, J.M., D.A. Pelzkill and Bartels, 1993. Irrigation cut-off data affects growth, frost damage and yield of jojoba. J. Amer. Soc. Hort. Sci., 118: 731-735.

Oosas-Anderson, P., T.R. Sincdior, M. Balota, S. Tallury, T.G. Isloib and T. Rufty, 2013. Genetic variation for epidermal conductance in peanut. Crop Sci., 7: 1-28.

Oosterhuis, D.M., D.W. Alberts, W.H. Baker, C.H. Eblhar, M.W. Cotheren and Bumester, *et al*, 1994. A summary of three years Beltwide study of soil and foliar fertilizer with potassium nitrate in cotton, pp: 1532-1533. In P. Dugger and D. Ritchter, edt (1994), Beltwade Cotton Conf., San Deigo CA 5-8 Jan., 1994.

Qiu, Nianwei, L.U., L.U. Quingtao 2003. Congming. Photosynthesis, photosystem II efficiency and the xanthophylls cycle in the salt adapted halophyte *Atriplex centralasiatica*. *New Phytologist*, 159(2): 479-486.

Rodriguez, A.A., A.M. Stella, M.M. Storni, G. Zulpa and M.C. Zakccro, 2006. Effects of cyanobacterial extracellular products and gibberellic acid on salinity tolerance in *Oryza sativa* L. Saline Systems, 2: 7-10.

Sawan, Z.M., M. Mahmoud and A.H. El-Guibali, 2008. Influence of potassium fertilization and foliar application of zinc and phosphorus on growth, yield components, yield and fiber properties of Egyptian cotton (*Gossypium barbadense* L.). J Plant Ecol., 1 (4): 259-270.

Shabala, S. and T.A. Cuin, 2008. Potassium transport and plant salt tolerance. Physiol. Plant, 133: 651-669.

Snedecor, G.W. and W.G. Chochron, 1992. Statistical methods. 8th ed., Iowa State Univ. Press, Iowa, USA.

Stoeva, M. and M. Kaymakanova, 2008. Effect of salt stress on growth and photosynthesis of bean plants *(Phasolous vulgaris L.)*. Central Eur. Agric., 9: 385-392.

Thomas, P.H., 1982. Jojoba Handbook. 3rd Ed. Bonsall Publications. 4339 Holly, Bonsall California, USA.

Von Wettstein, D., 1957. Chlorophyll latalfaktoren und der submikroskopische formuechsel der plastidenn. Exper. Cell Res., 12: 327-433.

Walker, D.J., R.A. Leigh and A.J. Miller, 1996. Potassium homeostatsis Proc. Natl. Acad Sci., USA, 93: 10510-10514.

Yarmanus, D.M., 1979. Jojoba a crop whosev tiome has come. California Agric., pp: 4-11.

Zhao, H.J., H.M. Gao, W.Y. Guo, H.L. Xie and L.F. Zhao, 2006. Effect of potassium level on output and diosgenin content of Dioscorea zingiberensisg. Zhong Yao Cai., 29(6): 528-30.

Zhuo, D., D.M. Costerhous and C.W. Bednarz, 2001. Influence of potassium deficiency, chlorophyll content, chloroplast ultrastructure of cotton plants. Photosynthetica, 39(1): 103-109.