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Effect of Acacia ampliceps Shelterbelt System and Water Use on Growth and Forage Yield of Barley (*Hordeum vulgare L.*) Cultivars in High Terrace Soil

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Abstract

The study was conducted at Elmukabrab scheme in River Nile State. Soil was low in nitrogen and of few organic meters. during the years 2012/ 13 and 2013/14 with the objective of investigating the effect of Acacia ampliceps shelterbelt and water use in rows wide 5 m between hedge rows and 3 m spaces between trees on growth and yield of Barley (*Hordeum vulgare* L.) as forage crop . Treatments consisted of heavy pruned Acacia ampliceps shelterbelts with light intensity of about 60 to 65% compared with control (light intensity 100%). Heavy pruning was done to increase incoming radiation measured by solar meter in two different seasons. Treatments were arranged in a randomized complete block design with four replicates. The plot size was 6×5 m.. Results revealed that in both seasons Barley forage yield under shelterbelt was highly significant, compared with the control. Barley fresh and dry forage yield under shelterbelt was increased by 46, 42% in the first season and by 41, 59% in the second season respectively compared with the control. In addition, water applied in shelterbelts with barley was measured. Water consumption differed ($p<0.001$) between shelterbelt and mono-cropping systems. Shelterbelts plots consumed less water ($739m^3$) than the control ($883\ m^3$). Water was saved in Acacia ampliceps shelterbelt by 23 and 26% for barley cultivars in the first and second seasons, respectively.

Keywords: Acacia ampliceps, pruning, radiation, Barley, solar meter, water use

تأثير نظام زراعة ممرات الاحزمة الشجرية المكونة من أشجار الأمبلسيبس على نمو وإنتاجية الشعير كمحصول علفي وعلي مياه الري بولاية نهر النيل – السودان

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المستخلص

أجريت هذه الدراسة بمشروع المكابراب الزراعي بولاية نهر النيل و تتميز المنطقة بمناخ شبه صحراوي وتربة منخفضة النتروجين والمادة العضوية في موسمي 2013/12 و2013/ 14 بهدف: معرفة تأثير نظام زراعة ممرات الأحزمة الشجرية المكونة من أشجار الأمبليسبس على نمو وإنتاجية الشعير كمحصول علفي ومياه الري- تم تقليبم شجرة الأمبلسبس (تقليم الأفرع الجانبية على إرتفاع 3.5 من سطح الأرض وثلث تاج الأشجار) بحيث أصبح الإشعاع تحت ظل أشجار الحزام حوالى 60-65 % تقريباً، مقارنة بالشاهد (الإشعاع 100%) تم قياسه بجهاز قياس الضوء (سولميتر) فى الموسمين، أوضحت النتائج إزدياد إنتاجية الشعير الأخضر والجاف كمحصول علفي داخل ممرات الحزام الشجري معنوياً في الموسمين مقارنة بالشاهد حيث كانت الزيادة بنسبة 46 ، 42% في الموسم الأول و41 ، 59% في الموسم الثاني على التوالي. كذلك وجد أن هنالك فرق معنوي في إستهلاك مياه ري الشعير كمحصول علفي بين نظام زراعة ممرات الحزام الشجري والشاهد، إستهلك حوالى 739 متر مكعب من المياه فى الزراعة بين ممرات الحزام الشجري المكون من أشجار الأمبليسبس مقارنة بحوالي 883 متر مكعب إستخدمت لري الشاهد. وفر ما مقداره 23 و 26% فى ممرات الحزام الشجري مقارنة بالشاهد فى الموسمين الأول و الثاني على التوالي.

كلمات مفتاحية: أمبلسيبس، تقليم، إشعاع، الشعير، سولميتر، المياه المستهلكة.

