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Full Length Research Paper

Effect of different soil conditioners application on some soil characteristics and plant growth I-Soil moisture distribution, barley yield and water use efficiency

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Field experiment was carried out in Research and Production Station, National Research Centre, El-Nobaria, El-Beheara Governorate, Egypt during the season of 2013 on a sandy loam soil (23% silt; 8% clay). The experimental design was randomized completely block in sex replicates. Barley (*Hardiumvulgare* L.) Giza 124 was sown and irrigated by sprinkler irrigation with total amount of irrigation water 405 mm/season. The aim of the work is to study the effect of bentonite (as a soil conditioner) application rates on the some soil properties and barley plant growth comparing with FYM effect in common application rate (2%). Bentonite used is characterized by clay in texture, 4.8 dSm^{-1}, 7.88, 4.6 % and 1.8 % for ECe, pH, $CaCO_3$ and organic matter content. Bentonite application rates were 0, 2, 4, 6 and 8 %, in addition to farm yard manure treatment (FYM) at 2 %. Half of the plots were treated by bentonite examined rates in two equal doses (50%), the first one applied before maize and the second one during soil preparation for sowing barley. The obtained results showed that increasing bentonite rates to treated soil associate with increase in soil moisture content on weight base in all studied depths and the rate of increase clearly observed in the first and second examined depths (0-15 and 15-30 cm) in the 1st rate (2%) by 24% and 14.5 % in previous sequences. Water content before irrigation was not far from values of that after irrigation that means increase ability of soil to retain more water and the increase was 43 % if 2 % bentonite was applied and 89.7 % when sandy soil treated by 8 % bentonite. Whereas, 2 % FYM increased soil moisture content by about 25.6 % (comparing with control) in the 1st depth.Application bentonite in two doses had a superior effect on water use efficiency (WUE) of barley grain yield more than one dose. The best bentonite application rates that fulfill maximize WUE of grains of barley were 6 in one or two dose of application.

Keywords: sandy loam, bentonite, water distribution, barley, yield, WUE.

INTRODUCTION

Sandy soils are amongst the most extensive soils in the world, covering more than 900 million hectares (Driessen et al., 2001), which are found in the arid and semi-arid regions and they have been identified as inherently

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infertile, degraded and having poor physical characteristics (Noble et al.,2000), consequently, they are regarded as marginal for crop production. In this respect crop yields are low and farming is only marginally economically viable.

Barley (*Hordeumvulgare L.)* is characterized by relatively high drought resistance and salt tolerance, where it can grow with lesser soil moisture. Barley is one of the most important cereal crops being used in making bread, beverages, malting, brewing industry and animal feeding. Barley is a widely cultivated cereal crop in the temperate regions. Its cultivation extends farther north than any other crop and at the same time it can be cultivated in sub-tropical countries (Zoidberg, 2007). Barley also in Egypt is grown under wide range of environmental conditions. Generally, it grown in areas where water supply is limited and where crop production depends mainly upon rain fed (Ashour and Selim,1994). In Egypt, barley cultivated mainly in the Northern coastal region and in the marginal areas of Nile Valley and Delta and also in the new reclaimed soils in order to its tolerance to salinity and drought than wheat.Hussien et al, (2010) reported that barley yield was increased by soil conditions application

Noble et al.,(2000) mentioned that the important step in the process of improving soil physio-chemical characteristics of these degraded soils, is to address the problem of decline not only nutrient but also water holding capacity associated with a reduction in soil organic matter. Calcium bentonite can only hold 1-5 times its weight in water and is used in gardening as it is more stable (Abou-Gabal, 1990, Matloub, 1998 and Wahab et. al, 2010). They added that calcium bentonite stores and releases water much easier than other types of clays. Bentonite clay has hundreds to thousands of times more surface area than sand particles hence it improves nutrient holding capacity of soils and helps provide a better home for soil micro organisms (Croker, 2004).

The aim of the work is to study the effect of bentonite (as a soil conditioner) application rates on the some soil properties and barley yield and plant growth comparing with FYM effect in common application rate (2%).

MATERIAL AND METHODS

Field experiment was carried out in Research and Production Station, National Research Centre, El-Nubaria, El-Beheara Governorate, Egypt, during the season of 2013 on a sandy loamy soil(23% silt; 8% clay).The experimental design was completely randomized in sex replicates. The plot area 42 m^2 (1/100 of fed).

