New Botanist, Vol. XX, 1993 : 195-209
Today & Tomorrow's Printers and Publishers, New Delhi - 110 005; (Printed in India)

SEASONAL PARTITIONING OF DRY MATTER AND NITROGEN IN *ANDROPOGON TECTORUM* REGENERATED FROM RHIZOMES

S.O. Oke and A. O. Isichei

Department of Botany
Obafemi Awolowo University
Ile-Ife, Nigeria.

Seasonal partitioning of dry matter and nitrogen over a growing season in *Andropogon tectorum* regenerated from rhizomes were studied under nutrient and water regimes in sand culture. The dry matter and nitrogen content of *Andropogn tectorum* was partitioned into leaf, stem, root and rhizoms fractions under both regimes.

The leaves constituted the largest component of the biomass under both treatments over the growth period and its contribution ranged from 30.96% to 72.19% while the rhizome constituted more or less the least component of the biomass (3.19% to 38.25%) over the entire growth period except at the early stage and stem and root had intermediate proportions.

Percentage total nitrogen in leaf, stem, root and rhizome generally declines from the begining of growth period to maturity. The total nitrogen concentration of leaves of both treatments was constantly higher than those of other parts monthly throughout the study period. The proportion constituted by the leaves declined from the early stage to maturity whereas in rhizomes the proportion was increasing from the early stage to maturity.

At maturity a notable general trend of percentage total nitrogen proportions constituted by different parts of plants is that proportion constituted by below-ground parts was higher than those of above-ground parts while reverse was the case with dry matter.

The flowering plants employ a wide variety of asexul reproduction methods which complement or replace the sexual process (Helslpop-Harrison 1982). The most familiar processes are those which come under the heading 'vegetative reproduction'(clonal growth). These depend on the distribution and separate establishment of physiologically independent individuals from segments of the parent plant. These segments may be underground rhizomes as in many grasses, or small propagules readily; detachable from the shoot, such as bulbils of onions.

The grasses, except for some primitive bamboos, are purely herbaceous plants and many have evolved a most successful habit of vegetative growth, which allows the plant to withstand the depredations of grazing animals, periods of drought and even death of the aerial parts. These they achieve by the production of underground rhizomes or creeping surface stems, and they have the ability to produce aerial shoots from buds in the axils of their scale leaves. Some grasses have also developed the tufted habit whereby branching of the main stem usually occurs from the basal buds (tillering), which results in a plant with numerous stems, each capable, if damaged, of new basal erect branches and continuing the life of the plant. All these peculiar attribute to typical grass, together with its fibrous, usually extensive and efficient root system have contributed to the success of the grasses in present day vegetation.

Harris and Davy (1986) noted that multi-node rhizome fragments hold an important advantage over seeds in their ability to produce viable shoots following burial. Their response is more flexible in that imposed dormancy of surbordinate buds on rhizomes makes more resources available to the dominant shoot, improving the likehood of successful emergence, and it also conserves buds and resources against the threat of repeated mechanical disturbance. This is in contrast to seed where germination is an-all-or-nothing gamble.

Puttens (1990), who made a study of different methods of establishing *Ammophila arenaria* (Marram grass), by planting bundles of culm, sowing seed and disc-harrowing rhizomes, observed that rhizomes produced more robust tillers and more above-ground biomass than bundles of culm and seedling when fertiliser was applied. Without fertiliser, culms gave most biomass production, but seedling growth was very poor. Earlier, Wareing (1964) and Berg (1972) stated that underground vertical stems rhizoms have never been used for establishing *Ammophila arenaria.*

Nicholson (1952) and Ranwell (1972) had also observed that in constrast to seeds, the rhizomebud of *Elymus farctus* are not primarily dispersive structures, although once removed from the parent plant by breakage or decay of rhizomes they can produce shoots and adventitous roots. The weight of evidence in *E. repens* suggest that production of new shoots and roots from buds on detached rhizomes fragments is dependent to a large extent on accumulated reserves in those rhizomes (Harris and Davy, 1986).

Much work has been done on the seasonal partitioning of nitrogen in Graminea, and many workers have shown that mobile elements, such as nitrogen, are concentrated in young tissues. The gradient of nitrogen concentration from roots to leaf supports the concept that nitrogen compounds are translocated from underground organs to the leaves and meristematic tissue of the shoot apex Pate (1968). Wilman *et. al.* (1976), in an experiment with Italian ryegrass (*Lolium multiflorum* Lam) showed that the nitrogen content of green leaf was consistently higher than that of other fractions. Russell *et al.*

(1954) also showed that the nitrogen percentage in bromegrass (*Bromus inermis* Leyss) forage increased notie ably with increase in the rate of fertiliser applied and that there was a progressive decline in nitrogen percentage throughout the growing season, although differences due to the rate of nitrogen fertilisation persisted. They noticed that there was a rapid accumulation of nitrogen in bromegrass forage during the early stages of growth.

If tillers, tufts or shoots, roots and rhizomes are not physiologically independent entities, it is important to determine the role they play in the development of a population. The purpose of this study to determine the proportion constituted by leaves, stems, roots and rhizomes of *Andropogon tectorum,* in terms of biomass and nitrogen accumulation as season progresses under nutrient and water regimes and to find out whether the amount of nitrogen in the soil affects the partitioning of nitrogen in plant parts. The present work describes the result from a destructive sampling procedure which permitted biomass and nitrogen accumulation to be partitioned and measured along the sequence of growth phases of *Andropogon tectorum* regenerated from rhizomes under water and nutrient regimes.

