Influence of alleycropping microclimate on the performance of groundnut (*Arachis hypogaea* L.) and sesame (*Sesamum indicum* L.) in the semi-desert region of northern Sudan

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Abstract

An alley cropping system was established at Hudieba Research Station (17.57'N and 33.8' E) on a loamy sand soil of the semi-desert region of northern Sudan. The objective of this study was to investigate the influence of modified microclimate in 6-m wide alleys formed by Acacia ampliceps and Acacia stenophylla on growth and yield of groundnut. and sesame. Above-ground interactions were determined by measuring air temperature, relative humidity, wind speed, solar energy and shade length and behaviour. Groundnut and sesame were evaluated for growth and yield by laying out sample plots at southern, central and northern part of the alleys and at control plots. Due to microclimatic modifications in the alleys, the yield of both crops in the alleys significantly (p=0.01) exceeded that of the sole crop. Yield reduction at the northern alley was fully compensated by high yield increase at southern and central alleys. The yield of groundnut increased by 37.7 and 19.6 % in the A.stenophylla and A.ampliceps alleys, respectively. On the other hand, the yield of sesame increased with the stenophylla-alley (+40.3%), while it decreased with ampliceps-alley (-51.5%). The results indicated that the competition for light was the major factor contributing to the increase or reduction of growth and yield of groundnut and sesame.

Introduction

The northern region of Sudan is viable for production of a number of food crops, however, desertification is a threat to the development of agricultural activities. Growing trees is a high priority for productive and sustainable agriculture. However, high cost of irrigation and lack of short-term incentives from the trees restrict plantation of pure tree stands. Trees for protective and productive role could be established on the base of alley cropping technology, which has been defined as " a production system in which trees and shrubs are established in hedgerows" on arable crop land, with food crops cultivated in the alley between the hedgerows (Kang and Wilson, 1987)" .

Alley cropping or tree-crop association has been advocated by several workers as a means to improve productivity, maintain soil fertility, control soil erosion, reduce environmental degradation, and offer better utilization of natural resources (Kang and Wilson, 1987; Kang et al., 1990). In the semi-desert of the northern Sudan, the soil is marked by the virtual absence of soil organic matter and extremely low nitrogen content. In addition, the area seriously suffers from desertification. Thus, alley cropping, using N-fixing trees, is sought of as a potential production practice that can provide several conservational and production benefits in the study area. Despite, the

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economic and nutritional importance of groundnut and sesame, both crops have received little attention in alley cropping research. The objectives of these trials were to examine the effect of alley cropping on microclimate and consequently on growth, yields and yield components of these two crops.

Materials and methods

An alley-cropping experiment was established on loamy sand soil during the period 1998 -2000 at Hudieba Research Station (HRS)., The study area lies within arid to semi-arid zones with mean annual rainfall ranging from 0 to 100 mm. The seedlings of Acacia stenophylla and Acacia ampliceps were planted in hedgerows, 3m within row spacing and 6.3 m between rows. Each hedgerow was 180 m long and arranged in an east-west direction. The groundnut and sesame were grown in the alleys formed by the two acacias assigned randomly in a spilt plot design replicated three times. The plot size was 3X6 m. The alley was divided into three zones: northern, central and southern alley. The central alley had the largest width (4 m), while the northern and the southern alleys were each 1.0 m wide. According to the orientation, and position of the sun at different times of the day and season, radiation varies in each zone. Groundnut (Arachis hypogaea, sub ssp hypogaea, var hypogae) and sesame (Sesamum indicum L.) seeds were sown between rows according to recommendations released by Agricultural Research Corporation in the Sudan. Plant samples were taken at harvest from an area of one square meter in the center of the northern, central and southern alleys and control plots to determine plant characters, yield and yield components.

The Stevenson screens (Meteorological Instrument, 19961) were positioned at a height of 2 m above ground level at each of the three zones of the alley and control plot. The readings of all thermometers were taken simultaneously between 8.00 – 9.00 LT every day and continuous measurements were made from June to October. Cup anemometers were used for measuring wind speed. Tube solarimeters were placed at ground level across the three zones of the alley to measure solar irradiance.

Statistical analysis was carried out using the computer program MSTAT package by SAS Corporation.

Results and Discussions

Table 2 shows that the average reduction in maximum temperatures and solar irradiance was 1.8 ˚C and 54% of the control, respectively. Relative humidity gave average increase of 12%. The southern alley had the highest reduction in maximum temperatures and the highest increase in relative humidity. Its transmitted radiation was higher than in northern alley. On the other hand, the northern alley gave higher reduction in maximum temperatures and higher increase in relative humidity than the central alley. Table 1 demonstrates that there was significant (P=0.01) differences in yields and yields components between the alley cropping and the control plots. Stenophylla–alley, gave higher significant (P=0.01) yields of groundnut and sesame than ampliceps–alley. Regarding the zones of the alley, the southern zone gave the highest yield and yield components.

In agroforestry systems, the tree canopy reduces and modifies the light availability to plants in the understory, with possible beneficial consequences for photosynthesis, water relations and morphogenesis (Bergez et al, 1997). In this study the stenophylla-alley with its relatively higher average radiation (62% of the control) remarkably

increased the economic yield of both groundnut and sesame by 37.7 and 40.3%, respectively, compared to the control. On the other hand, ampliceps-alley, with its low radiation (46% of the control), increased the yield of groundnut by 19.6 %, while it decreased that of sesame by 51.5%. The southern zone of the alleys had intermediary radiation, and gave the highest yield. This indicates that the groundnut and sesame yields did not increase as light supply had increased as other environmental factors, seemed to be influential (e.g. temperatures, humidity and wind speed). The highest radiation in the central alley coincided with the least improvement in temperature and humidity, while the lowest radiation in northern alley was concurrent with the complicity of the co-existence of tree-crop roots competition.

Tab. 1: Yield and yield components of groundnut and sesame in the alley and control plots (1999-2000)

Treatments	Groundnut			Sesame		
	Plant height (cm)	weight of kernels kg\ha	Yield as % O f control	plant height (cm)	Wt. seed Kg/ha	Yield as % Of control
Control	**17**	**437**	**-**	**136**	**747**	**-**
Northern-*stenophylla*	20.6	546	+ 24.9	160	853	+ 14.2
Southern-*stenophylla*	26.2	676	+54.6	163	1426	+ 90.8
Central-*stenophylla*	26.8	584	+ 33.6	171	850	+13.8
A.stenophylla-alley	**24.5**	**602**	**+ 37.7**	**165**	**1043**	**40.3**
Northern-*ampliceps*	23.1	320	- 26.7	150	333	- 55.0
southern-*ampliceps*	26.9	681	+ 55.8	136	420	- 43.7
Central-*ampliceps*	24.7	570	+ 30.4	144	326	- 56.3
A.ampliceps-alley	**24.9**	**523**	**19.6**	**143**	**359.7**	**-51.8**
Sig. L	*	*	-	* *	*	-
S.E+\-	1.2	13.4	-	4.9	6.8	-
C.V %	9.4	10.4	-	2.0	115	-

*significant for P<0.01 * * significant for P<0.001

On the other hand, the yields of groundnut in the southern and central zones of the ampliceps increased by 55.8 and 30.4%, respectively, while it decreased by 26.7% in northern alley. In addition, the sesame yield in the southern, central and northern zones of the ampliceps decreased by 43.7, 56 and 55 %, respectively. The increase in groundnut yield and decrease in sesame yield in ampliceps-alley may not only be due to low radiation (42 – 50% of the control), but may also be due to competition for water. The severe reduction of yield in the northern and central alley of A.ampliceps may be due to complexity of the co-existence of the root of the tree – crop mixture. The competitive roots of the ampliceps extended laterally up to the central alley and compete with sesame for water. Sesame requires adequate moisture for early growth and before flowering, which have the greatest impact on yield (Weiss 1971). Therefore, water-use might be another factor in reducing sesame yield within ampliceps-alley.

Tab. 2: Differences in temperatures (˚C), relative humidity (%) and % of irradiance in various zones of the alley as percentage of control (kw /m^2)

	A.ampliceps-ally				A.stenophylla-ally				ā	Control
	S	N	Ce	x	S	N	Ce	x		
Max. temperatur	-2.7	-1.9	-1.3	-1.9	-1.8	-1.7	-1.5	-1.7	**-1.8**	41.5
Relative humidity	+18	+13	+10	+14	+12	+10	+8	+10	**+12**	42.0
Solar energy	46	42	50	46	58	54	75	62	**54**	0.354

*S= Southern alley *N=Northern alley *Ce=Central alley *Co= Control
* x = average * Am = Acacia ampliceps * St = Acacia stenophylla
* (-) Reduction in maximum temperature * (+) increase in relative humidity
* ms-1 = wind meter per second

Conclusions

Thus, the current conditions in the Northern Region of Sudan are favourable for adopting agroforestry technology in order to arrest environmental deterioration and to secure productivity and sustainability of agricultural crops. The study revealed that trees influenced the plant-environment-relationship in a way that conditions become more conducive for crop growth. Although, the micro-environmental variables were responsible for yield increase or decrease, but in reality, it seemed difficult to separate the complex interacting climatic factors involved in the system. Nevertheless, the obtained results indicated that the competition for light was the major contributing factors responsible for yield reduction or increase in the different alley' zones. Groundnut had proved to be shade tolerant and it gave the highest yield with *A.ampliceps* with low radiation (46% of control).

In high terrace soils of northern Sudan, groundnut is recommended to be alleycropped with *A.stenophylla* and *A.ampliceps* trees, while sesame is recommended to be alleycropped with Acacia stenophylla.

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