Introduction

The northern states (River Nile and Northern state) lie in the desert ecological zone (75-300mm rain fall) between lat.16 and 22 N and long. 25; 30 and 34 E, and severely affected by desertification processes. Particularly wind erosion. Wind erosion is the predominant desertification process in the Northern state. Wind erodibility of soils (WE) is the main indicator of wind erosion (Mukhtar and Ganawa ,2009). Desertification in Northern Sudan is a very serious problem threatening the agricultural land and the existence of people who depend on agriculture for their livelihood. Sand encroachment is the most important element that directly affects soil by causing strong erosion hazards and endangers all valuable agricultural land resulting in a continual decline in the area of cultivated crops in northern Sudan. One of the main effects of forest, shelterbelts and agroforestry on microclimate is on solar radiation, since the sun's rays bring not only light but also heat, (Shapo *et al.*, 2007). In Africa feed shortage is among the few most critical problems of livestock farming. The grazing lands are gradually shrinking in size due to expansion of crop farming to satisfy the food needs of the increasing human population (Kechero, 2008). In countries which are characterized by long cold winters, clipping of barley was reported to increase tiller density (ELshatnawi and Haddad, 2004). Up to date, only two types of forage (Abu Sabeen and Alfalfa) occupy around 95% of the area cropped to forage crops in Khartoum state (Ministry of Agriculture, Khartoum state, 2007) which resemble situation of River Nile and Northern state. There is a pressing need to diversify the present production system with variable forage types of a high-yielding and high quality forage crops suited to Sudan's condition. Barley is grown for many purposes, but the majority of all barley is used for animal feed, human consumption, or malting (Kling, 2004; Kent, 1983) and also used for medical purpose (Ceccarelli and Grando, 1996). In Sudan, barley is mainly produced in limited areas in the northern states for grain and forage production and farmers usually grow local genotype. Barley is reported to give high yield of good quality forage in a single cut in Gezira scheme (Khair *et al*., 2001 and Salih, et al, 2006).

Acacia ampliceps an exotic tree released by the Agricultural Research Corporation (ARC), used as shelterbelts in River Nile State at Mukabrab irrigation scheme in agroforestry research programme during 2006.

The objectives of this study were to assess the effects of *Acacia ampliceps* shelterbelts grown in rows wide 5 m between hedge rows and 3 m spaces between trees on growth and yield of Barley (*Hordeum vulgare* L.) as forage crop in addition to water use productivity (IWP) of shelterbelt trees and Barley as forage crop yield production.

Materials and methods

Site study

The experiment was carried out during two seasons, 2012/13and 2013/14 in River Nile State at Mukabrab Irrigated scheme. The Experimental site lies in semi-desert climatic zone between latitudes 17º26 and 17º35 N and longitudes 33º57 and 34º08 E; about 10 km south east of Ed Damer town. The soil of the experimental site is non-saline and non-sodic with alkaline soil reaction (pH = 8.2). Low in both organic carbon (0.046%) and nitrogen content (116 ppm). $CaCO_3$ (8.3). phosphorus content is 0.83 ppm. Soil under shelterbelt is more rich in total nitrogen, phosphorus and organic carbon compared to the mono-cropping.

Experiment components

Acacia ampliceps shelterbelt

Acacia ampliceps Seedlings were raised at Gezira Research Station nursery, three-month-old seedlings (35 – 40 cm length) were transplanted in 2006. The seedlings were grown at 3 meter in-row spacing and 5 meter intera rows spacing. Each hedge row was one km long and arranged in an east-west direction. A shelterbelt was composed of four rows. Heavy pruning was done by cutting all branches at 3 to 3.5 m above ground level of the main stem and one third of the tree canopy.

Crop management and practices

Land under shelterbelt and control plots was ploughed, harrowed and levelled. Barley was planted in lines (20 cm apart). Seed rate was 96 kg/ha. Nitrogen (46 % urea) was applied at the rate of 86 kg N/ha) by broadcasting in split dose given after second and fifth irrigation.

Data collection

Crop parameters

Forge crop yield and yield components were assessed at the end of the season as follows: Fresh and dry yield (ton/ha), plant height (cm), number of plant/M^2 , number of tiller/M^2 , fresh and dry weight of leaves and stem of five plants (g) and leaves to stem percentage.

Water applied

Applied irrigation water (m^3) for each plot in each irrigation event was measured directly in the field by a current meter using the following equation:

$$I = A \times T \times V \quad (1)$$

Where, I = applied irrigation water (m^3), A = cross section area (m^2), T = total time (s) and V = velocity ($m\ s^{-1}$) which was derived from the equation:

$$V = 0.008 + 0.2667n \quad (2)$$

Where, n = revolutions per second ($rev\ s^{-1}$) obtained from the formula:

$$n = \frac{\text{number of pulse counts}}{\text{times in second}} \quad (3)$$

Water productivity

For wheat crop irrigation water productivity (IWP) values were calculated as the ratio between the actual crop yield (Ya) and total amount of irrigation water applied (I):

$$IWP = Ya / I$$

Statistical analysis

Statistical analysis was carried out using GENSTAT statistical package the data obtained were analyzed for each season separately, and then combined analysis was run for the two growing seasons.