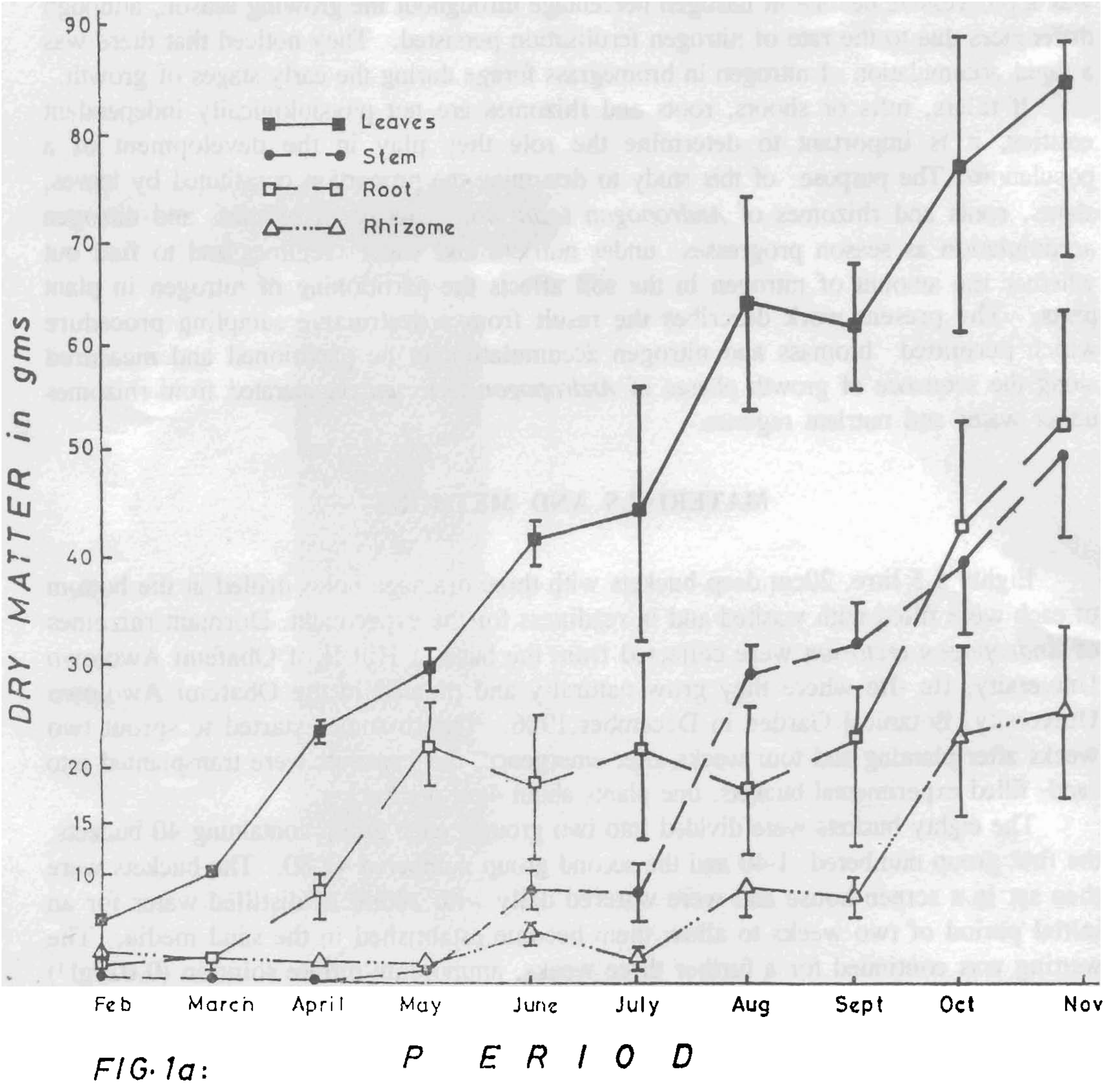
MATERIALS AND METHODS

Eighty 5.5 litre, 20cm deep buckets with three drainage holes drilled at the bottom of each were filled with washed and in readiness for the experiment. Dormant rhizomes of *Andropogon tectorum* were collected from the base of Hill II of Obafemi Awolowo University, Ile -Ife where they grow naturally and planted in the Obafemi Awolowo University, Botanical Garden in December,1986. The rhizomes started to sprout two weeks after planting and four weeks after emergence, the sprouts were transplanted into sand- filled experimental buckets, one plants about 4gm per bucket.

The eighty buckets were divided into two groups, each group containing 40 buckets, the first group numbered 1-40 and the second group numbered 41-80. The buckets were then set in a screen house and were watered daily with 200ml of distilled water for an initial period of two weeks to allow them become established in the sand media. The wetting was continued for a further three weeks, ammonium nitrate solution ($0.029gl^{-1}$) which supplied an equivalent of 5ppm nitrogen to the plants was also applied. This was to further ascertain that the plants were firmly established before the commencement of the experiment.

On the 1st of February, 1987, the actual experiment began with the daily wetting of the plants in buckets numbered 1-40 (group 1) with 200ml (per bucket) of a nutrient solution that contained 35ppm nitrogen in form of potassium nitrate ($0.216gl^{-1}$; 30ppm) and ammonium nitrate ($0.029gl^{-1}$; 5ppm). The plants in buckets numbered 41-80 (group 2) were fed with 200ml of plain distilled water daily. The nutrient solution contained the necessary mineral nutrient solution that are known to be utilized by plants, in the proportions formulated by Hewit (1952). The chosen level of nitrogen was considered adequate for grass growth.

At the end of each month, starting from February ending, till November ending 4 buckets were randomly sampled from each group. At harvest the plants were separated into rhizomes roots, stems and leaves by cutting. The plants were dried to constant weight at 80 °C, weight and ground in an 800RPM 8". Labratory mill through a 1.5mm mesh ready for analysis for percentage total nitrogen.



FIG·1a:

Fig. 1a: Monthly mean oven dry weight per pot of leaves, stems, roots and rhizomes of *Andropogon tectorum* growing season.

