

Intercropping of Cow Pea (*Vigna unguiculata*) as Summer Forage Yield with *Grewia tenax* in Irrigated Saline Soil of Khartoum State, Sudan

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Abstract

Agroforestry in terms of intercropping cow pea as summer forage with *Grewia tenax* was undertaken under sub-irrigation system in two consecutive seasons of 2017 and 2018 in saline soil of Khartoum State of Sudan. The aims were to find out suitable agro forestry system for saline soils as well as to investigate effect of tree spacing on field summer forage crop under semi-irrigation system. Therefore *G. tenax* trees that spaced at 4×4 m were used as main factor versus cow pea crop that incorporated at 25×50 cm intervals by using completely randomized block design with 3 replications. Trees and crop parameters were determined in terms of plant growth and yield. In addition to land equivalent ratio and soil chemical and physical properties at different layers were determined. The results revealed that, soil parameters in terms of CaCO₃, SAR, ESP, pH paste and EC ds/m were increased with increasing soil depths. Meanwhile tree growth did not show any significant differences in the first season in 2017. Whereas in the second season in 2018 tree growth namely; tree height, tree collar and canopy diameters were higher under intercropping than in sole trees. Cow pea plant height recorded significant differences under sole crop in the first season in 2017. Unlike the forage fresh yield that was significant under the inter cropped plots. Tree fruit yield was higher under sole trees and land equivalent ratio was more advantageous under GS2 (1.5 m) which amounted to 4. Therefore it is possible to introduce this agroforestry system under saline soils to provide summer forage of highly nutritive value to feed animals and to increase farmers' income as far as to halt desertification and to sequester carbon.

Key Words: intercropping, *G. tenax*, cow pea, saline soils, land equivalent ratio

Introduction

Agro forestry is a land use system that incorporates trees into agricultural lands. That can be occurred either through the integration of forests into agricultural lands or integration of agricultural lands into forests lands (Baumer 1983). Therefore, the ultimate role is to obtain protective and/or productive measures for the lands as well as to conserve environment to safeguard human beings and animals.

Thus some agro forestry techniques/systems were used either to maintain or increase soil fertility and consequently sustain the farming systems (Lundgren 1982; Raintree 1985). In this respect, using of multi- purpose trees such as leguminous species were found to be prominent to achieve this role. Moreover, introducing of other multi- purpose trees in marginalized soils such as saline soils will increase their potentiality regarding their productivity and sustainability (Van Den Beldt 1990). Therefore, agro forestry sys-

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tems or practices such as alley cropping or intercropping have potentiality in reclaiming such soil types (King 1968; NasreAldin et al. 2010). Besides in diversifying the cropping systems, in terms of field crops and none wood forests' products as well as in reducing the hazards which could be attributed to mono cropping systems (Kessler and Breman 1991). Hence, such hazard impacts could be manifested in drought phenomena particularly in arid and semi arid zones. Besides other factors that could be related to soil infertility or lack of technical knowledge (Ojo 1966; Miede 1986; Young 2000). However, applying such appropriate agro forestry systems will maintain the farmer's food security and increase his income (NasreAldin et al. 2011). Besides, it increases the farmers' capacity to withstand the harsh environmental conditions as far as tolerating such circumstances.

Grewia tenax locally known as "Guddeim" is a small tree reaching up to 2 m in height in its natural stands. It found throughout semi-arid Africa, from Namibia northwards, also in the Arabian Peninsula beside Iran and India. In Sudan it is widely spread in central and southern parts besides Khartoum State. *G. tenax* can tolerate most of soil types such as rocky, sandy and clay. It can grow in elevation of 0-1,500 m high can tolerate cold weather and heat but not frost. The species has several multipurpose uses; the fruits are most valued for containing large amounts of iron which are commonly used into making a refreshing drink. The tree is recognized as a very important browse source that tolerates repeated browsing in arid and semi arid regions of the Sudan (Elamin 1990; Vogt 1995).

Cow pea (*Vigna unguiculata*) is a summer annual legume. It is originated in Africa and widely grown in most of the continents; Africa, Latin America, south eastern Asia and in the southern United States. It is mainly used as grain

crop, animals fodder or as vegetable. The cow pea seeds have nutritious components such as proteins, carbohydrates, fiber and fats. It can be used at all stages of its growth as a vegetable crop for human feed. Besides cow pea was considered as quality legume hay for livestock feed due to its high digestibility when compared with alfalfa. Cow pea is grown under both irrigation and none irrigated regions, however it performs well both under irrigation system and dry conditions. Moreover, it is drought resistant crop than the other common beans. Cow pea can tolerate a variety of soils, thus it is suitable for pH 5.5-6.5. And can be harvested in period of 60-90 days according to the varieties and its purposes (Davis et al. 1991).

Therefore introduction of this agro forestry system in terms of intercropping of *G. tenax* with cow pea field crop in the saline soil will increase the potentiality of these soils to be productive as well as to diversify farmer s' income. Also to minimize the hazardous effects of these soils and will halt desertification and to sequester carbon. In this respect the objectives of this paper were; to find out an agro forestry system that suits saline soils of Khartoum State and to investigate the effect of *G. tenax* spacing on cow pea field crop growth and yields in saline soils.

Materials and Methods

Site description

This experiment was conducted in Forestry and Gum Arabic Research Centre Farm in Soba, in Khartoum State, Sudan during the period of July 2017 to November 2018. The experiment site was located at latitude 15° 51' N and longitude 32° 61' E. The site is classified as Sodic Haplocombids (Elbageer soil series) with pH of 7.6-8.6 for the following layers; 0-10cm, 10-30 cm, 30-60 cm and 60-100 cm re-

Table 1. Soil chemical and physical properties at different depths

Depth (cm)	EC (ds/m)	CaCO ₃ (%)	SAR	ESP	pH paste	N (%)	O.C (%)	C/N ratio
0-10	2.0	1.8	9	10	7.8	0.810	0.485	6
10-30	2.2	2.1	10	11	8.0	0.820	0.486	6
30-60	2.5	2.3	10	11	8.4	0.830	0.486	6
60-100	16.1	5.2	30	30	9.1	0.820	0.486	6

EC, exchangeable conductivity; SAR, sodium absorption ratio; ESP, exchangeable sodium percentage; N, nitrogen content; O.C, organic carbon.

spectively, with parts contain CaCO_3 concretions and also with parts contains salts. The soluble salts come up to the surface with irrigation are deposited in the forms of white crystals and incrustations of chlorides and sulphates of sodium and calcium. Land form is plain with slope of 1%. The soil is slightly sticky and slightly plastic wet, moderate medium and fine sub-angular blocky structure, few stones, fine ravel and common sand grains, few CaCO_3 grey nodule sand white soft aggregates, few coarse, medium and fine roots for the soil layers as indicated in Table 1.

Vegetation types are Hegleg (*Balanites aegyptiaca*), Tundub (*Capparis decidua*) and Mesquite (*Prosopis chilensis*). Climate is semi desert, rainfall is 180 mm/annum and drainage is moderately to well drainage (Farah 2017). The Maximum average temperature is 32°C in January and the lowest is 7°C . While in May and June the maximum average temperature is 42°C and average minimum is 27°C in July (Bosshard 1966).

Methods

One-year-old seedlings of *Grewia tenax* (Gedum) were produced at the nursery of the Forestry and Gum Arabic Research Centre. The seedlings were planted in March 2017 under field conditions using a spacing of 4×4 m. The seedlings were watered periodically at a once-a-week interval from a permanent water supply source during the period March to June. Then they subjected to natural rainfall during the wet season, in addition to supplemental irrigation using the permanent water source from July to November. The improved cowpea (*Vigna unguiculata*) variety known as "Ain Algazal" which was released by Alobeid Agricultural Research Station in Western Sudan was integrated as intercrops within the trees as a summer forage crop. The tree and crop treatments were arranged in randomized complete blocks design with three replicates. The main treatment was the tree (*Grewia tenax*) component which was established at a fixed spacing of 4×4 m. The cowpea intercrop was sown in first August using a spacing of 50×25 cm for inter and intra spacing and 3 seeds per hole. The intercrops were carried out at two different distances of 1.0 (GS1) and 1.5 (GS2) metres from the trees trunks. In addition to sole crops and trees were incorporated as controls. The cultural practices viz. ploughing and weeding were carried out for trees and crops as necessary.

The experiment was repeated in 2018 as a second season with the same treatments and in the same time but the *G. tenax* trees were reached 17 months old.

The experiment plot size was 12×8 m for each treatment and the number of the trees per treatment was 12. Therefore, the total area of the experiment was $225 \times 150 \text{ m}^2$ and total number of trees per ha was 1,250 trees.

Grewia tenax tree measurements

G. tenax were measured in terms of tree height in cm, tree collar diameter in mm and tree canopy diameter in m in November before crop harvesting for the two seasons 2017 and 2018. Also tree fruit yield was estimated for 3 trees per a treatment in gram in November for the two consecutive seasons as mentioned above.

Crop parameters measurements

Cow pea crop growth parameters were determined in terms of plant height in cm, number of plant per ha and forage fresh yield kg/ha for the two consecutive seasons in November 2017 and 2018 respectively.

Land equivalent ratio (LER)

Land Equivalent Ratio (LER) is expressed in terms of $\text{LER} = \text{Intercrop1/pure1} + \text{intercrop2/pure2} + \text{etc.}$ were calculated for the two seasons in 2017 and 2018. Therefore if the value is more than one it gives the advantageous of the intercropping system. And vice versa if the values are less than one indicates mono-cropping system is superior than intercropping as stated by Sullivan (1998).

Statistical analysis

Statistical analysis for tree measurements and crop parameters were determined by using GENSTAT Software. Thus data means were generated and presented in ANOVA Tables, histogram figures and the differences were explained in terms of LSD (Least Significant Differences at 5% level).

Results

Grewia tenax tree growth

No significant differences were recorded for the *G. tenax* tree growth in terms of tree height, tree collar diameter and

tree canopy diameter in first season 2017 as indicated in Table 2. However, tree fruit was higher under intercropped treatments than control particularly in GS2 as indicated in Fig. 1.

In the second season 2018, tree height was significant at ($p < 0.05$) when compared intercropped treatments with control one. Whereas tree collar diameter and tree canopy diameter were highly significant at ($p < 0.003$ and $p < 0.001$) respectively under intercropping compared with control one as indicated in Table 2. Unlike the fruit yield that was higher under sole trees than in the intercropped

ones as indicated in Fig. 1.

Cowpea parameters

In the first season 2017, cow pea plant height was showed highly significant differences at ($p < 0.001$) when compared control treatment with intercropped ones. On contrary forage fresh yield was significant at ($p < 0.05$) when compared intercropped treatments with control one. Whereas number of plant per ha did not differ as indicated in Table 3. In the second season 2018, cow pea growth in terms of plant height, number of plant and forage fresh yield per hectare did not differ either under intercropping or as sole crops as indicated in Table 3.

Land equivalent ratio (LER)

Land equivalent ratio (LER) in the first season 2017 was more advantageous in GS2 than GS1. Likewise in the second season 2018, LER was advantageous under GS2. Generally GS2 has been more advantageous than GS1 in this intercropping as shown in Table 4.

Discussion

Grewia tenax locally known as “Guddeim” is a small tree can reach up to 2 m in height in its natural stands. In Sudan

Table 2. *G. tenax* tree height (cm), tree collar diameter (mm) and tree canopy diameter (m) in inter cropped and control plots in first and second seasons on November 2017 and 2018

Treatment	Tree height in cm	Tree collar diameter in mm	Tree canopy diameter in m
Season 2017			
GS1	185.4 ± 17.03 ^a	10.7 ± 3.69 ^a	6.3 ± 2.20 ^a
GS2	171.3 ± 17.03 ^a	11.1 ± 3.69 ^a	5.8 ± 2.20 ^a
G	167.9 ± 17.03 ^a	9.5 ± 3.69 ^a	4.9 ± 2.20 ^a
Season 2018			
GS1	264.9 ± 21.03 ^a	20.4 ± 2.95 ^a	8.4 ± 0.63 ^a
GS2	274.5 ± 21.03 ^a	23.1 ± 2.95 ^d	8.7 ± 0.63 ^a
G	231.6 ± 21.03 ^a	20.4 ± 2.95 ^a	6.6 ± 0.63 ^d

Means followed by the same letters are not significantly different at ($p \leq 0.05$).

GS1 and GS2 (*Grewia tenax* inter cropped with barley at spacing of 1 m and 1.5 m) from tree trunk.

G, Sole *Grewia tenax*.

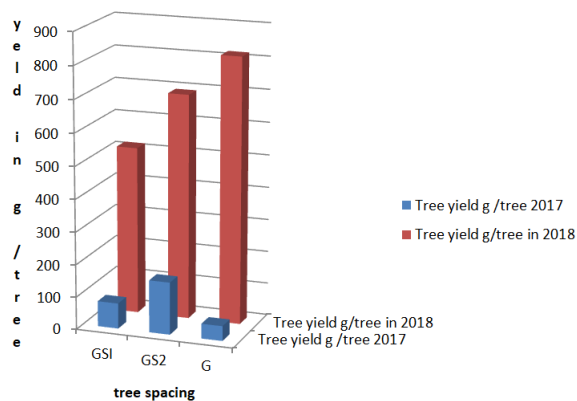


Fig. 1. *Grewia tenax* fruit trees for 2017 and 2018.

Table 3. Cowpea plant height (cm), number of plants /ha and forage fresh yield (kg/ha) inter cropped with *G. tenax* and as control in the first and second seasons in 2017 and 2018

Treatment	Plant height in cm	No. of plant ha ⁻¹	Forage fresh yield kg ha ⁻¹
Season 2017			
GS1	12.2 ± 11.7 ^a	675,567 ± 182,933.2 ^a	1,747 ± 491.9 ^a
GS2	12.3 ± 11.7 ^a	492,233 ± 182,933.2 ^a	1,385 ± 491.9 ^a
Control	51.8 ± 11.7 ^d	506,700 ± 182,933.2 ^a	603 ± 491.9 ^d
Season 2018			
GS1	29.5 ± 7.7 ^a	1,366,667 ± 3,547,212 ^a	11,839 ± 655.2 ^a
GS2	44.6 ± 7.7 ^a	1,133,333 ± 3,547,212 ^a	2,788 ± 655.2 ^a
Control	36.7 ± 7.7 ^a	1,788,889 ± 3,547,212 ^a	4,062 ± 655.2 ^a

Means followed by the same letters are not significantly different at ($p \leq 0.05$).

GS1 and GS2 (*Grewia tenax* inter cropped with barley at spacing of 1 and 1.5 m) from tree trunk.

G, Sole *Grewia tenax*.

Table 4. Land Equivalent Ratio (LER) for intercropping of cow pea with *Grewia tenax* in the first and second seasons in 2017 and 2018

Treatment	Inter cropped forage fresh yield kg/ha	Inter cropped trees fruit yield kg/ha	LER
Season 2017			
GS1	1,747	88.1	4.6
GS2	1,385	181.5	5.8
Sole crop	603	-	
G		51.4	
Season 2018			
GS1	1,839	644.3	1.1
GS2	2,788	863.8	1.5
Sole crop	4,026	-	
G		1,021.3	
Mean			
GS1			3
GS2			4

GS1 and GS2 (*Grewia tenax* intercropped with barley at spacing of 1 and 1.5 m) from tree trunk.

G, Sole *Grewia tenax*.

it is widely spread in central and southern parts besides Khartoum State. However, *G. tenax* can tolerate most soil types such as rocky, sandy and clay and can grow in elevation of 0-1,500 m high. Besides that *G. tenax* can tolerate cold weather and heat but not frost as reported by Elamin (1990).

Under This experiment *G. tenax* tree performance was not recorded any significant differences in the first season with respect to tree growth. That might be due to little effect of competition because the trees were in their early stage of development and growth. Besides that *G. tenax* is drought resistant and tolerates some salinity as reported by some writers such as (Baumer 1983; Elamin 1990; Vogt 1995). This in line with Raddad and Luukkanen (2007) who reported that trees did not affect with intercropping in the early stage of growing when working on *Acacia senegal* intercropped with field crop in Blue Nile of Sudan. But in the second season the significance for tree growth in terms of trees height, collar diameter and canopy diameter were attributed to favourable site conditions under intercropping. Since the intercropped site was subjected to more watering and cultural practices when compared with sole trees that had been watered around trees trunks only. Though as due the site became more lose for tree roots to penetrate deeply

in the soil than under control trees. Besides that the trees have reached vigorous size when compared that with the first season. Therefore the trees were well established and found abundant watering which reduced competition with crop. Also it could be related to leaching of soil salinity due to irrigating of the crop site; hence salinity came up to soil surface. This in line with Bosshard (1966) who observed that under irrigated saline soil of Khartoum Green Belts, salts had come up to the surface with pH ranged between 8 and 9.5 due to irrigating of the site. Despite that the soil salinity in the study site was higher with increasing soil depths. On the other hand, *G. tenax* tree fruit yield was varied between first and second seasons might be related to the fact that the trees were in early growth or to soil salinity. But generally it could be attributed to competition between the trees and the crop as appeared in the second season. However, some studies mentioned that *G. tenax* can get fruit in period amounted to 8 months and could reach to 1.5 metre in height as far as still other research is needed about suitability of *G. tenax* to site conditions (Vogt 1995).

The significant of plant height in the control crop could be attributed to effect of competition. Thus trees and crops compete for above and below ground resources. In this respect, some writers said that under dry land trees and crops interface for light interception, water and nutrient uptakes (Ong et al. 1996). Thus the competition will be more severe in case of light if the below ground competition is minor. In this study the canopy coverage for the intercropped treatments was about 62% that properly might affected plant height when compared with sole crop that has zero tree coverage. This is in agreement with Kessler and Breman (1991) who stated that the amount of light that is intercepted depends on tree crown, spacing and species.

Whereas for forage fresh yield, the variation in the first season might be related to favourable site conditions under the intercropped treatments due to water availability and good microclimate. Besides to minor effect of competition in the wider spacing (1.5 m) from the tree trunk. In this respect, Davis et al. (1991) reported that cow pea could perform well under irrigation and different soils types, despite it is drought hardy and can tolerates minor salinity. Soil salinity in the study site exceeded the favourable level that consequently could affect cow pea performance and growth. It is worth to mention that, Marsh et al. (1992) reported that

biomass of 1,000 plant of cow pea ranged between 0.7-2 ton/acre while the average forage fresh yield for this study is 2 tons per ha for intercropped treatments and 3.3 tons per ha for mono-cropping. Whereas Taha and Khair (2014) found that under favourable conditions of Gezira Scheme of the Sudan; some other similar crops such as *Vigna trilobata* has yielded 5.4 ton dry matter per ha while *Lablab purpureus* and *Clitoria ternate* were yielded 5 tons per ha in terms of dry matter.

Land Equivalent Ratio (LER) was higher under this agro forestry system properly due to higher proportions either for sole crop or fruit yield due to seasons. Thus the proportion between intercropped crop and fruit were as follows; 3 and 2 for GS1 and 2.3 and 3.5 for GS2 in the first season 2017 respectively. In the second season 2018, LER was recorded 0.5 and 0.6 for proportion of intercropped crop and fruit for GS1 and 0.7 and 0.8 for GS2 respectively. That indicated the adverse effect of competition in the second season when trees have reached maturity. But generally tree fruit can add benefits to the farmers through increasing their income and contributes in their purchasing power for some necessities such as food. Besides diversifying farmers' crops and compensating due to any environmental hazards. Similar results were obtained that LER is advantageous under intercropping systems and can maintain farmers' food security (NasreAldin et al. 2011; Osman et al. 2011).

Based on above findings it could be concluded that GS2 (1.5 m) from the tree trunk is the most suitable spacing for intercropping of cow pea with *G. tenax*, since it gave higher forage fresh yield, fruit and higher LER. In order to produce summer forage yield of low cost and high protein contents to feed animals. Besides in providing tree fruits of high nutritive value for the farmers as well as to halt desertification and to sequester carbon in the dry lands.

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