Barley (*Hardiumvulgare. L*) Giza 124 was sown in the $1^{st}$of December in both seasons and was lasted about 145 days. The amount of water applied was based on estimated evapotranspiration of the experimental site to all plots at the same time and same quantity during thegrowing season by sprinkler irrigation. Sprinklers (discharge is 0.95 m/l at 2.1 bar) were set up at square design (9x9 m) with 18 % overlapping and its precipitation was 15 mm /h. Rainfall during the experiments took place. The total amount of irrigation water that applied to the barley during growing season is 405 mmand irrigation was stopped 15 days before harvesting. Maximum and minimum mean values of the temperature and relative humidity during growing season were 28.4, 9.0 ^{o}C and 59, 47 % at April and January, respectively.

Bentonite used in current work is characterized by clay in texture, 4.8 dSm^{-1}, 7.88, 4.6 % and 1.8 % for ECe, pH, $CaCO_3$ and organic matter content. Bentonite application rates were 0, 2, 4, 6 and 8 %, in addition to farm yard manure treatment (FYM) at 2 % on weight basis. Half of the plots were treated by bentonite examined rates in two equal doses (50%), the first one applied before maize and the second one during soil preparation for sowing barley.

Some soil characteristics of the experimental soil before cultivation are determined after (Rebecca, 2004) i.e. $CaCO_3$ (2.5 %), OM (0.36%), ECe (1.24dSm^{-1}in soil paste extract), pH (8.12 in soil: water 1:2.5).

Three soil depth samples were collected from experimental plots after barley harvested from the surface layers 0-45 cm, 15 each to determine the investigated variables.

All fertilizers were applied just before barley sowing. Rates of incorporated nutrients were as follows: 100 kg/fed of calcium super phosphate (15 % P_2O_5) and 50kg/fed potassium sulphate (50%K_2O) were applied during preparation of experimental soil. Ammonium sulphate was applied by 75 kg/fed in three equal doses to the experimental plots as follows: 10 days and 30 days after germination and the last one was applied before tellering. Herbicides and all other agro-technologies were applied according to standard practices.

The data were subjected to the analysis of variance (ANOVA) appropriate to the randomized complete block design applied after testing the homogeneity of error variances according to the procedure out- lined by Dospekhov (1984). The significant differences (LSD) between treatments were compared with the critical difference at 5% probability level.

RESULTS AND DISCUSSION

Soil moisture content was monitored through soil profile 24 hours after irrigation that represent soil water content at the FC in the examined soil depths. The obtained soil moisture values were plotted in Figure (1). Data noticed that increasing bentonite rates to treated soil associate with increased in soil moisture content on weight base in all studied depths. Also, data noticed that the rate of increase clearly observed in the first and second examined depths

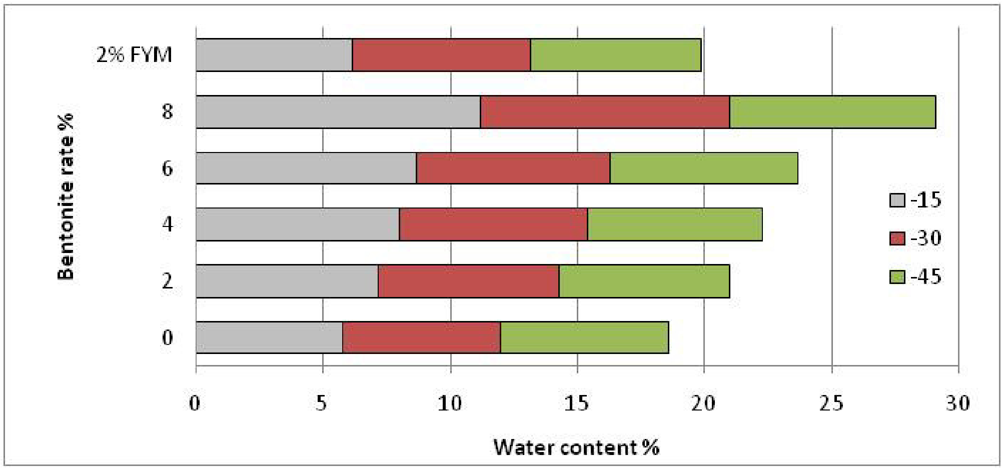

Figure 1: Effect of bentonite and farm yard manure application on soil moisture content 24 hours after irrigation (barley).