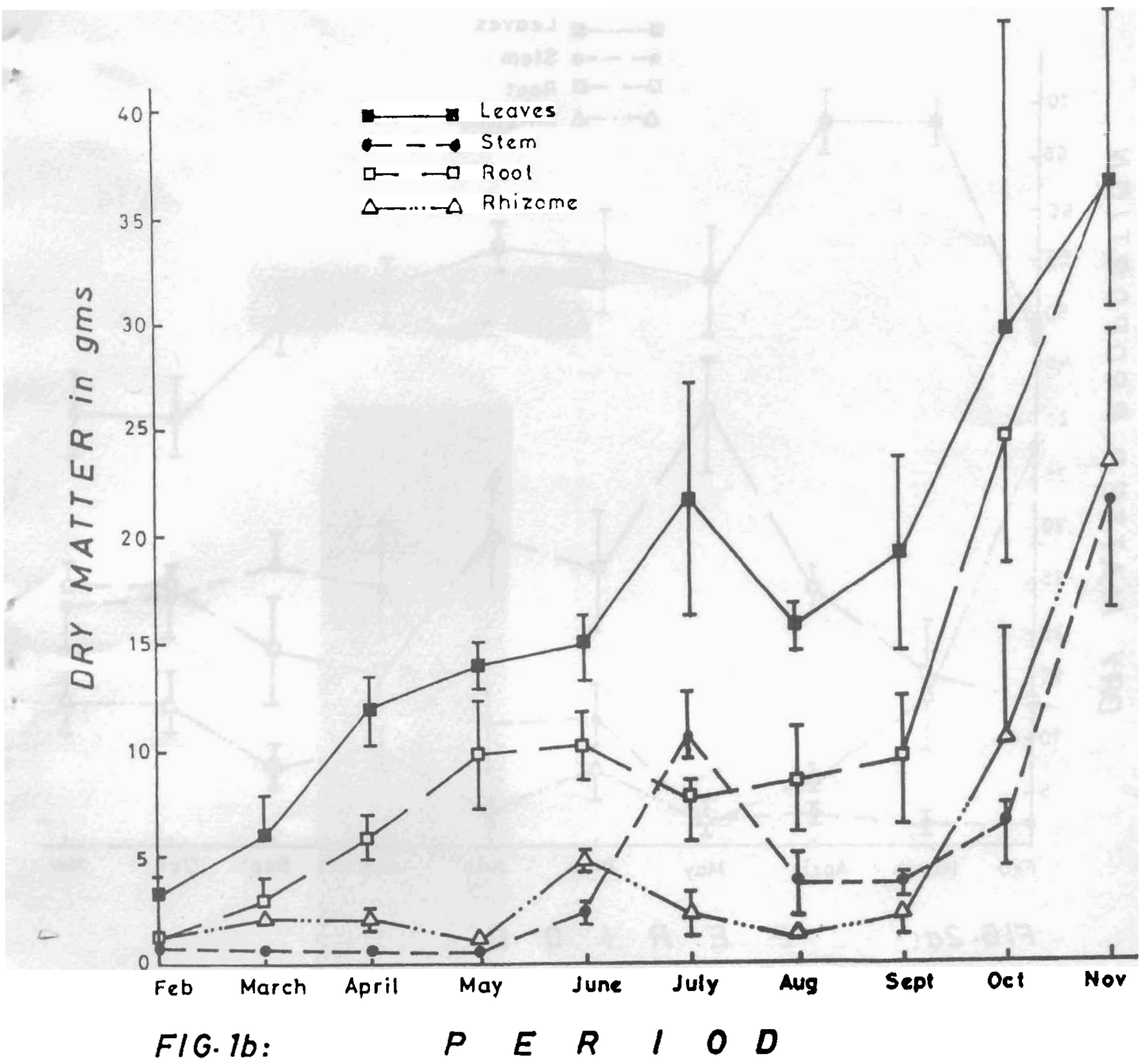


FIG. 1b:

Fig. 1b· Monthly mean oven dry weight per pot of leaves, stems, root and rhizomes of *Andropogon tectorum* grown under water regime over one growing season.

