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Effect of Shelterbelt- Distance on Nutrient Contents of Pearl Millet (*Pennisetumglaucum*) in Arid Land of Nigeria

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ABSTRACT- ***A field experiment was conducted for 3 years in Azare, northern Bauchi State using a shelterbelt. Treatments consist of six shelterbelt distances namely; -5m (the control treatment on the windward side), 5, 15, 25, 35 and 45m (on the leeward side) of the belt. Treatments were arranged in a randomized complete block design and replicatedfour times. Results of the analysis of variancerevealed that shelterbelt-distance significantly (P = 0.05) affectedgrain-NPK contents of millet with 25m giving significantly higher contents all through the years of experiment. These parameters were numerically higher in the year 2005 than it was in 2003 and 2004.However, beyond 25m shelterbelt-distance, grain NPK contents of millet dropped significantly, though, with values greater than the control treatment on the windward side of the belt. Based on this result, the 25m shelterbelt-distance is recommended for high quality grain in millet, especially in arid areas of Nigeria.***

Keywords: Shelterbelt- distance, nutrient-content, pearl-millet, arid land

1. INTRODUCTION

The term shelterbelt is synonymous with windbreak, which are vegetative barriers (trees, shrubs, or perennial grasses), planted in single or multiple rows at appropriately spaced intervals across the direction of the prevailing wind so as to reduce wind speed and provide sheltered areas on the leeward (side away from the wind) and windward (the side toward the wind) sides of the shelterbelt (Johnson and Brandle, 2003). As wind approaches the belt, some goes round the end of the belt, some goes through the belt and most go over the top of the belt. Air pressure builds up on the windward side and decreases on the leeward side. It is this difference in pressure that drives the shelter effect and determines how much reduction in wind speed occurs and how much turbulence is created (Johnson and Brandle, 2003).Shelterbelt provides an effective way to incorporate trees into farming land bringing both environmental and economic benefits (Cleugh, 2000). Windbreak trees, for example, when planted within agricultural areas have been shown to have a variety of effects on the local microclimate influencing temperature and humidity, moisture availability, and light conditions, and the zones of influence extend into nearby crops (Smiley *et al.,* 2004).

Studies have demonstrated that field shelterbelts benefit crops growing in their shelter (Ujah and Adeoye, 1984; Kort, 1988) by improving microclimate (Rosenberg, 1975) and reducing evaporation (McNaughton, 1988; Onyewotu, 1996). Stigter (1985) expresses the view that in semi-arid areas the real value of shelterbelts lies largely in making the limited supply of soil moisture effective in food production by lowering the water requirement of plants. Under arid conditions, such as prevalent in northern Nigeria, large scale heat advection (especially in hot dry air) is inevitable (Olaniran, 1979; Stigter, 1985). Heat advection is the movement of heat in a horizontal direction that is exchanged vertically within an area. Specific crop areas under the strong influence of heat advection will require more water to maintain a tolerable soil-plant microenvironment. This means that under the low rainfall condition of these areas water stress even more easily develops. Reducing air movement in such cases will be beneficial, as it reduces the heat transported towards the crops (Onyewotu, 2000). Crop response in fields adjacent to shelterbelts has been reported in numerous studies. These responses vary with year and weather conditions (Johnson and Brandle, 2003), and have resulted from microclimate (Carberry*et al*., 2002).

Micro-site enrichment by trees which ultimately maintain or increase productivity of the land (Grace, 1988), is reported to be the net effect of several factors, the most important being soil fertility improvement (Grace, 1988). Kellman (1979) while reporting preferential enrichment of the soil below trees in terms of calcium (Ca), magnesium (Mg), potassium (K), phosphorus (P) and nitrogen (N) in highly weathered and infertile ultisols of the Mountain Pine Ridge savanna of Belize (Central America), concluded that the gradual accumulation of mineral nutrients by perennial, slow-growing trees, and the incorporation of these into an enlarged plant-litter soil nutrient cycle was the mechanism responsible for this soil enrichment. Similar results of substantial enrichment in N, P, K and increased availability of micro-nutrients such as zinc (Zn), manganese(Mn) and cupper (Cu) under tree species growing in drylands elsewhere were also recorded (Agrawal, 1980, Mann and Saxena, 1980, Shankarnarayan*et al*., 1987, Sharma and Gupta, 1989 and Rao*et al.*, 1990). However, these workers in their works showed that soil fertility improvement by trees in drylands is a slow process and it is extremely important in the fragile economic and ecological context of drylands (Vandenbeldt, 1990). Reports from Central Arid Zone Research Institute (CAZRI), India, revealed that combination of trees with crops would yield better overall returns in comparison with separate plots of trees and crops whilst reversing the land degradation in drylands (Shankarnarayan*et al.*, 1987).This study was therefore carried out to evaluate the effect ofsix differentshelterbelt-distanceson grain NPK content of pearl millet in Azarean arid area of Bauchi State.

2. MATERIALS AND METHODS

Field experiment was conducted for three years in 2003, 2004 and 2005 wet seasons using an established shelterbelt plantation at Azare, Northern part of Bauchi State (Latitude 11^{o} 40'N, Longitude 10^{0}10'E, 609. 45m above sea level) in the Sudan Savanna ecological zone of Nigeria. The site was classified as arid because of its characteristic low rainfall of short duration, and poor distribution pattern, often punctuated by periodic droughts (Marguba, 1991; Kowal and Knabe, 1972). The average annual rainfall and temperature of the area during the 3-year study were presented in Table 1. The soilphsico-chemical properties of the experimental site before cropping in each year werepresented in Table 2. The shelterbelt used for the study was thirteen years old and comprised of a network of a monoculture of *Azadirachtaindica* and *Eucalyptus camaldulensis* planted in ten rows at spacing of 3m by 3m and 30m wide. The land was ridged in all the years of experiment using animal traction. The experimental fields, both at the windward and leeward sides of the shelterbelt were marked out into 20 plots of 5m x 5m, and a path of 5m between plots and replications was provided.

2.1Treatments and experimental design

Millet (*Gero*var.) was used in all the three years of experiment. Treatments consisted of six distances (-5m, 5m, 15m, 25m, 35 and 45m) from the shelterbelt. The treatments were arranged both at the leeward and windward sides of the shelterbelt in a randomized complete block design with four replications. Treatments perpendicular to the shelter on the windward side serves as the control. One out of these control-treatments was randomly picked and designated as -5m.Treated seeds of millet (*Gero*var.) were sown directly into the fields between 7-15th June in all the years of experiment after the establishment of regular rainfall. Spacing of 30cm along the rows and 60 cm between rows was maintained in each year of the experiment. Twelve seeds of millet were sown, these were thinned to two plants per stand at 2 weeks after sowing (WAS) during weeding. After harvest, grain yield was pooled according to experimental treatments and representative samples collected for analysis of nitrogen(N), phosphorus (P) and potassium (K) concentrations from Kjeldahl digest using the Micro-Kjeldahl digestion and distillation apparatus and the values read with the Atomic Absorption Spectrophotometer (A.O.A.C., 1980).

2.2 Data analysis

Data collected were subjected to analysis of variance (ANOVA) according to Steel and Torrie (1980) using the General Linear Model (GLM) in SPSS (1996) for windows. Means oftreatments were compared using Duncan multiple range test (DMRT), calculated only when the analysis of variance (F-test) was significant at P = 0.05 (Duncan, 1955).

3. RESULTS

3.1Grain nitrogen (N) content

The effect of shelterbelt-distance on the grain nitrogen content of millet was significant in all the years of experiment (Table 3). In 2003 wet season, nitrogen content was observed tobe significantly high with shelterbelt-distance of 25m. This was followed closely by 35m, as well as 45, 15 and 5m distances from the belt. The least millet grain- N content was recorded in the control treatment (-5m distance) on the windward side of the shelterbelt. This trend was equally observed in 2004 and 2005 wet seasons.

3.2Grain phosphorus (P) content

The grain phosphorus content of millet was significantly affected by distance from the shelterbelt (Table 3). Phosphorus content of grain was observed to be generally very low (1.63- 3.31 g kg^{-1}) in all the 3- wet seasons. Howeverin 2003 wet season, millet grain- P content was significantly high at 25m away from the belt. But from 35 to 45 and 5 to 15m away from the shelter, grain-P content of millet was not significantly different. This behaviour was similarly obtained in 2004 and 2005 wet season trials.

3.3Grain potassium (K) content

The effect of distance from the shelterbelt on the grain-K content of millet was significant in all the 3- wet season experiments (Table 3). Potassium content in 2003 increased much more higher from the control distance onthe windward, up to when millet seedswere planted at 25m shelterbelt-distanceon the leeward side. Thereafter declines significantly with planting millet at 35 and 45m distance from the belt. However, grain-K content at 5, 15, 35 and 45m was statistically the same. This characteristic behaviour of grain-K content was furtherrecorded in 2004 and 2005 experiments.

4. DISCUSSION

Data on rainfall during the field experimentsrevealed that high rainfall of 862mm was recorded in 2005, followed by 2003 with 592mm and the least rainfall of 361mm was obtained in 2004 wet season (Table 1). The soil physico-chemical analysis (Table 2) showed that soil fertility status of the experimental area was very low (Esu, 1991). The pattern of response therefore recorded in millet grain-NPK contents in the three wet seasons, could be linked to the differences in rainfall which might have created a distinct growing environment for the parameters to perform differently. High rainfall (862mm) in 2005numerically increased the NPK contents of grains in millet compared to moderate (592mm) and low (361mm) amounts of rainfall recorded in 2003 and 2004 respectively.The results of this study further revealed that grain-NPK contents, increased significantly (P=0.05) at different distances from the shelterbelt.At the control plots, physiological development of millet was depressed due to direct effect of wind blow and soil blasting.This negatively influenced the grain qualityattributes of millet such as in grain NPK contents. Whereas, the millet grain quality attributes within a distance of 25 shelterbelt- distance were significantly increased and higher compared with the rest of other distances. The increases at this range might have resulted from reduction in the amount and severity of wind damage to the crop and improved microclimate. This finding is in conformity with that of Snell (1999) and Carberry*et al*. (2002) who observed that, by reducing wind speed, shelterbelts influenced crop water and energy balances resulting in lower evaporative demand and increased grainquality parameters. Crops differ in their responsiveness to shelter (Anon. 2003). Winter wheat, barley, rye, alfalfa and hay are highly responsive to protection, while spring wheat, oats and corn respond to a lesser degree. The same worker also reported that sheltered crop had higher protein content. This supports the present study. Beyond 25m shelterbelt-distance, grain NPK contents of millet dropped as the influence of the shelterbelt diminished. However, the values within these distances were still significantly higher than the unsheltered control treatment, which indicates the significance of shelterbelt. This diminishing trend could probably continue up to the point of no significanteffect of shelterbelt as reported by Kohli*et al*. (1990).Working on winter season agro ecosystems, these researchers reported that beyond 11m shelterbelt-distance, no influence of *Eucalyptus* was noticed.

5. CONCLUSION

Based on this work, shelterbelt-distance of 25maffected grain NPK contents of millet significantly. It is therefore recommended for high quality grain in millet, especially in arid areas of Nigeria.

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Table 1: Rainfall (R), temperature (T) and relative humidity (RH) of Azare during the 2003, 2004 and 2005 wet seasons

Months	**2003**			**2004**			**2005**		
	R(mm)	**T (°C)**	**RH(%)**	**R(mm)**	**T(°C)**	**RH(%)**	**R(mm)**	**T (°C)**	**RH(%)**
April	61	31.7	48.8	0	31	69	62	34	35.8
May	67	32.1	55	14	30	73	172	33	38.8
June	85	26.5	80.1	62	29	70	214	28.3	47.4
July	61	27	85.1	51	27	79	65	28.6	48
August	163	31.7	84.6	183	27	83	108	28.8	64.1
September	113	25.1	82.1	15	28	79	184	28	61.8
October	42	24	45.3	36	28.5	77	57	29	59.2
Total	592			361			862		

Source: Bauchi State Agricultural Development Project Northern Zone
R.RainfallT. TemperatureRH. Relative humidity

Table 2: Physico-chemical properties of the soil at the experimental site within 0-30cm depth during the 2003, 2004 and 2005 wet seasons

Soil properties	**2003**	**2004**	**2005**
Physical properties			
Particle size distribution (g gk^{-1})			
Sand	844.8	868.0	828.0
Silt	27.2	17.2	47.2
Clay	124.8	114.8	124.8s
Texture	Sandy loam	Sandy loam	Sandy loam
Chemical properties			
Soil pH 1:2 (H_2O)	5.66	6.02	5.91
Organic carbon (g kg^{-1})	2.21	2.17	2.21
Total N (g kg^{-1})	0.61	0.51	0.52
Available P (mg kg^{-1})	7.98	8.63	10.6
CEC [C mol (+) kg^{-1}]	4.18	6.50	8.27
Exchangeable bases [Cmol (+) kg^{-1}]			
Ca	3.26	2.68	2.62
Mg	0.68	0.60	0.55
K	0.28	0.27	0.24
Na	0.16	0.13	0.24

Table 3: Effect of shelterbelt- distance on the grain nitrogen (N), phosphorus (P) and potassiumcontents (gkg^{-1}) of pearl millet from 2003-2005 wet seasons at Azare

Distance (m)	**2003**			**2004**			**2005**		
	Grain-NPK Contents (gkg^{-1})								
	N	**P**	**K**	**N**	**P**	**K**	**N**	**P**	**K**
-5(Control)	7.36d	1.70d	7.15c	5.30d	1.63d	7.53d	6.08d	1.71d	7.40e
5	13.18c	2.11c	12.18b	15.02c	2.12c	11.04c	16.75c	2.81c	12.20d
15	13.50c	2.20c	12.37b	15.07c	2.17bc	11.19c	16.88c	2.91b	12.31cd
25	18.99a	2.93a	12.92a	17.54a	2.82a	12.45a	19.42a	3.31a	13.23a
35	15.28b	2.49b	12.43b	17.22ab	2.35b	11.92b	17.93b	3.00b	12.79b
45	13.59c	2.32b	12.33b	16.15bc	2.23bc	11.52bc	17.53bc	2.97b	12.57bc
SE±	0.25	0.06	0.13	0.44	0.07	0.16	0.26	0.03	0.12

Means followed by common letter(s) are not significantly different at 5% probability level (DMRT)