(0-15 and 15-30 cm) in the 1st rate (2%) by 24% and 14.5 % for the studied depths in previous sequences, whereas the rate of increase is not clear at the 3rd studied depth. The increase in the 2nd depth was attributed mainly to the increase fine particles that migrates from surface to the subsurface depth, which include fine and colloidal particles, was reduced in the 3rd soil depth. These particles play an important role in clogging macro pores and change pore size distribution towards fine pores that a key role in retained water (Al-Omran et al., 2004 and Hassan; Abdel Wahab, 2013).

The percentage of the increase was highly in the 1st layer (0-15 cm) and the highest value (93.1 %) was obtained by addition of 8 % bentonite and the lowest one was (24.1 %) recorded at 2% bentonite relative to the untreated plot (control). While the rate of increase was 6.7 % after addition 2%.FYM. In case of soil water content before the next irrigation, mainly represent soil water content near PWP, data indicated that water content before irrigation not far from values of after irrigation that pointed out to increase ability of soil to retain water. Also, the percentage of increase was 43 % if 2 % bentonite was applied and 89.7 % when sandy soil treated by 8 % bentonite. Whereas, 2 % FYM increased soil moisture content by about 25.6 % (comparing with control) in the 1st depth. Same trend was attained in the following studied depths where the moisture content in the 2nd depth was greater than the 3rd one which expected. Also, bentonite play an important role in providing plants by its needs of sufficient water and nutrients that should recover to form high yield with good quality. Also, at high rates of bentonite added to sandy soil, it could be avoided moving up of salts if the net flow of water is upward for insufficient periods of time. High concentration of salt may accumulate near the surface in the absence of sufficient irrigation to maintain downward water flow. The obtained results agreed with those obtained by Abdel-Nasser (2005) who stated that highly impact of OM application in improving hydrophysical soil properties. Highly positive significant correlation between bentonite application rates and soil water content was obtained (0.9176**).Abdel Hady (2005) and Abd El-Hady and Ebtisam (2012) mentioned that both soil fine particles such as silt and clay and organic matter content had a potential effect to improve soil ability to retain water and increased soil available water under coarse textured soils.

It is widely used to improve poor soils particular sandy ones. Small amounts of bentonite have been shown to increase growth rates and yields of many plants in sandy soils.

Figure (5) illustrated the effect of bentonite application from 0 to 8 % wither under 1 and/or 2 equal doses and FYM at 2 % on barley yield. Data on hand revealed that increasing both grains and straw of barley was associated with increasing bentonite rates. The highest and lowest values of grains and straw of barley were attained at 8 and 0 % bentonite a like by one or two equal doses.

The impact of addition of bentonite to sandy soil in two equal doses reflect by increasing grain yield of barley, where increasing bentonite by unite (2%wb) increasing yield by 6.3 % and at 8 % bentonite by 45 % at one dose. While at two equal doses of bentonite yield grains of barley increased by about 50 and 79.8 % relative to the control in same sequences (Figure 5). Also one can notice that the increase in yield grain as a result to FYM (2%) addition was 1.96 % ton /fed which resemble 94.1 and 71.4 % as compared with the maximum grains obtained by 6 % bentonite addition at one and two doses, respectively. Also, data revealed that the rate of change in grains yield of barley resulted from bentonite addition was superior if