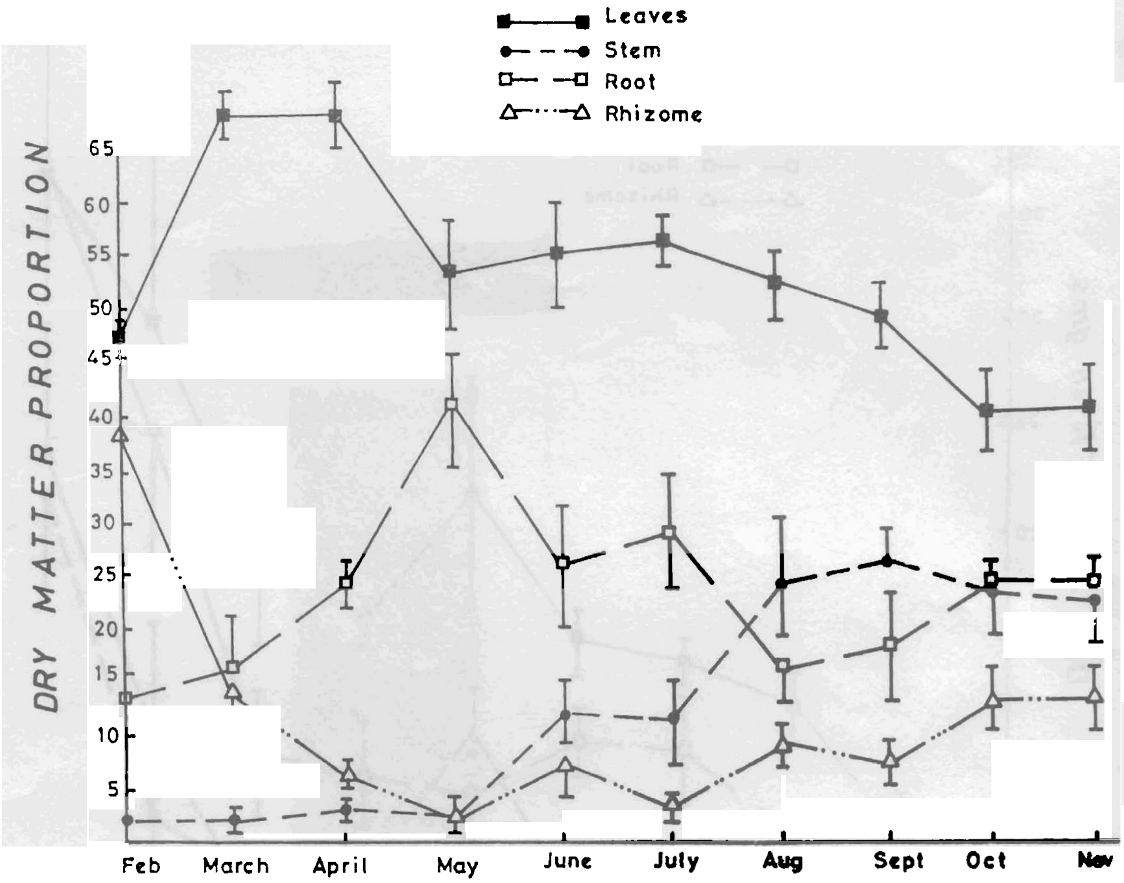


FIG. 2a: PERIOD

Fig. 2a: Mean monthly percentage allocation of biomass to leaf, stems, root and rhizome in *Andropogon tectorum* grown under nutrient regime over one year.

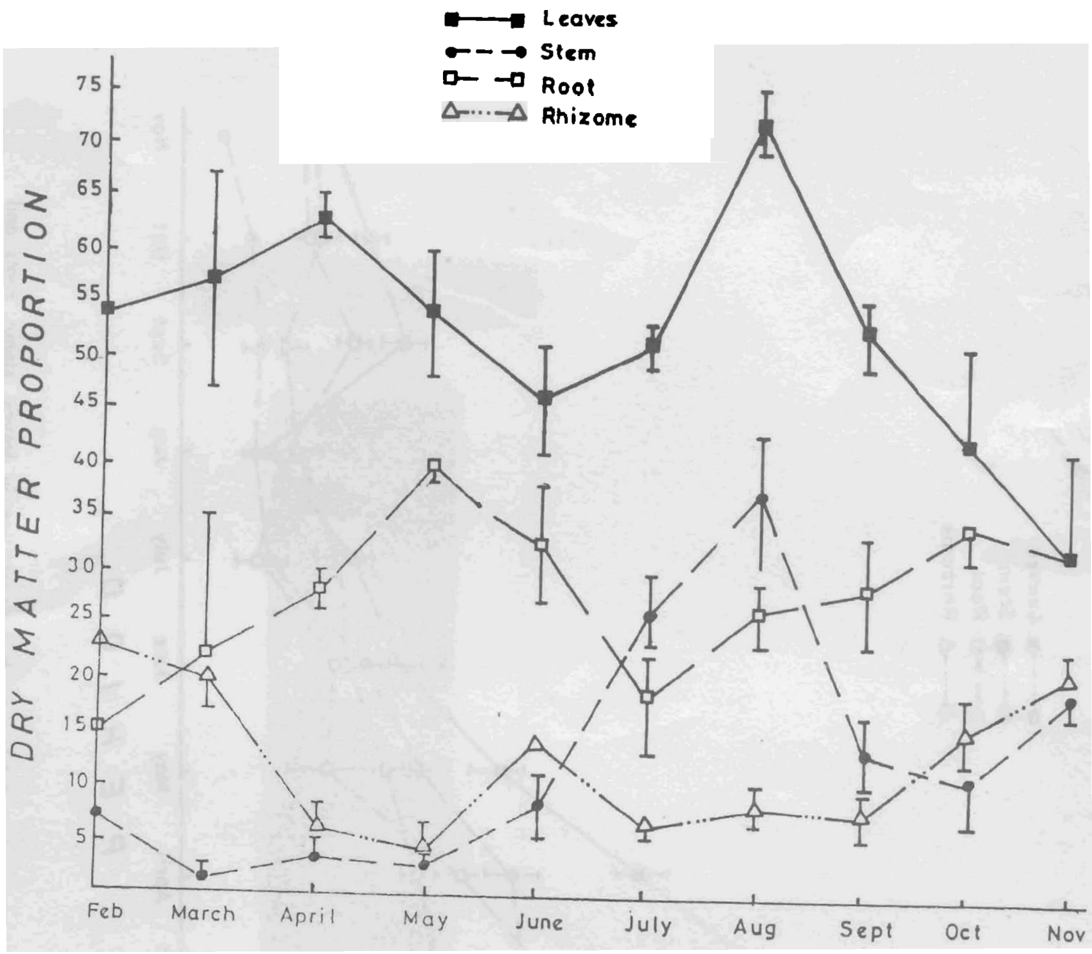


Fig. 2b: Mean monthly perccentage allocation of biomass to leaf, stems, root and rhizome in *Andropogon tectorum* grown under water regime over one year.

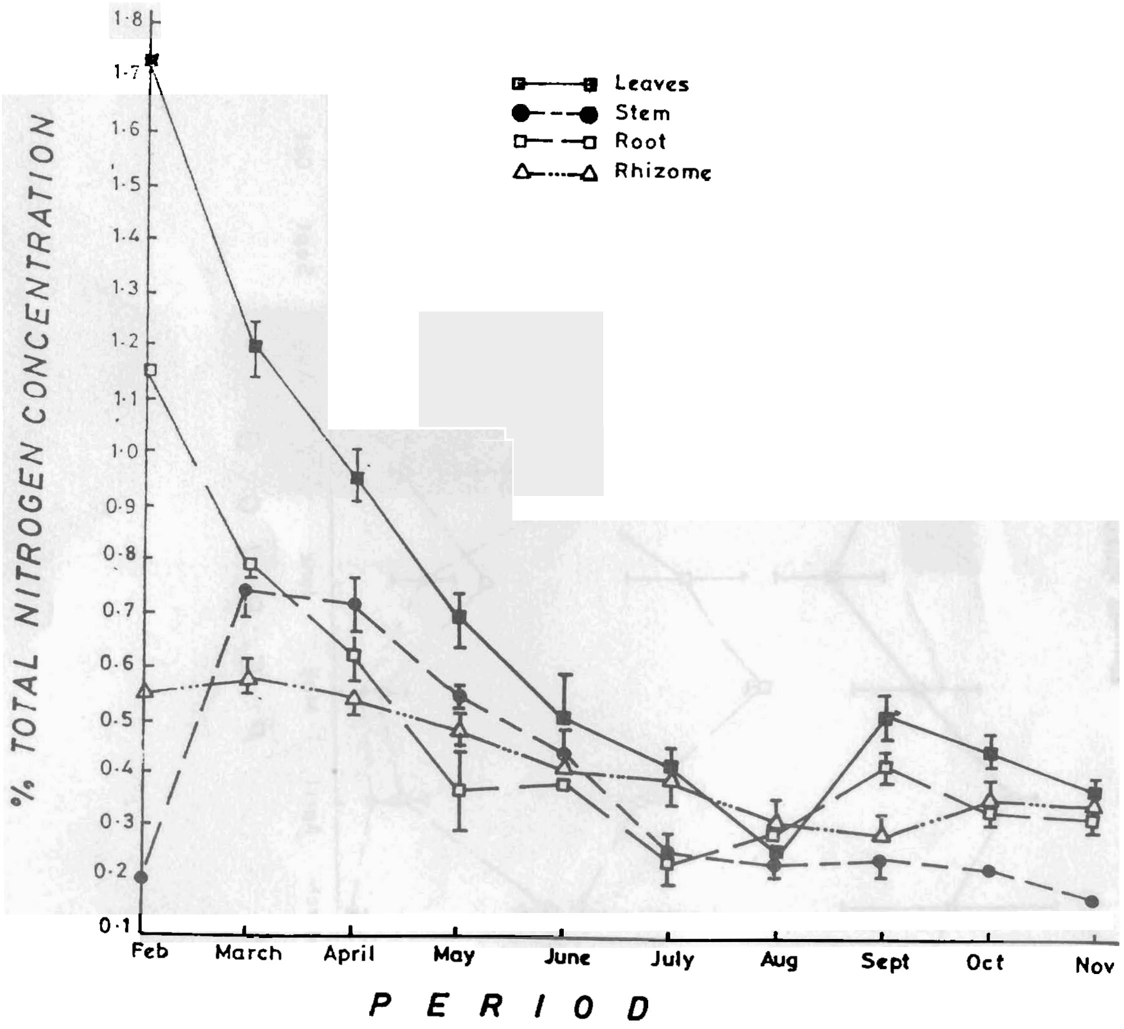


Fig. 3a: Mean monthly percentage total nitrogen concentration in leaves, stems, roots and rhizome of *Andropogon tectorum* grown under nutrient regime over one growing season.

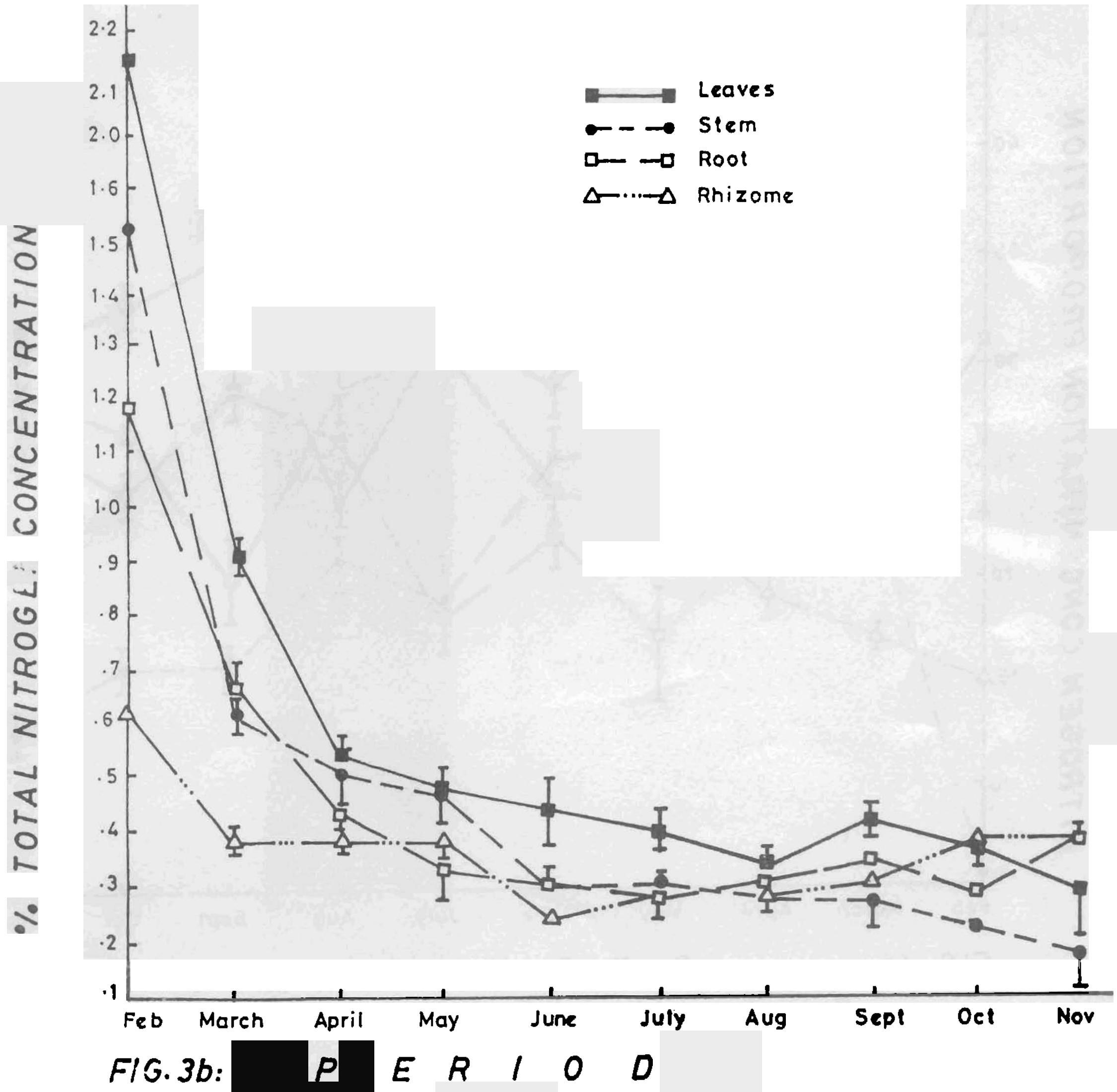


Fig. 3b: Mean monthly percentage total nitrogen concentration in leaves, stems, roots and rhizomes of *Andropogon tectorum* grown under water regime over one growing season.

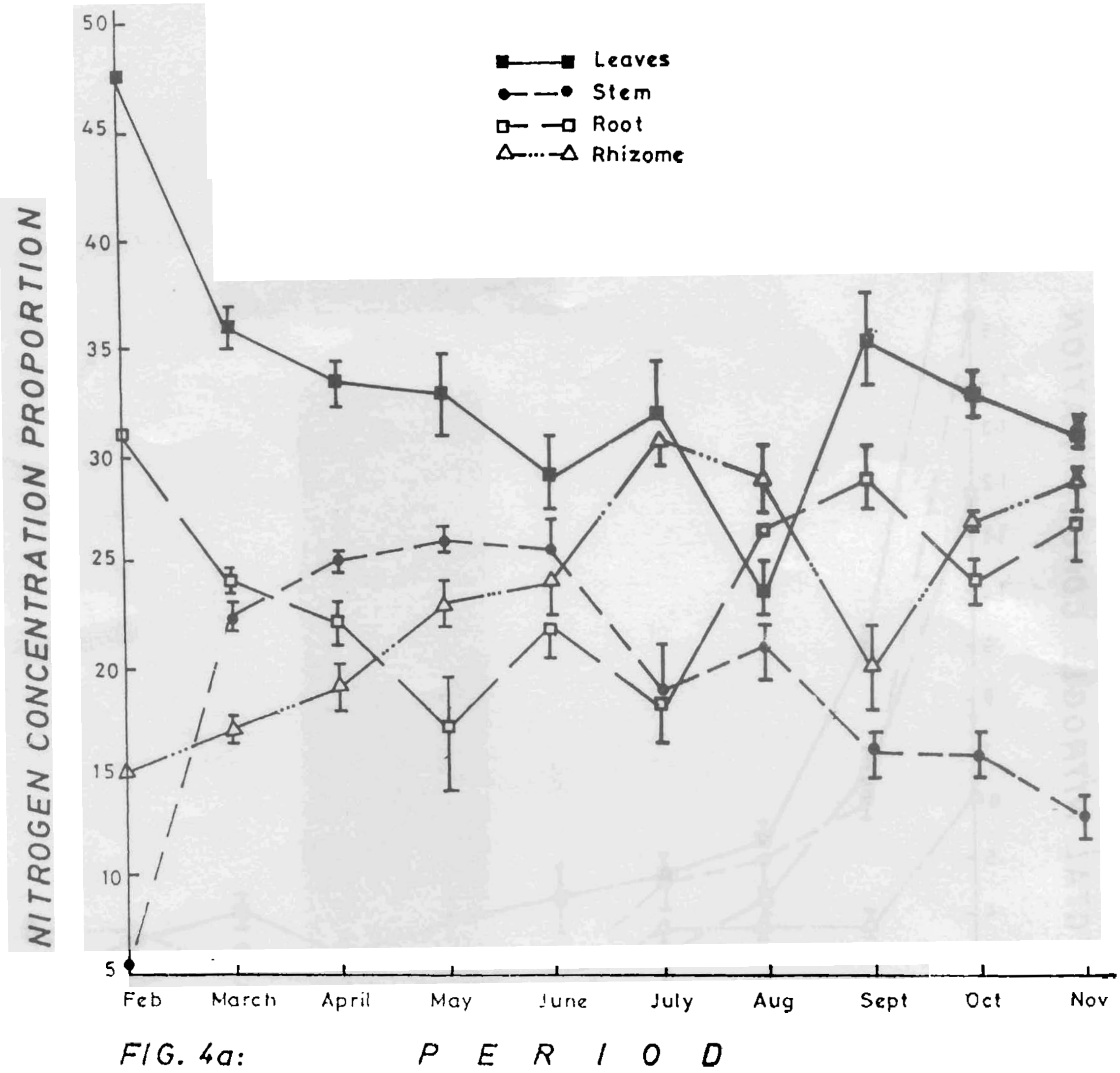


Fig. 4a: Percentage allocation of total nitrogen in *Andropogon tectorum* grown under nutrient regime to various plant parts at various stages of growth.

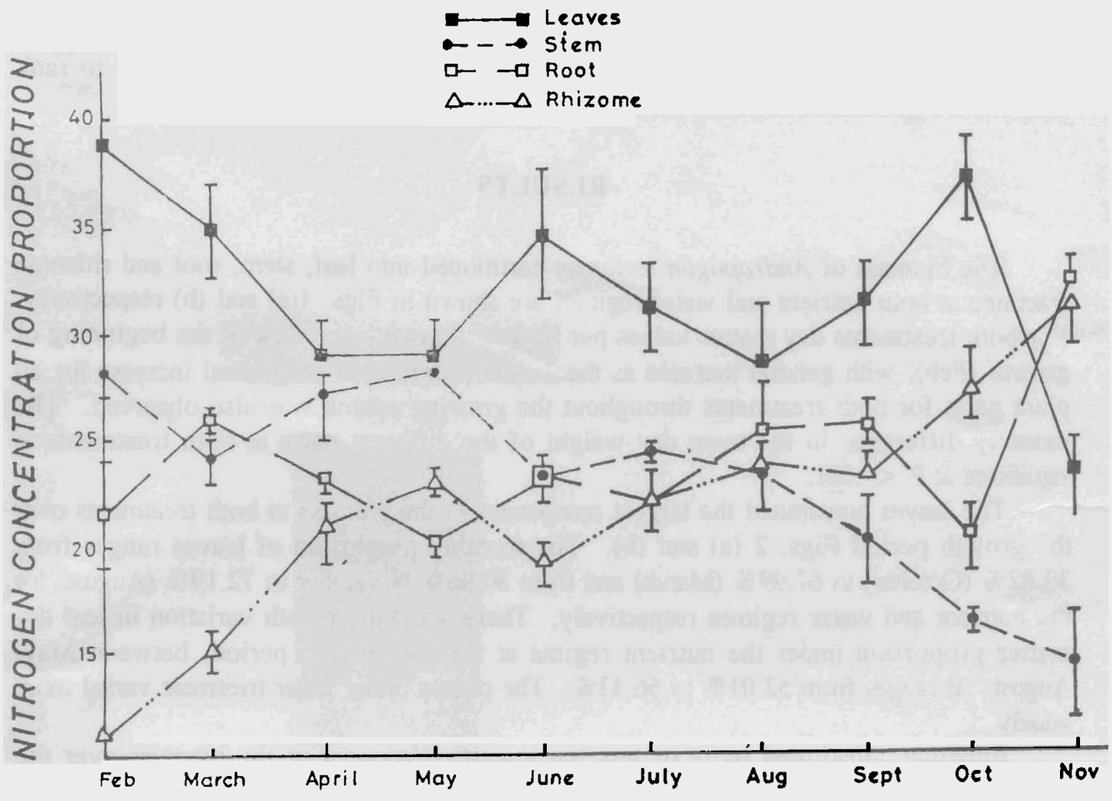


FIG. 4b:

Fig. 4b: Percentage allocation of total nitrogen in *Andropogon tectorum* grown under water regime to various plant parts at various stages of growth.

Analysis for total nitrogen was carried out by Kjeldahl method as described by Tel and Rao (1982).

Analysis of variance was to test significant differences in data and where necessary the student-Newman Keuls a posteriori test (Kokal and Rohlf 1969), was used to rank data when significant difference existed.

RESULTS

The biomass of *Andropogon tectorum* partitioned into leaf, stem, root and rhizome fractions at both nutrient and water regimes are shown in Figs. 1(a) and (b) respectively. For both treatments dry matter values per bucket in grams were low at the beginning of growth (Feb), with general increase as the season progressed. A general increase for all plant parts for both treatments throughout the growing season was also observed. The monthly difference in the oven dry weight of the different parts at both treatments is significant at $P < .001$.

The leaves constituted the largest component of the biomass at both treatments over the growth period Figs. 2 (a) and (b). The monthly proportion of leaves ranges from 39.82% (October) to 67.99% (March) and from 30.96% November to 72.19% (August) for the nutrient and water regimes respectively. There was little month variation in leaf dry matter proportion under the nutrient regime at the mid-growth period, between May-August. It ranges from 52.01% to 56.33%. The pattern under water treatment varied more widely.

Rhizome constituted more or less the lowest component of the biomass over the entire growth period; except at the early stage (February-April). This was not unexpected, since the rhizome was the means of propagation used, and before the subsequent flush of new shoot emerged, the rhizome is expected to have the largest dry matter proportion. The lowest dry matter proportion constituted by rhizomes was more prononuced at the mid-growth period (May-September). The monthly dry matter proportion contributed by the rhizomes under nutrient regime ranges from 2.99% in May to 37.37% in February while under water regime it range gram 3.72% (May) to 23.61% (February) Figs 2(a) and (b). This is also not unexpected because rhizomes serve as a feeder to other parts of the plants.

The monthly allocation of day matter to stem and root were intermidiate between leaves and rhizomes under both nutrient and water treatments. Root proportion was more than that of the stem under both treatments Figs. 2(a) and (b).

Regarding the rate of dry matter accumulation, it was observed in both treatments that the highest rate of dry matter accumulation was in the leaves, and the lowest in rhizomes, while that of the stem and root were intermediate

The proportion of dry matter allocated to the roots ranges from 13.83% in February to 42.81% in May and 15.03% in February to 42.64% in May, in nutrient and water regimes respectively, while proportion allocated to the stem range from 2.37% in February to 26.17% in September and 2.30% in March to 37.61% in August in nutrient and water regimes respectively.

NITROGEN ALLOCATION

Percentage total nitrogen in leaf, stem, root and rhizome generally declines from the begining of growth in February to maturity in November [Figs 3 (a) and (b)]. The monthly difference in the total nitrogen concentration of the different parts at both treatments were significant at $P<.001$.

The total nitrogen concentration of leaves of both treatments was constantly higher than those of other parts throughout the study period except in the month of November under the nutrient regime and in the month of August under water regime where it ranked third. The other parts cannot be generally ranked because they did not show a definite constant pattern throughout the study period [Figs. 3(a) and (b)].

The nitrogen analyses on leaves show that the proportion constituted by the leaves ranges from 31.17% (November) to 47.8% (February) and 23.42% (November) to 39.31% (February) in nutrient and water regime respectively. These results indicate that at the beginning of the growth the percentage total nitrogen concentration proportion of the leaves was high at both nutrient and water treatments and low at the mature stage (Figs. 4 (a) and (b).

In contrast to what was observed in leaves the total nitrogen percentage proportion of rhizome at both treatments was low at the beginning but continued to rise until maturity. The proportion of nitrogen in the rhizomes ranges 15.5% in February (early growth) to 28.82% in November (maturity) and 11.29% (February) to 30.88% (November) in nutrient and water treatments respectively [Figs. 4 (a) and (b)].

The stem's percentage total nitrogen concentration allocation fluctuated from the begining (early growth) the stem's proportions was higher than that of the root while the root's proportion was higher than that of the steam towards maturity. The proportion allocated to stem ranges from 5% (February) in the nutrient and water regimes irrespectively. Similarly the nitrogen proportion contained in the root ranges from 17.43% (May) to 31.81%(February) and 20.29%(October) to 31.64% (November) in nutrient and water regime respectively. These differences in the proportions constituted by the different parts monthly at both nutrient and water treatments were significant at $P<.001$.

At maturity a notable general trend in percentage total Nitrogen allocation to different parts of the plants is that below-ground parts (roots and rhizomes) proportion is higher than those of aerial/above ground parts (leaves and stems) at both treatments.

Another observation in the results is that whether the grass was given only water or low level of nitrogen (35ppm), plant parts, that is the leaves, stems, roots and rhizomes, development in terms of physical size and nutrient accumulation follows the same trend/pattern.

DISCUSSION

A plant's size directly reflects the conditions under which it is growing and plant growth analysis summarizes the overall performance of a sets of plants growing under a particular set of condition. Yield component analysis partitions total yield into a series of multiplicate factors like roots, rhizomes, stems and leaves, (Waler, 1986). *Andropgon tectorum* invested the largest component of thier biomass in the leaves throughout the growth period and the lowest component in the rhizomes while the stem and the root dry matter proportions were intermediate between leaves and rhizomes. This pattern was not unexpected since the rhizome was the means of propagation used, and serve as feeder to other parts of the plants. The greater allocation of resources to leaf is in agreement with other workers observations that in herbs or annual plants there is greater allocation of resources to leaf development (Bray, 1963). This greater than aveerage allocation of dry matter to leaf was consistent in monthly samplings throughout the growing season.

Furthermore, the consistently low allocation to the rhizome may indicate that a low investment in the rhizome of total biomass represents the minimum necessary for growth. The roots: rhizome ratio in relation to biomass was consistently increasing as the season progresses and this is an indication of ability of the rhizomes to successfully support the root which will latter translocate materials to above-ground to enhance good shoot production. This is in agreement with the observation of Thornley (1975) that root: rhizome ratio increases with age in herbaceous plants. Plummer (1943) has also showed with range grasses that the rapid elongation of the seedling root is important off successful establishment of annual pastual species.

The observed progressive decline in nitrogen concentration with season is in agreement with studies of Russell *et al.* (1954) on *Bromus inermis* Leyss, Flemming and Murphy (1968) who used mixed sward, Opakunle (1978) on *Andropogon gayanus* and *Schizachyrium sanguineum* and Isichei (1983) who worked on major grasses of the Derived and Guinea savanna zones of Nigeria. The large difference in nitrogen concentration between early growth and late growth (at maturity) is attributed to the preponderance of carbohyderate—rich mature tissue as opposed to protein—rich young tissues with high amount of cytoplasmic components.

Several workers have also reported that there is translocation of nitrogen from the above-ground to the below-ground parts of grasses (Isichie 1983) so the observed lower levels of nitrogen at maturity in the two treatment regimes used for this study is not unexpected.

The ability of this plant to accumulate considerable nitrogen in the below-ground parts (roots and rhizome) and decrease the level in its aboveground parts as the season progresses enables it to use the nitrogen conserved below-ground for new growth in the field after the first rains. The continously increasing allocation in nitrogen to rhizomes was consistent in monthly samplings throughout the growing season. This ability of rhizome to accumulate more nitrogen is also a strong indication of translocation of reserves away from old rhizomes to new ones to support the first flush of new roots and shoots (Harris and Davy 1986). The ability of these rhizomes to remain alive underground during the dry season and burning has contributed to *Andropogon tectroum* success in a abitat that experiences prolonged drought and annual burning. The basal meristem of the rhizome enables *A. tectorum* to withstand grazing.

REFERENCES

Berg, A.R. (1972). Grass reproduction. *The Biology of utilization of Grasses: (Ed by V.B. Younger and C. M. Kell. Page 334-337.* Academic Press London.

Bray, J. R. (1963). Root production and the estimation of net productivity. *Canadian Journal of Botany* 41: 65-72

Fleming, G.A. and Murphy, W.E. (1968). The uptake of some major and trace elements by grasses as affected by season and stage of maturity. *Journal of British Grassland Society 23 (2) 174-185.*

Harris, D. and Davy, A.J. (1986): Regenerative Potential of *Elymus farctus* from rhizome fragments and seed. *Journal of Ecology, 74: 1057-1067.*

Helslop-Harrison, J. (1982). The reproductive versatility of flowering plants: an over-view. *In: strategies of plant Reproduction (Ed. W.J. Mendt) pp 3-18.* Allenheld. Osmum Publishing, London.

Hewit, E.J. (1952). Sand and water culture methods used in the study of plant nutrition. *Commonwealth Bureau Horticulture Plantation Crops (Great Britain).* Technical Commonwealth 22.

Isichei, A.O. (1983). Nitrogen concentration in the major grasses of the Derived and Guinea savanna zones of Nigeria in relation to season and site. *Tropical Agriculture (Trinidad) 60: 48-52.*

Nicholson, I. A. (1952). A study of *Agropyron junceum* in relation to the stabilization coastal sand and the development of sand-dunes *M.Sc. Thesis* University of *Durham.*

Opakunle, J.S. (1978). