Effects of Water Harvesting Techniques in Dry Lands on Establishment of *Faidherbia albida* (Del.) A. Chev. Seedlings in Nyala Locality, South Darfur State

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ABSTRACT

This study aimed to assess the effects of water harvesting techniques on the establishment of *Faidherbia .albida* seedlings in dry lands of two sites (Savanna and Musai) in Nyala Locality, South Darfur State. The study was conducted during May 2010 to March 2011. Five water-harvesting techniques; namely, control, Trapezoidal bund, contour bund, semi-circular bund, and Negarim micro-catchments, were tested. Three months old *F. albida* seedlings, representing each treatment, were transplanted in prepared holes in August 2010. Seedlings height, diameter and number of branches were measured monthly from transplanting until the termination of the experiment in March 2011. Soil moisture content was determined at depths of 0-30 and 30-60 cm for all treatments in the two sites. The results showed that the seedlings height and diameter and number of branches were significantly better in the semi-circular bund compared with the control and the other techniques. The survival rate of *F. albida* seedlings was very low in the control and was the best in the semi-circular bund in the Savanna site. In Musai site, the survival rate of seedlings in all the treatments was similar. The results of the soil moisture content showed that the semi-circular technique was the best in collecting and preserving water in Savanna site, while the contour bund was the best treatment in the Musai site.

Key words: Water harvesting; *Faidherbia albida* seedlings; two sites; Nyala

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INTRODUCTION

Water harvesting techniques (WHTs) and practices are devices and procedures for collecting, storing and utilizing water caught from precipitation (Critchley and Siegert, 1991; Moges, 2004; Audrey, 2005). However, there are major differences in the conception of devices and procedures employed concerning the end uses of the water collected. These are either envisaged to collect water in containers and reservoirs for domestic or irrigation usages or either destined to harvest or divert water in order to increase soil moisture content for agriculture or afforestation. In this study focus is laid on the second type of WHTs destined to increase soil moisture for utilization in afforestation particularly in the dry lands.

Tree regeneration and afforestation in dry lands are strongly challenged by many factors, among which the natural causes are drought and desertification. The anthropogenic causes include irrational agriculture, overgrazing, over-exploitation and fires (Evans, 2001a; FAO, 2003). Many tree species render valuable goods and services, particularly in the dry land where tree thriving is precarious, and thus need to be domesticated by deploying arduous efforts (Leakey and Simons, 1998; Evans, 2001b). One of the valuable species in the dry lands is *F. albida*. It is a big tree and it belongs to the family Fabaceae. It is pan African in its distribution and widely present in the tropical and subtropical regions of the continent and it is found the Middle East. It is present in different areas of Sudan including Darfur, Kordofan and Blue Nile and preferably found in light soils in valleys and along water courses (Wickens, 1969; Vogt, 1995; Miehe, 1988; El Amin, 1990; Barnes and Fagg, 2003). It is a multipurpose tree rendering many services and goods. The extracted goods from the species can include sawn and round timber; fire wood and charcoal; utensils and implements; fodder (foliage and pods) and fencing material. Meanwhile, the services are exampled in agroforestry; soil conservation, amelioration and fertility; shade; amenity; bee keeping and honey and medicine (Miehe, 1986; Vogt, 1995; Saka and Bunderson, 1989; Barnes and Fagg, 2003). Thus, in view of the obvious benefits drawn from the species it deserves to be domesticated, because it is becoming more vulnerable under natural conditions (Over exploitation and degradation due to natural and anthropogenic factors). This study aimed to assess the field establishment of *F. albida* transplants in a dry land by using some water harvesting techniques.

MATERIALS AND METHODS

Sites description and characteristics:

The study was conducted in Savanna and Musai districts, which are located, respectively at 3 km to the South and 7 km to the Southeast of Nyala town premises (South Darfur State). Semi-arid climate dominates the region of the study area. Annual rainfall amounts to about 400 mm yr^{-1}, falling mostly during June and October, but it is characterized by a high erratic nature of occurrence. Mean temperature is about 28 °C. The average maximum may rise to 39 °C in the summer hottest months April and May and the average minimum may descend to 16 °C in the winter coldest months (December to February) (Weather Forecaster, 2013). Violent hot winds prevail throughout the dry period often accompanied with dust tempests (El Tom, 1975). Soils range from clay loam to sandy clay loam, strongly marked with erosion features. Vegetation of the study area is of low plant density composed of some scattered trees of *Acacia mellifera*, *Acacia tortilis*, *Acacia nubica*, *Balanites aegyptiaca*, *Adansonia digitata* and *Hyphaene thebaica*; some shrubs, herbs and grasses (WSDC, 1985). The area is abandoned fields of previous cultivation of rain fed crops, but now the refugees, herders and their livestock continuously roam it; all heavily cut and devastate the vegetation for various purposes.

Five Water Harvesting Techniques (WHTs) treatments as specified by Critchley and Siegert (1991), were selected for raising *F. albida* transplants according to conditions of the experimental sites (topography, slope and soil): 1) Control, a flat area with dimensions of 6 ×1 m; 2) Contour bunds with dimensions of 6 m ×1 m; 3) Semi-circular bunds with dimensions of 3 m ×1 m; 4) Trapezoidal bunds with dimension of 6× 3 m and 5) Negarim microcatchment with dimensions of 5 m × 3 m. These WHTs were constructed, in the two sites in June 2010 after adequate rainfall by using manual shovels and hoes. They were arranged in a completely randomized block design (CRBD) in 3 blocks with 5 replicates. *Faidherbia albida* seeds were procured from local provenance and the seedling stock was raised in 25 May 2010 in Nyala Agricultural Research Station Nursery. The seedlings were transported to the field, when they were 3 months-old and 12.8 cm high, and transplanted in the prepared WHTs at 25 and 26 August 2010 in the Savannah and Musai sites, respectively. Three seedlings were planted in each WHT at 2 m spacing in holes (50 cm deep recharge pits). Growth monitoring and parameter measurements started in August 2010 at the beginning of planting; the measurements were taken monthly and included shoot height (cm), diameter (mm) and number of branches. In addition soil moisture was measured monthly by taking samples at 0-30 cm and 30-60 cm depths by auger. Soils were described in the field by opening profiles (Soil Survey Division Staff, 1993) and sampled for analysis of physicochemical properties. The laboratory determinations for the soil physicochemical parameters were carried out according to the international procedures of plant and soil analyses (Pansu and Gautheyrou, 2006; Kalra, 1998).

RESULTS

Savanna site

Soil characterization:

The soil surface in this site is flat with gentle northwest inclination towards wadi Nyala and almost frees of gravels stones. The soil profile showed that A_1 Horizon: 0-22 cm deep; pale brown color; sandy clay texture; weak fine sub angular blocky structure; hard dry and friable moist, sticky and slightly plastic wet; few medium voids; none stony; moderately calcareous; few fine roots; abrupt smooth boundary. B Horizon: 22-73 cm deep; very pale brown color; clay texture; massive structure; hard dry and friable moist, and sticky and plastic wet; porosity: nil voids; none stony; moderately calcareous; nil root; abrupt smooth boundary. C Horizon: 73-110 cm deep; brownish yellow color; sandy clay loam texture; massive structure; slightly hard dry and friable moist, and slightly sticky and slightly plastic in wet; nil voids; none stony; moderately calcareous; nil roots. Sand and clay fractions dominate the particle size distribution, thus the soil texture is sandy clay. The soil bulk density is of medium magnitude through out the profile and it is carbonated. The soil reaction is alkaline and it is free from salts. The soil has low CEC and it is poorly furnished in nutrient elements including nitrogen and phosphorus (Table 1).