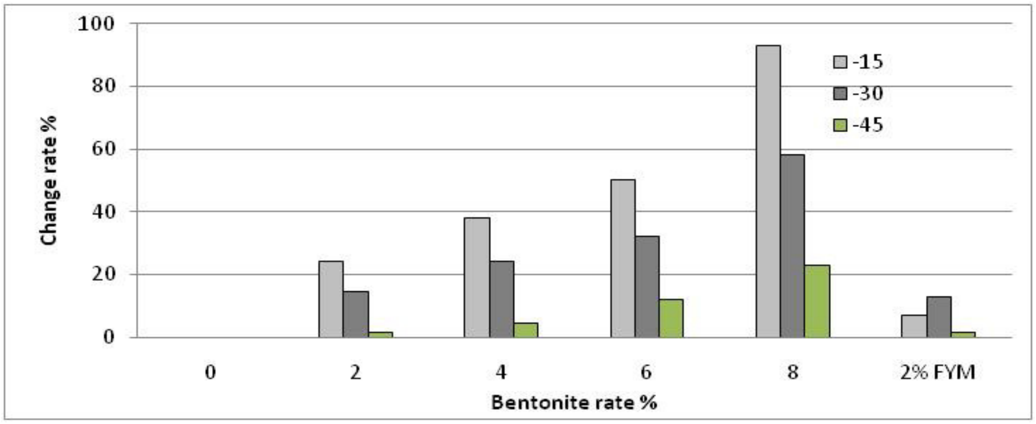

Figure 2: Effect of bentonite and farm yard manure application on increased percentage of soil moisture content before next irrigation (barley).

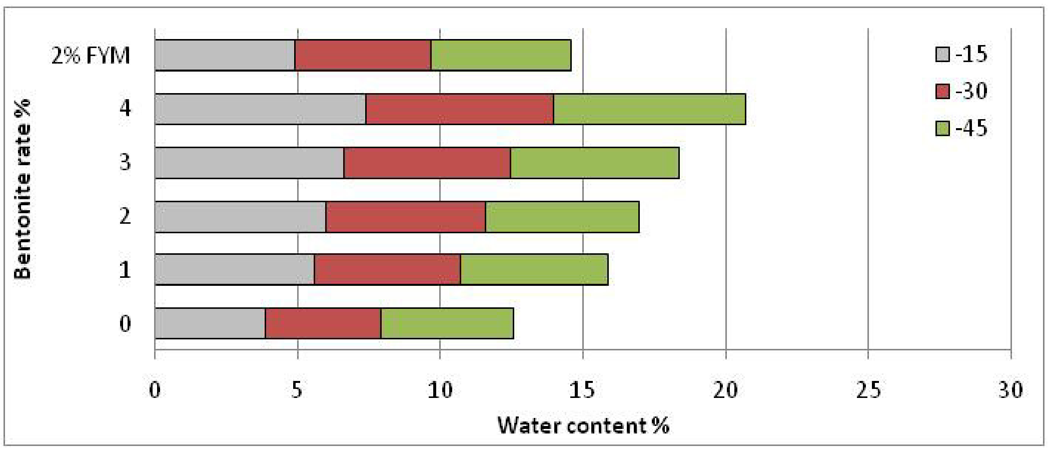

Figure 3: Effect of bentonite and farm yard manure application on increased percentage of soil moisture content before next irrigation (barley).

added in two equal doses where the increase reached 104.2 % at 6 % bentonite comparing with untreated plot and followed by 31.8 % comparing two doses with one dose.

Regarding to the barley straw yield, results indicated that bentonite at 6 and 8 % increased straw yield by about 130.6 and 124.8 % relative to control (without significance level difference among) for using bentonite at one dose. With respect to bentonite application bentonite application in two equal doses increase straw yield by about 101.2 and 72.7 % for 6 and 8 % bentonite as compared with control, respectively. According to the straw yield resulted from addition of FYM at 2% , the percentage of increase were 79 and 90 % under sandy soil treated by 6 % bentonite in one and two doses.

With respect to the role of bentonite in improving barley yield, one can notice that straw yield was improved as a result of adding bentonite in one dose, while application of bentonite in two equal doses improved grains yield comparing with control in each (Figure 3 and 4).Also, results showed that there is no significant difference at 5% between grain yields treated by bentonite at 6, 8 % and 2% FYM. However, bentonite at 8 % reduced grain yield by about 5.9 and 2.8 % relative to the 4 and 6 % bentonite under one dose application. While FYM application was more effective to slightly improve of straw yield which increased about 7.3, 6.0 and 5.3 comparing with the 2, 4 and 8 % bentonite application rate. this finding agreed with obtained by El-Kholy et al., (2000) and Hassan and Abdel Wahab (2013).

To evaluate how grain yield of barley responses to bentonite and FYM application rates , those responses were fitted to the following equations:

$y = 99.9x + 1344$ $R^2 = 0.8699$**Eqs. (1) for one dose
$y = 280.8x + 804.8$ $R^2 = 0.6343$*Eqs. (2) for two dose

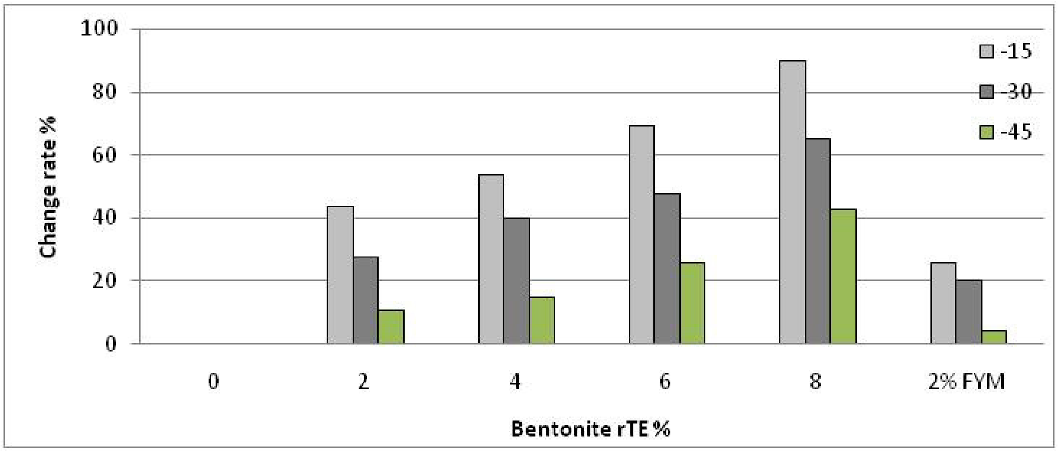

Figure 4: Effect of bentonite and farm yard manure application on increased percentage of soil moisture content before next irrigation (barley).

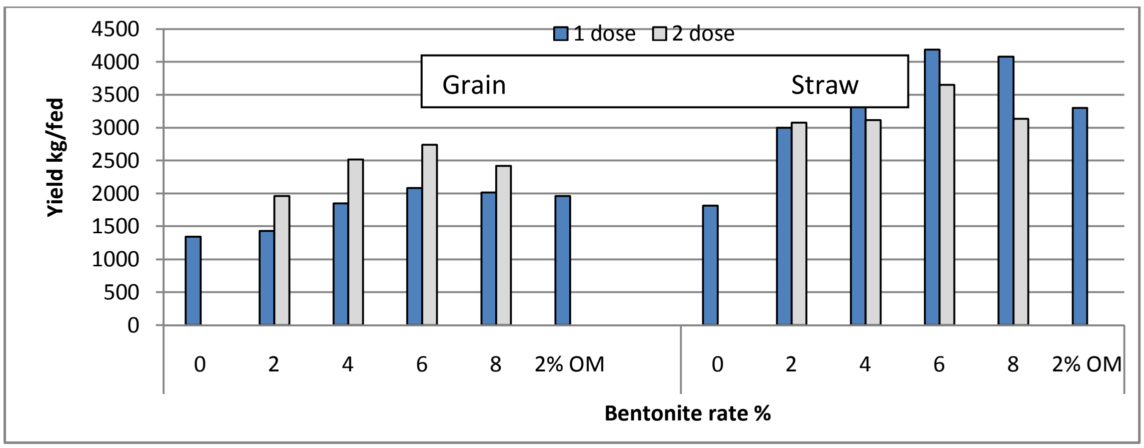

Figure 5: Effect of bentonite and farm yard manure application on barley yield.

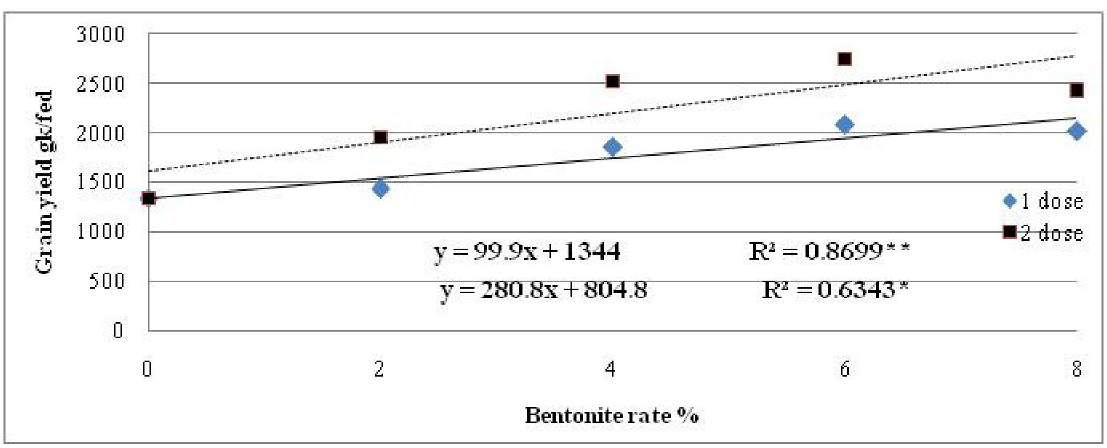

Figure 6: Relation between bentonite and farm yard manure application rates and grain barley yield under 1 and 2 doses of application.

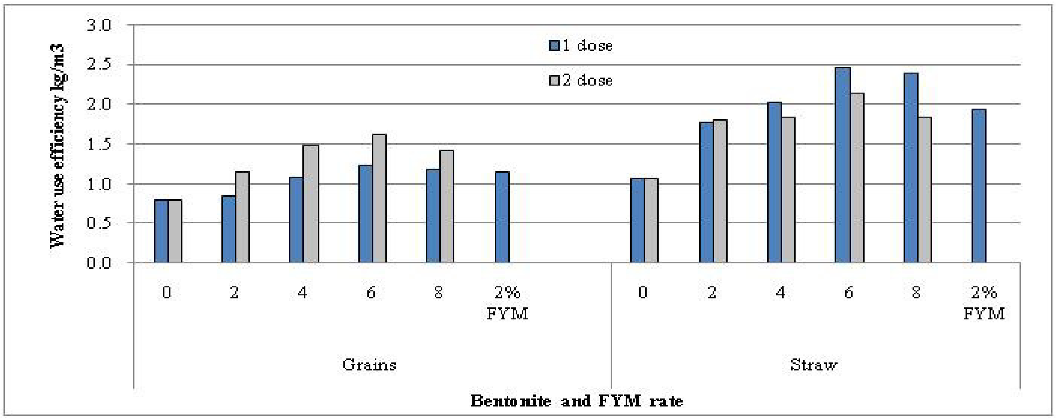

Figure 7: Effect of bentonite at one and two equal doses and farm yard manure application on barley yield.

by using linear regression equations, regardless FYM application. Figure 6 showed the regression coefficients for the obtained two equations were highly significant in one dose application rate (0.8699**), while significant at 5 % at the two dose application of bentonite (0.6343*). Elkholy et al (2000) and Hussein et al (2013) supported the obtained data, and attributed the increase in wheat yield to the soil ability to storage water for plant till needed.

Regarding to the water use efficiency (WUE) of barley grain yield as affected by bentonite and FYM application under both one and two doses, data pointed out that almost application bentonite in two doses had a superior effect on WUE of barley grain yield than the one dose. Also, data indicated that the best bentonite application rate that maximize WUE of grains of barley were 6 followed by 4 and 8 % of bentonite application in both method of application. WUE of barley grains as affected by FYM was slightly close to 4 % bentonite application rates if added in one dose. This finding could attributed mainly to the role of bentonite at high rates and FYM application. Obtained data pointed out that the highest increase in barleyt WUE of grain and straw relative to 1 and 2 dose application rate were obtained at 6 % bentonite and the percentage values 55, 104 and 31, 101 % comparing with untreated plot (control), respectively, while the rate of increase were 46 and 82 % if comparing FYM treatment with control at one dose. From the above mentioned results we can concluded that under restricted water used that has had their bentonite at different rates, soil will provide barley plants by their needs of irrigation water without any stress and bentonite at rate 6 % followed by 8% were better than FYM at 2% if they applied at one or two doses to maximize WUE for both grain and straw. the resulted data supported by those obtained by Hussein et al (2013).

CONCLUSIONS

The use of bentonite on coarse textured (sandy) soils of Nubaria is a promising technology to increase biomass production and rehabilitate the exchange properties of these degraded soils regarding to the its fraction and economic application rates. In addition bentonite or organic matter applied at high rates will supply barley plants substantial amounts of water.

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