Results and Discussion

Effect of *Acacia ampliceps* shelterbelt pruned on barley forage yield

In both seasons barley as forage crop show that fresh yield, dry yield, plant height, number of plant, fresh weight of five plant leaves, dry weight of five plant leaves, fresh weight of five plant stem, dry weight of five plant stem and leaves/ stem ratio were significantly, higher ($p = 0.001$) under *Acacia ampliceps* shelterbelt compared to control. Fresh and dry yields were increased by 46, 42% and 41, 59% under *ampliceps* shelterbelt trees compared to control in the first and second seasons, respectively (Table 1). It was expected that competition for light will be from major factor affecting production. However, it was observed that the crop under shelterbelt trees perform better with (60 – 65%) transmitted radiation. The most benefit of shelterbelts is protecting adjacent soil and crops from injury of the erosive wind. Although shelterbelts occupy valuable land of production and compete for moisture and nutrients with crops. Modified microclimate might lead to an increase in the barley growth and yield component, scientific research in other parts of the temperate regions shows that improved yields adjacent to shelterbelts can help to compensate loss in production due to reduced area (Yuhai et al., 2012). Also, Dalia et al, (2020) mentioned that sorghum and cowpea as fodder crops increased under alley cropping system by 81.8, 62.4 and by 63.6, 60.2 % over control under *Sesbania formosa* and *Sesbinia sesban* respictivley. Also Adlan *et al*., (2019) mention that the yield of groundnut increased by 14 and 6% in the Ampliceps- alley and A. stenophylla-alley, respectively and maize increased by 27and 15% in the *Acacia ampliceps*- alley and *Acacia stenophylla*-alley, respectively, in additional water applied for both ampliceps and stenophylla- alley cropped with groundnut and maize water consumed less water (571m^3/ha) than the control (805m^3/ha), water was saved in the ampliceps-alley by 34 and 33% and in stenophylla-alley by 24 and 24% for groundnut and maize, respectively.

With respect to the interaction effect under shelterbelt and control treatments, though in the both seasons combined analysis, yield and yield components of barley as forage crop gave significantly higher results, except on number of tillers (m^2) (Table 2). Yield of sorghum in the alley plots was increased by 195% over the control plots as a result of microclimatic improvement in the alleys (Shapo , *et al* 2007).

Water use:

Water use consumption differed significantly (p=0.001) between heavy pruned *Acacica ampliceps* shelterbelts and mono-cropping systems. Shelterbelt plots consumed less water (739m^3) than the control (883m^3) as presented in Table (4).

Saving in irrigation water varied within different treatments, water was saved in the shelterbelt by 23 and 26% for barley cultivars in the first and second seasons, respectively. In both seasons irrigation water use productivity of barley as forage crop growth under shelterbelt was high compared with the control (Table 5 and 6). Shapo et al. (2011) reported that *Acacia stenophylla* resulted in the highest saving of irrigation water and considerably increased 40% sesame seed yield, sesame seed yield was reduced by 46% under Acacia ampliceps- alley cropping in the semi-desert region of the northern Sudan.

Conclusions

Acacia ampliceps shelterbelt has seemed to create a good and conducive environment to increase yields. The investigation was a significantly increased in barley fodder yields grown under *acacia ampliceps* shelterbelt if spaced 3 meters between trees and 5 meters between hedges rows with 60-65% light. Generally shelterbelts, which integrates crops and or livestock with trees and shrubs-has a great potential in the area as it provide farms with multiple benefits and better water use.

Table1. Yield and yield components of Barley fodder under shelterbelt and control plots during 2012/ 13 and 2013/14 season.

Season 1	2012/ 13											
Treatment	**Fresh yield ton/ha**	**Fresh yield% as Co**	**Dry yield ton/ha**	**Dry yield% as Co**	**Plant height (cm)**	**N. of plant (M^2)**	**N. of tillers (M^2)**	**FreshW.5 p. L(g)**	**Dry W.5 p. L (g)**	**Fresh W.5 p.S (g)**	**Dry W.5 p.S (g)**	**L&S Ratio %**
Shelterbelt	13.3	46	4.7	42	70	75	235	49	14	55	13	52
Control	9.3		3.3		48	58	265	18	9	21	10	47
Sig.L	*		*		*	*	No.s	*	*	*	*	*
S.E	0.5		0.1		3	1.2	11	2.4	0.6	2	0.4	0.4
C.V%	8		6		10	3	8	12	9	9	6	2
Season 2	**2013/ 14**											
Shelterbelt	12.7	41	4.3	59	65	70	227	54.1	13	52	12	53
Control	9		2.7		48	53	260	18	8	20	9	46
Sig.L	*		*		*	*	No.s	*	**	**	*	*
S.E	0.5		0.1		2.4	2.3	11	2.6	0.2	1	0.2	0.6
C.V%	8		6		7	7	7	13	4	5	4	2

Co= Control,N = Number, W.5 P. L = Weight of five plant leaves, W.5 P. S = Weight of five plant stem and L&S = Leaves and stem percentage.

Table 2. Combined analysis of yield and yield components of Barley fodder under shelterbelt and control plots during 2012/13 and 2013/14 and season

Season	1		2		Mean		Sig.L	S.E±	C.V%
Treatments	Shelterbelt	Control	Shelterbelt	Control	Shelterbelt	Control			
Fresh yield (ton/ha)	13.3	9.3	12.7	9	13	9.2	**	0.5	8
Dry yield (ton/ha)	4.7	3.3	4.3	2.7	4.5	3	**	0.1	6
Plant height (cm)	70	48	65	48	68	48	**	2	9
Number of plant(M^2)	75	58	70	53	73	56	**	2	5
Number of tillers (M^2)	235	265	227	260	231	263	No.s	11	8
Fresh weight five plant leaves (g)	54	21	52	20	53	21	**	1.1	7
Dry weight five Plant leaves (g)	14.3	8.7	13.3	8	13.8	8.3	**	0.3	7
Fresh weight five plant stem (g)	54	18	49	17	52	18	**	1.8	12
Dry weight five plant stem (g)	13	10	12	9	12.5	9.7	**	0.2	9
Leaves & stem Ratio %	53	46	53	46	53	46	**	0.4	2

Table 3. Irrigation water applied (m^3/ha) for Barley fodders under shelterbelt and control plots in during (2012/13 and 2013/ 14).

Season	**2012/ 13**					
Month Treatments	**December**	**January**	**January**	**January**	**February**	**Total irrigation water (M^3/ha)**
Shelterbelt	656	533	500	622	711	**3022**
Control	800	689	656	711	867	**3723**
Sig.L	No.s	*	*	No.s	*	
S.E±	44	8	21	39	21	
C.V%	11	2	6	10	5	
Season	**2013/ 14**					
Shelterbelt	655	567	533	722	767	**3244**
Control	811	767	700	911	911	**4100**
Sig.L	No.s	*	*	**	*	
S.E±	42	24	27	8	8	
C.V%	10	6	7	3	2	

Table 4. Combine analysis of irrigation water applied (m^3/ha) for Barley fodders under shelterbelt and control plot seasons (2012/ 13 and2013/ 14).

Month	December		January		January		January		February	
Treatment	Shelterbelt	Control	Shelterbelt	Control	Shelterbelt	Control	Shelterbelt	Control	Shelterbelt	Control
Season 1	656	800	533	689	500	656	622	711	711	856
Season 2	655	811	567	767	533	700	722	911	767	911
Mean	656	806	550	728	517	678	672	811	739	883
Sig.L	*		**		**		*		**	
S.E±	30		13		17		20		11	
L,s,d	118		49		67		78		43	
CV.	10		5		7		7		4	

Table 5. Amount of irrigation water applied (m^3/ha) of Barley in shelterbelt and control plots in two seasons (2012/ 13 and2013/ 14).

Season	First season (2012/ 13)		Second season (2013/ 14)	
Treatments	Water applied (m^3/ha mean)	Water saved as% of control	Water applied (m^3/ha mean)	Water saved as% of control
Shelterbelt	604	23	649	26
Control	744		820	
Sig.l	*		*	
S.E±	17		19	
l.s.d	101		115	
C.V	4		5	

Table 6. Irrigation water use productivity (m^3/ha) of Barley fodder under shelterbelt and control plots season 2014.

Season 1	2012/ 13			
	Fresh yield		Dry yield	
Treatments	Shelterbelt	Control	Shelterbelt	Control
Yield(ton/ha)	13.6	9.3	4.7	3.3
Water applied (m^3/ha)	3022	3723	3022	3723
Irrigation water use productivity (m^3/ha)	0.01	0.002	0.002	0.001
Season 2	2013/ 14			
Yield(ton/ha)	12.7	9	4.3	2.7
Water applied (m^3/ha)	3244	4100	3244	4100
Irrigation water use productivity (m^3/ha)	0.004	0.002	0.001	0.0007

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