The soil moisture content in the control treatment at 0-30 cm depth was at the maximum level in August (13.7%), it dropped to its minimum level in October (2.1%), after which period it rose again in December and then decreased gradually through February to April (Figure 1a). The soil moisture content in the Semi-circular, Trapezoidal and Negarim treatments increased strong between August and October, but the moisture increase in the Contour-bund was moderate; thereafter, the soil moisture decreased strongly until December and then continued with gradual decline until April in all the treatments. The soil moisture content in the control treatment at 30-60 cm depth was about 9% in August; it was reduced to about half in October but increased again to the August level in December and then decreased progressively there after to April when the last measurements were taken (Figure 1b). Soil moisture in the trapezoidal and negarim microcatchment was less (5.1%) than that in the control (8.6%) in August 2010; the semi-circular treatment had similar moisture content (8.4%) to that of the control. The soil moisture in all the treatments, except the control, increased sharply towards October (11% to 21%), but it fell strongly after this month, and then continued to decrease gradually towards April 2011. In the contour bund, the soil moisture was the lowest (4%) in August 2010, but it increased progressively to a maximum (14%) at December and after that, it declined steadily towards April 2011.

Table 1. Physicochemical properties of Savanna site soils

Horizon	Depth (cm)	Clay (%)	Silt (%)	Sand (%)	Bulk density (gcm^{-3})	$CaCO_3$ (%)	PH	Ece dSm^{-1}
A	0-22	37.1	9.6	53.3	1.3	6.0	8.5	1.0
B	22-73	41.9	22.8	41.3	1.5	7.3	8.3	0.8
C	73-110	32.1	2.4	65.3	1.4	6.0	8.3	0.7

Table 1. continued

Horizon	Depth (cm)	Ca†	Mg†	K†	Na†	CEC†	N (%)	P (ppm)
A	0-22	3.0	2.0	0.1	5.4	29.7	0.084	1.03
B	22-73	5.0	4.0	0.1	4.6	37.4	0.042	1.01
C	73-110	2.5	2.5	0.1	5.0	25.8	0.028	1.17

†Units in mmol+/l

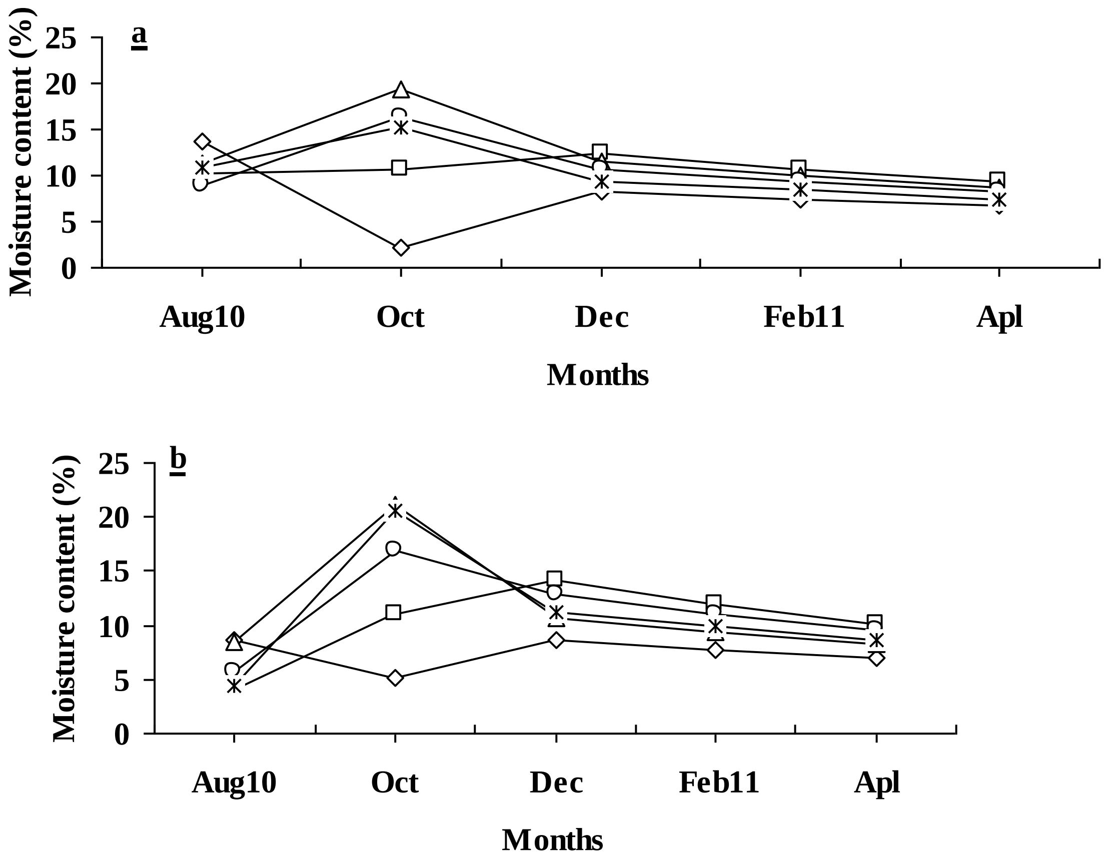

Figure 1. Soil moisture content at a: 0 – 30 cm and b: 30 – 60 cm depths and in the various water harvesting techniques (◊: control; □: contour bund; Δ: semi-circular bund; ○: trapezoidal bund and x: negarim microcatchment) in Savanna site.

***Faidherbia albida* transplants growth:**

The *F. albida* transplants growth in the control treatment was moderate with very little increment from the planting date in August 2010. The transplants survived only for 2 months and all died after October. The growth pattern of *F. albida* transplants in the various water harvesting techniques implemented in this study was very similar to each other from August to December 2010; except that transplants' growth in the contour-bund and negarim techniques occurred at slightly upper parallel level to that in semi-circular and trapezoidal techniques (Figure 2). The transplants height growth in the contour-bund treatments declined sharply from an average of about 23 cm to 14 cm between December and January, then latter during February all the transplants were dead. In the trapezoidal treatment, the transplants height growth went on steadily till January 2011, and a sharp decline of the height occurred during the period January to February and also in the following month all the transplants were dead. In the negarim treatment, the transplants died all after February 2011. However, the semi-circular treatment had showed and maintained vigorous height growth until March

2011 and after that the transplants died. The *F. albida* transplants' height variations in the different water harvesting techniques were in the descending order: semi-circular bund > negarim microcatchment > trapezoidal bund > contour bund > control.

The diameter of the transplants in the control showed little increment (1 mm/month) from the planting date in August 2010 and the plants died after September. The diameter growth of the transplants in all treatments showed similar pattern from August to December, even though, transplants diameters in contour-bund and negarim treatments were slightly higher than in trapezoidal and semi-circular treatments and occurred at upper parallel rate. A sharp decline in diameters of transplants in the contour-bund occurred during December and January and after that all the transplants died. Transplants growth in the rest of the treatments was regular during the rest of the monitoring period; even though, plants in the trapezoidal and negarim treatments died in February and those in the semi-circular treatment persisted until after March. The *F. albida* transplants' diameter variations in the different water harvesting techniques were in the descending order: semi-circular bund > trapezoidal bund > negarim microcatchment > contour bund > control.

The number of branches in the control treatment transplants grew little between August and October, after all the plants were dead. The number of branches in the contour-bund treatment sprouted vigorously between August and October and after that their number decreased gradually until January 2011, and after that all the plants were dead. In the semi-circular, negarim and trapezoidal treatments the number of branches of the transplants increased steadily from August to November. There after, the number of branches in the trapezoidal and negarim treatments declined slightly December and January, respectively and further resumed sprouting towards February; while in the Semicircular treatments there was emergence of branches till February. The *F. albida* transplants' branching variations in the different water harvesting techniques was in the descending order: semi-circular bund > trapezoidal bund > negarim microcatchment > contour bund > control.

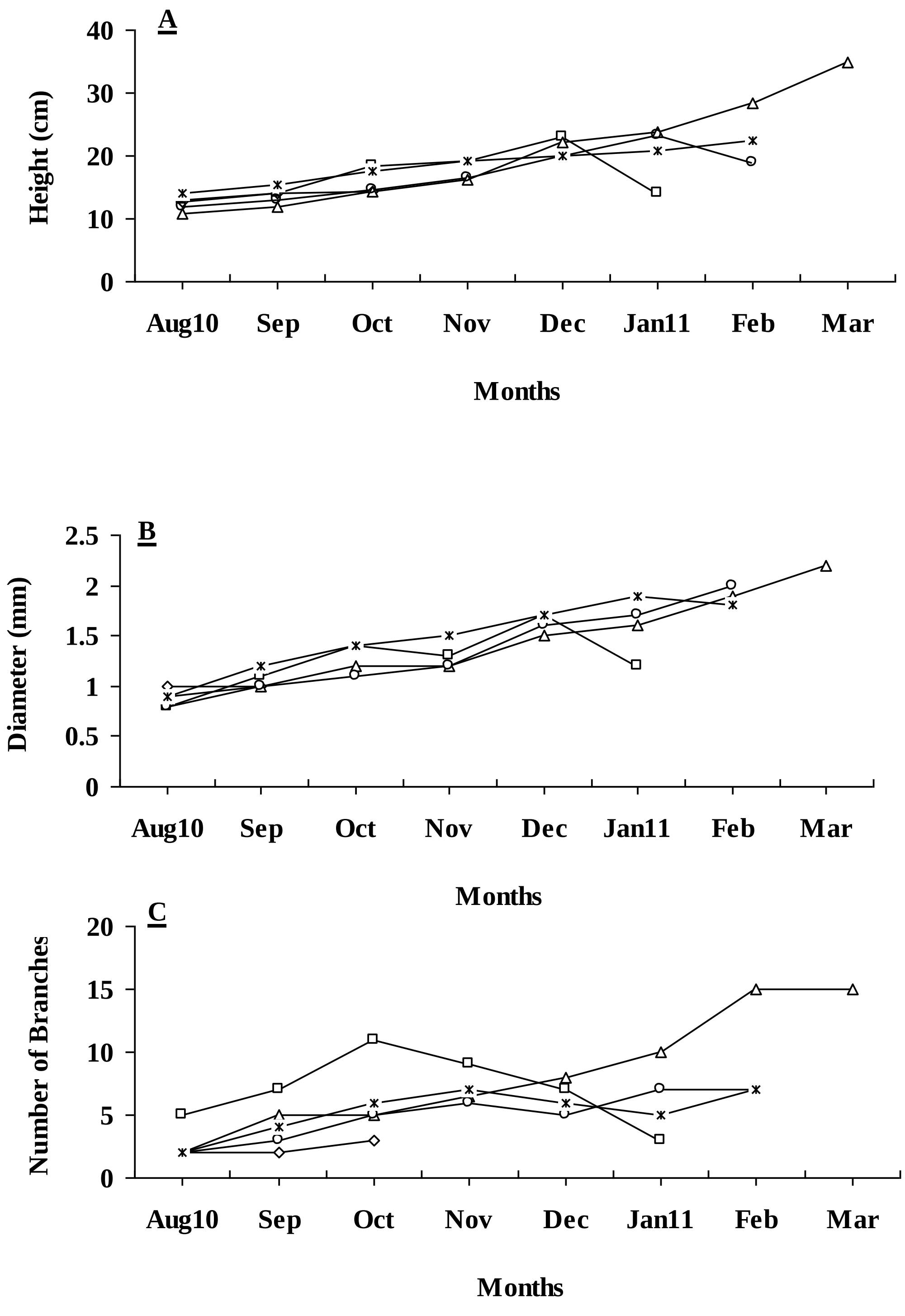

Figure 2: Growth of *Faidherbia albida* transplants established in various water harvesting techniques (◊: control; □: contour bund; Δ: semi-circular bund; ○: trapezoidal bund and ӿ: negarim microcatchment) in Savanna site. A: Height (cm); B: Diameter (mm) and C: Number of branches.

Musai site

Soils characterization:

The topography of the site is generally flat (slope ~ 1%) with some stones. The main features of the soil profile were: A_1 Horizon: 0-24 cm deep; very pale brown color; clayey texture; moderate fine sub angular blocky structure; hard dry and friable moist, sticky and plastic wet; very few voids fine; few stones; moderately calcareous; very few fine roots; abrupt smooth boundary. B Horizon: 24-109 cm deep; very pale brown color; clay loam texture; massive structure; hard dry and firm to very firm moist, slightly sticky and slightly plastic wet; nil voids; none stony; moderately calcareous; nil roots; abrupt smooth boundary. C Horizon: 109-125 cm deep; yellow color; clay loam texture; massive structure; hard dry and firm moist, slightly sticky and slightly plastic wet; nil voids; none stony; moderately calcareous; nil roots.

Clay fraction dominates the particle size distribution particularly in the upper horizons but sand and silt percentages are also considerable, thus the soil texture is clay loam. The soil has a medium bulk density. It is carbonated and has an alkaline reaction, but it is non-saline. Its CEC is of low value and it is poorly furnished in nutrient elements including nitrogen and phosphorus (Table 2).

The soil moisture content at 0 to 30 cm depth and in all the treatments including the control increased strongly from August to October and then it declined sharply towards December, after which period it gradually went down towards April (Figure 3).

Table 2: Physicochemical properties of soils of Musai site

Horizon	Depth (cm)	Clay (%)	Silt (%)	Sand (%)	Bulk density (gcm^{-3})	$CaCO_3$ (%)	PH	Ece dSm^{-1}
A	0-24	46.7	21.6	31.7	1.4	8.0	8.3	1.2
B	24-109	37.1	33.6	29.3	1.5	6.5	8.3	2.4
C	109-125	37.1	21.6	41.3	1.3	8.0	8.3	0.9

Table 2: continued

Horizon	Depth (cm)	Ca†	Mg†	K†	Na†	CEC†	N (%)	P (ppm)
A	0-24	2.5	1.0	0.059	8.3	37.4	0.126	1.42
B	24-109	4.0	3.0	0.077	17.4	29.7	0.0112	1.06
C	109-125	2.0	1.0	0.051	6.7	29.7	0.084	1.11

†Units in mmol+/l

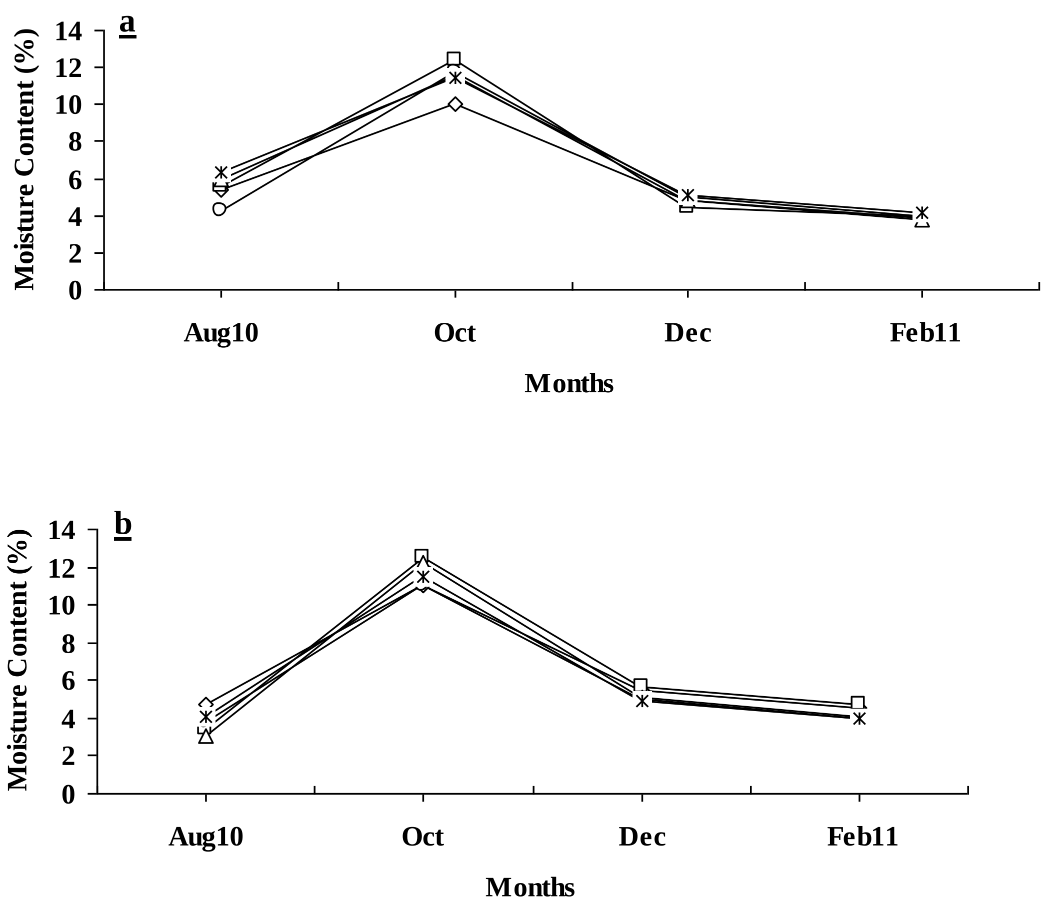

Figure 3: Soil moisture content at a: 0-30 cm and b: 30 – 60 cm depths and in the various water harvesting techniques (◊: control; □: contour bund; Δ: semi-circular bund; ○: trapezoidal bund and x: negarim microcatchment) in Musai site.

The soil moisture content at 30 to 60 cm depth and in all the treatments including the control ranged from 3% to 5% in August 2010. It increased strongly from August to October 11% to 13%, respectively, and then it declined sharply towards December to a level of about 5%, after which period it gradually went down towards April.

***Faidherbia albida* transplants growth** (Figure 4)**:**

The transplants heights in the control treatments grew very slowly during their survival period from August to October, after which month they were all dead. The average height growth of the transplants in the semi-circular, trapezoidal and negarim treatments decreased slightly between October and November, and the height growth in these treatments resumed thereafter with a rather strong vigor until March. Transplants height growth in the contour-bund treatment proceeded with strong increments from August to March and occurred at upper parallel rate to the other treatments. The transplants in all the treatments were dead after March. The *F. albida* transplants' height variations in the different water harvesting techniques were in the descending order: contour bund > semi-circular bund > negarim microcatchment > trapezoidal bund > control.

The transplants diameter in all the treatments increased steadily from August to October. After that period, the transplants' diameter growth in the trapezoidal treatment stagnated throughout towards March, while in negarim and semi-circular treatments the diameter growth stagnation lasted till November and January, respectively; and after that there was a rather strong resumption of transplants' diameter growth. The diameter growth of the transplants in the contour-bund treatment maintained with strong increment till December, after which time there was a slight decrease in the average transplants diameter during February and it further recommenced growth during March. The *F. albida* transplants' diameter variations in the different water harvesting techniques were in the descending order: contour bund > semi-circular bund > negarim microcatchment > trapezoidal bund > control.

In the control treatment, there was an increase in the number of branches of the transplants from August to September, and followed by a decrease in October after which the plants were dead. In the other treatments there was a strong increase in the number of branches from August to October. After that a strong decrease in the number of branches occurred between October and November in the contour-bund and trapezoidal treatments. The *F. albida* transplants' branching variations in the different water harvesting techniques was in the descending order: trapezoidal bund > contour bund > semi-circular bund > negarim microcatchment > control.

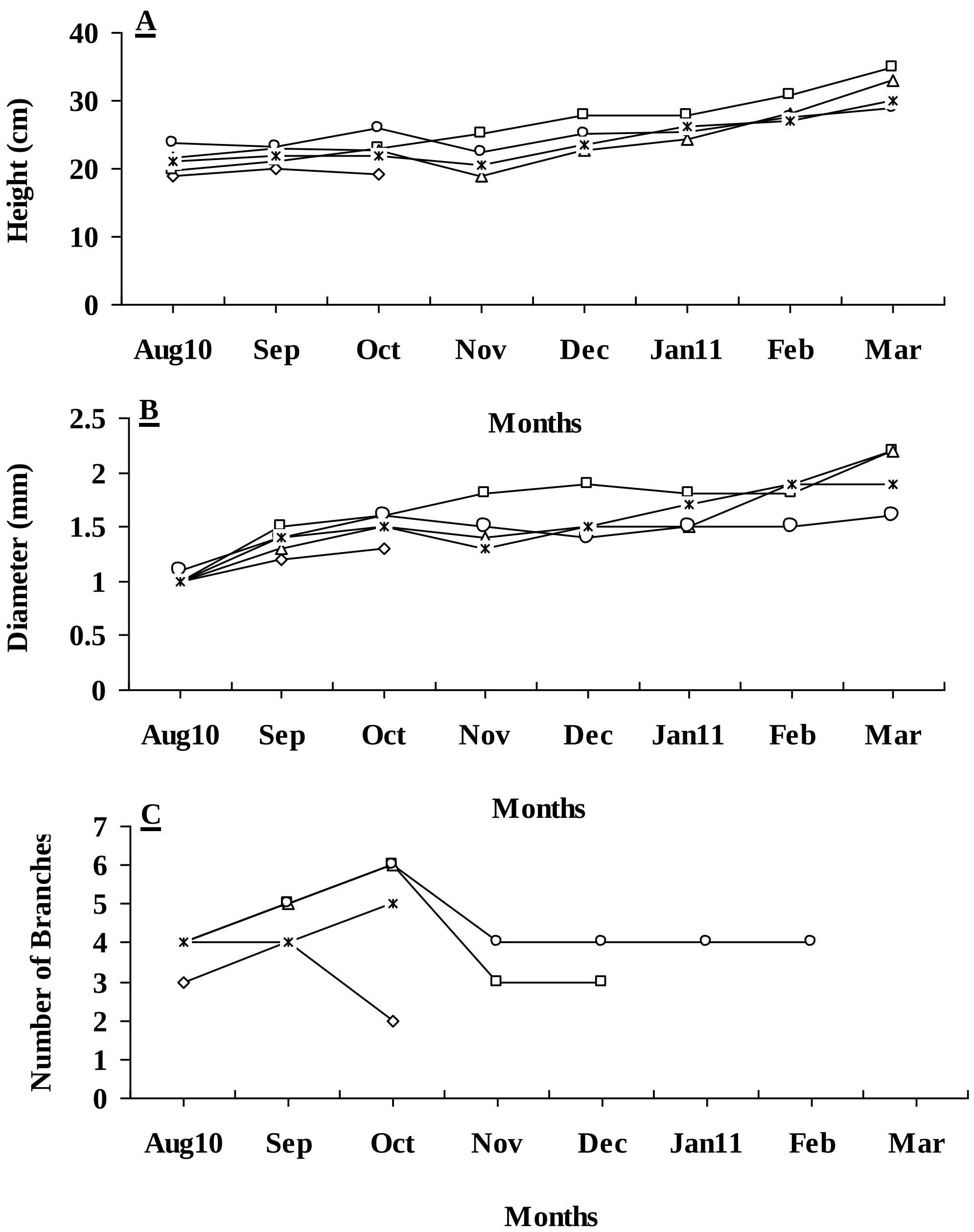

Figure 4: Growth of *Faidherbia albida* transplants established in various water harvesting techniques (◊: control; □: contour bund; Δ: semi-circular bund; ○: trapezoidal bund and ж: negarim microcatchment) in Musai site. A: Height (cm); B: Diameter (mm) and C: Number of branches.

Comparison of the growth parameters between Savanna and Musai sites

A/ Soil moisture content: The soil moisture content at 0 to 30 cm depth was higher in Savanna than in Musai site (Figure 5). Values of the moisture content occurred in parallel lines in all the treatments, with Savanna values positioned at the superior level to those of Musai. An exception from this trend was in the Control and the Contour bund treatments where October values in Musai were higher than Savanna values.

Soil moisture content at the rooting depth (30 to 60 cm) and in all the WHTs was higher in the Savanna than in Musai site; and that persisted almost through out the monitoring period (Figure 6). Comparison of February moisture measurements of the different techniques in the two sites showed that the Savanna techniques to have more than 2 folds moisture content than the Musai site.

B/ *Faidherbia albida* transplants height growth in the two sites (Figure 7)**:**

In the control treatment, the growth rate of the transplants height started at the same average values (13 cm) for Savanna and Musai in August. September readings showed that the growth for Savanna was higher than for Musai; but in October readings Musai growth was stronger than in Savanna. The transplants in the two sites died after October.

In the contour bund treatment, the transplants height growth was almost similar in the two sites from August to December. There was a sharp decline in the transplants growth in the Savanna site after December, and they died after January. Meanwhile, in the Musai site transplants continued to grow steadily progressively until March and then they died.

In the semi-circular bund treatment the transplants height for Savanna and Musai sites was similar along the monitoring period until March.

In the trapezoidal bund treatment, the transplants height occurred at slightly upper parallel level for the Musai site. There was a sharp decrease in the transplants height for Savanna site after January 2011, and the transplants in this site died after February. Whereas, the transplants of Musai site continued growth in height until March, and after that they died.

In the negarim microcatchment treatment transplants height growth was very close to each other in the two sites until November. After that the transplants height growth declined from November to December in Musai site, but the growth resumed strongly from December to March, and after that the transplants died. While, in Savanna site the transplants height growth rate was steadily progressive until February, after that they died.

C/ *Faidherbia albida* transplants diameter growth in the two sites (Figure 8)**:**

In the control treatment, the average diameter of the transplants started with the same value (1 mm) in August. The transplants growth in Musai was steady till October, while a slight decline in the transplants diameter was observed in September at the Savanna site. All the transplants died in the two sites after October.

In the contour bund treatment, the transplants diameter growth in the Savanna site occurred at a lower parallel level to that in the Musai site. The transplants diameter declined sharply between December and January in the Savanna site, but it increased steadily in the Musai site till March.

In the semi-circular bund treatment, the transplants diameter growth rate was very similar to each other in the two sites; but with exception that transplants diameter was slightly higher in the Musai site during August to December.

In the trapezoidal bund treatment, the transplants diameter in August in the Savanna site was lower than in Musai site. However, the transplants diameter increased progressively in the Savanna site until February, after which the transplants died. Meanwhile, in the Musai site the transplants average diameter was higher, and continued to be so until October, after that month the diameter readings began to decrease till December, and thereafter the diameter growth occurred at a fixed rate.

In the negarim microcatchment treatment, the transplants diameter growth rate was very similar in the two sites from August to December. The transplants diameter growth decreased slightly from December to January 2011 in Musai site, but the diameter growth resumed till March, beyond that month the transplants died; whereas, the transplants death occurred earlier in February in the Savanna site.

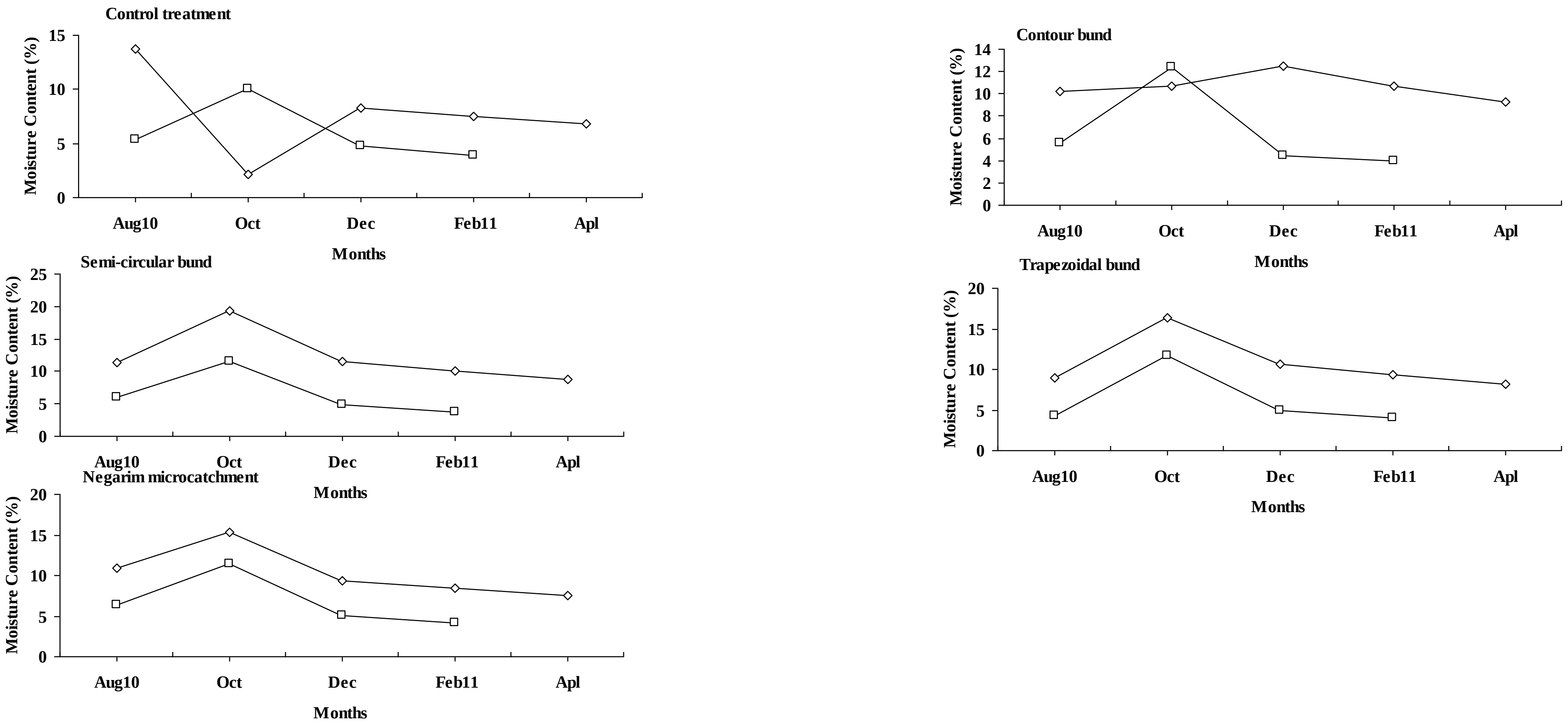

Figure 5: Comparison of soil moisture content (%) at 0-30 cm depth in the various water harvesting techniques between the Savanna (◊) and Musai (□) sites in Nyala District, South Darfur State.

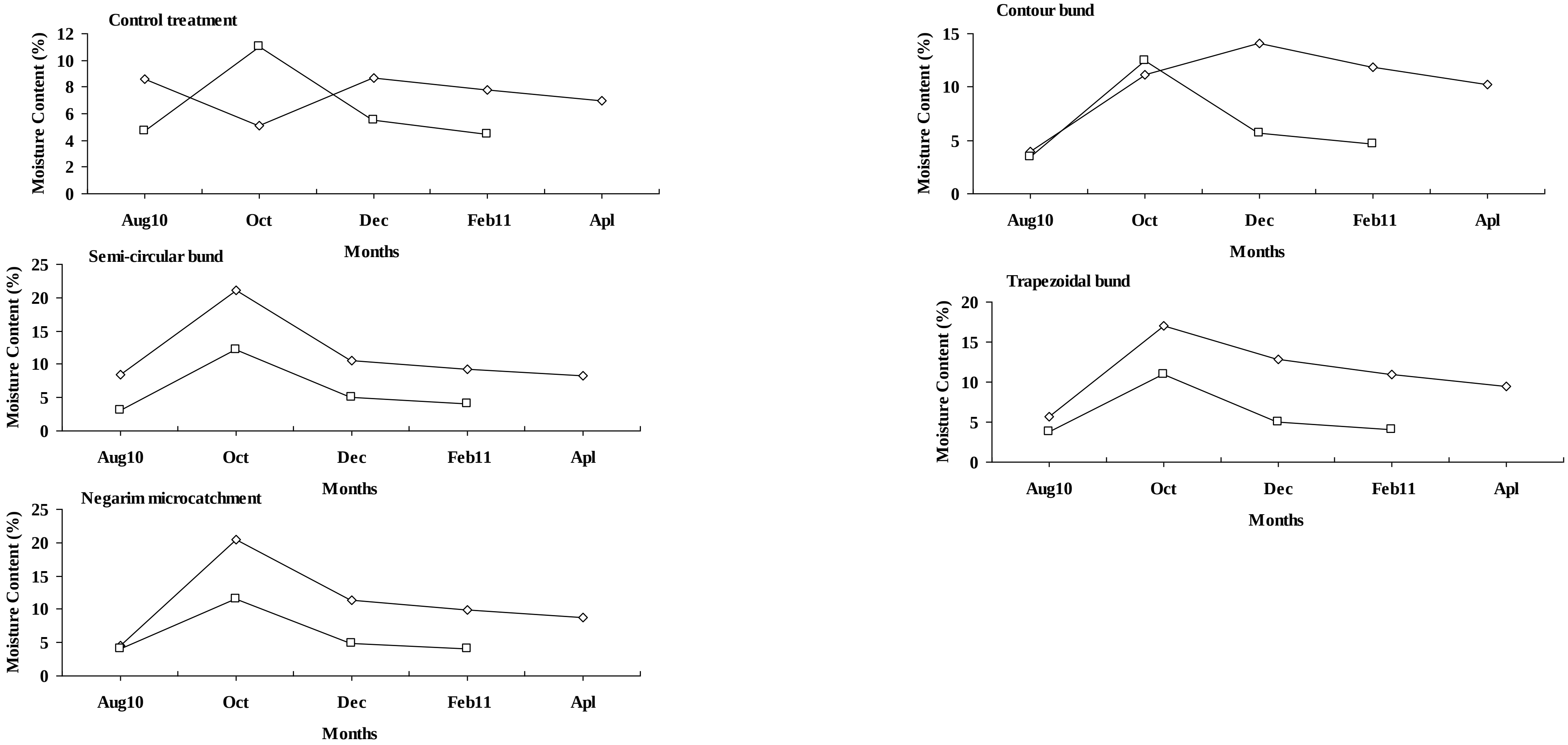

Figure 6: Comparison of soil moisture content (%) at 30-60 cm depth in the various water harvesting techniques between the Savanna (◊) and Musai (□) sites in Nyala District, South Darfur State.

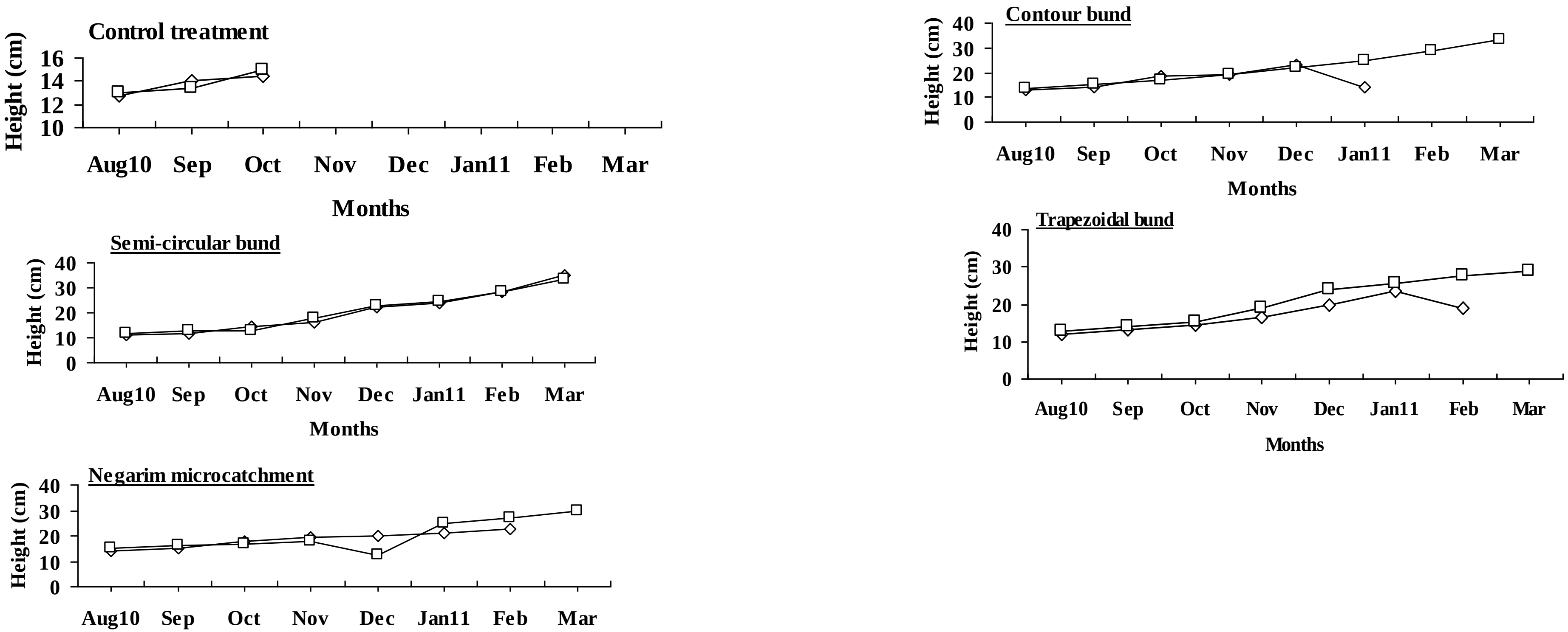

Figure 7: Comparison of *Faidherbia albida* seedlings' height growth in the various water harvesting techniques between the Savanna (◊) and Musai (□) sites in Nyala District, South Darfur State.

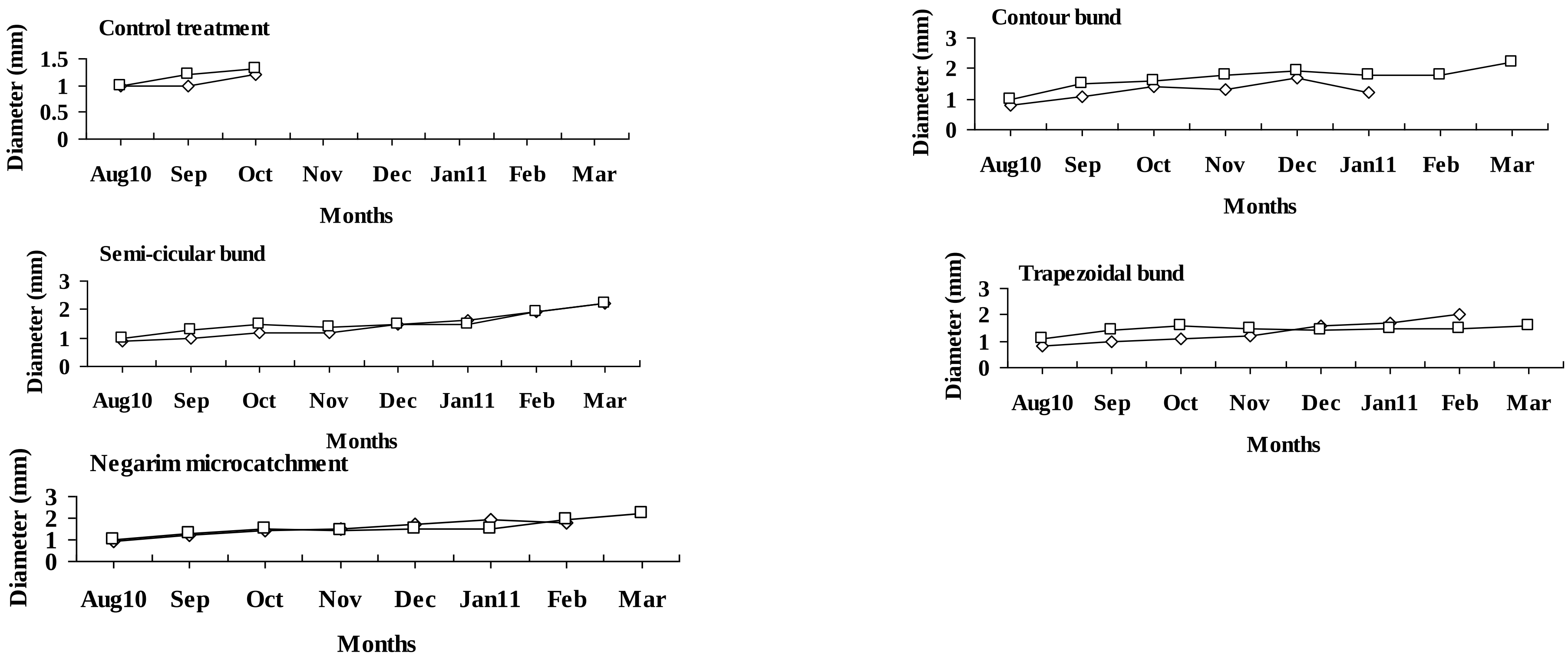

Figure 8: Comparison of *Faidherbia albida* seedlings' diameter growth in the various water harvesting techniques between the Savanna (◊) and Musai (□) sites in Nyala District, South Darfur State.

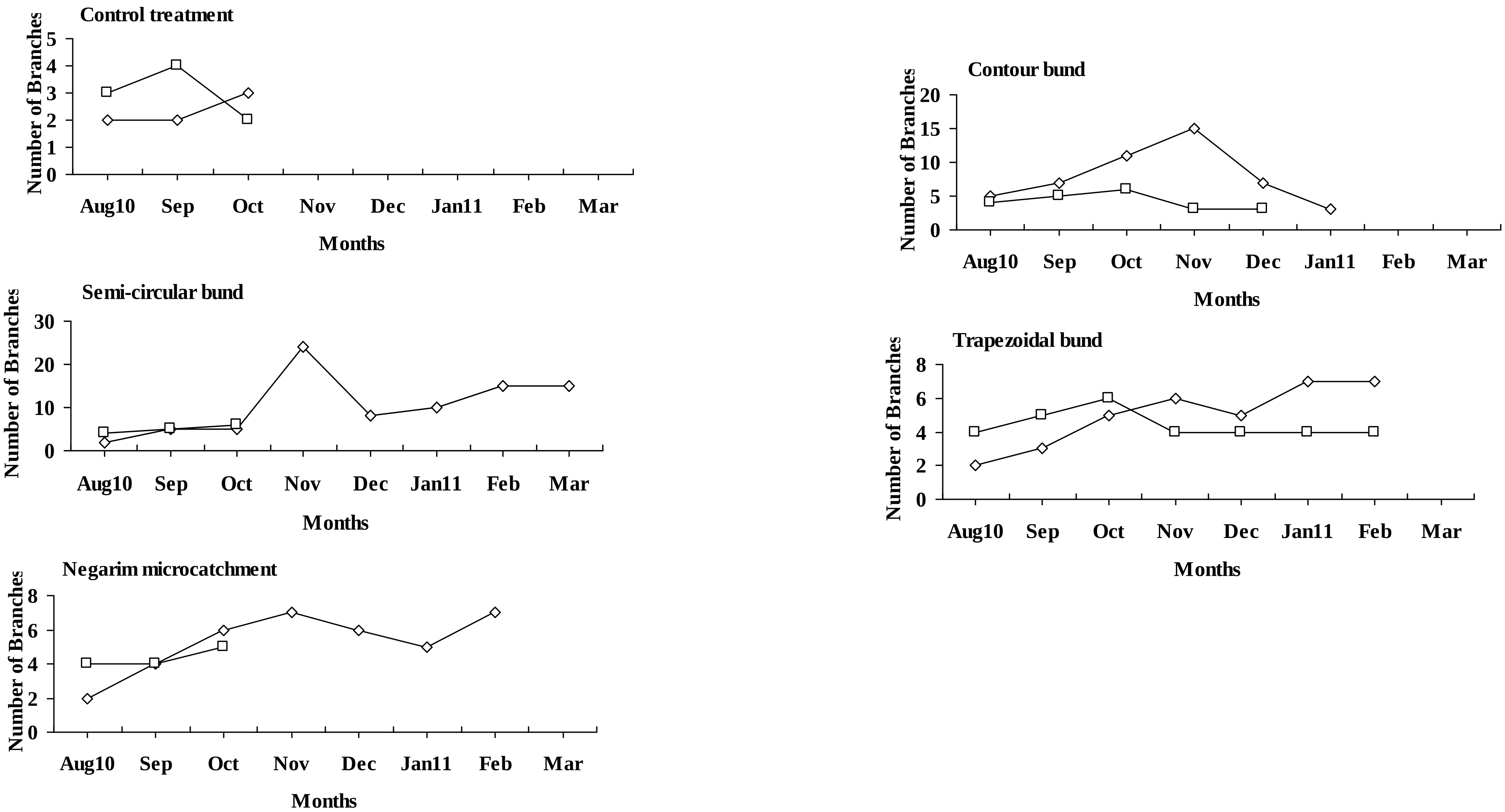

Figure 9: Comparison of *Faidherbia albida* seedlings' branches growth in the various water harvesting techniques between the Savanna (◊) and Musai (□) sites in Nyala District, South Darfur State.

D/ *Faidherbia albida* transplants branches growth in the two sites (Figure 9)**:**

In the control treatment, the number of branches of the transplants in the Savanna site was 2 branches per plant in August and September; the number of branches increased to an average of 3 per plant in October. In the Musai site the mean number of branches per transplants was 3 per plant in August; they increased to 4 per plant in September, and then strongly declined to 2 per plant in October.

In the contour bund treatment, the average number of branches per plant was 5 in August at the Savanna site and they strongly increased to 15 branches per plant at November; but there was a strong decrease to 3 branches per plant in January. The number of branches in the transplants of Musai site was 4 per plant, then they increased to 6 at October, after which, there was a decrease and stability at November and December, respectively.

In the semi-circular bund treatment, the number of branches per plant in the 2 sites was almost identical till October; but after that, transplants in Musai site died and those in Savanna grew with strong sprouting of branches at November, but there was a decrease at December and branch sprouting resumed after that, but at slow rate to reach 15 branches per plant at March.

In the trapezoidal bund treatment, the number of branches per plant in the Savanna site in August started at 2, then increased to 6 at October, and there was a decrease in December and a re-increase till January, after that there was a stability in branch sprouting. In the Musai site, the average number of branches per plant in August was 4, they increased progressively to 6 per plant at October, a sharp decrease occurred in the number of branches between October and November, and after which time there was no increase in the number of branches.

In the negarim micrcatchment treatment, the Number of branches per plant started at 2 in August in the Savanna site and they increased successively strongly till November, but followed by a decline till January 2011 and an increase in number of branches till February, after which the transplants died. Mean while, in Musai site the average number of branches per plant was about 4 in August and September and a little increase (5) occurred at October, and then the transplants died thereafter.

DISCUSSION

Soil moisture content in all the WHTs in the Savanna site was higher than in the control treatment, but in the Musai site there was no difference between all the techniques. On the other hand, soil moisture content was generally higher in the Savanna than in Musai site in all the treatments. This indicates greater impounding of runoff water into the techniques in the Savanna site; even though, climatic and physical conditions in the two sites are very similar. Soil moisture augmentation in the Savanna may be attributed to the lighter soil texture (sandy clay) in the surface that allows greater water infiltration; meanwhile the heavier soil texture (clayey) in the Musai site does not allow the same rate of water infiltration and most of the runoff overflows the borders of the techniques. Water infiltration and moisture recharge are known to be affected by many soil properties and conditions such as texture, structure, antecedent moisture content, presence or absence of water repellent materials as shown by the weather (Critchley and Siegert 1991; Moges 2004; Audrey 2005).

Faidherbia albida transplants survival in the two sites and in the different WHTs as compared to the control was remarkable (died 5 to 6 months after the control) and this is directly linked to the efficiency of the techniques in elevating the soil water storage that benefits the plants (Critchley and Siegert 1991; Singh *et al*., 2012). Similarly, the growth rate of all the parameters studied was higher in the WHTs in comparison to the control treatment in the two sites; even though, the relative performance of the techniques was not the same in the two sites. In the Savanna site, the performance of the techniques was discerningly arranged as follows: semi-circular bund > trapezoidal bund > negarim microcatchment > contour bund > control. While in Musai site, the performance of the techniques varied in the following order (for shoot and diameter growth): contour bund > semi-circular bund > negarim microcatchment > trapezoidal bund > control. Generally, the efficiency of the techniques in impounding the runoff water depends on their sizes and shapes, and the manner of their arrangement in relation to the terrain slope and height of the bunds. Thus, circular designs are found to be relatively efficient than the other designs as supported by this works of Critchley and Siegert (1991) and Prinz (2001). In addition, the lighter soils of savanna were not able to keep moisture for long and nutrient depletion mighthave occurred in the WHTs.

The death of the *F. albida* transplants in the different WHTs, specifically when they seemed to grow normally, implies occurrence of a catastrophic accident. This is partly expected, because livestock and herders can inflict serious damages to the plantations during their pass through the sites. In addition, during the dry months of summer, the soil moisture decreases greatly, that renders the *F. albida* transplants particularly vulnerable to drought, and other hazards, like damage by the termites. Further more, the areas where these trials were carried out are not the normal thriving sites of *F. albida* because it prefers sites along watercourses or alluvial soils according to the works of Miehe (1988), El Amin (1990) and Barnes and Fagg (2003). Even though, the use of WHTs in establishing tree transplants in the dry lands is advantageous to simple pit planting; however, protection against natural and anthropogenic factors is of paramount importance to avoid failure of afforestations.

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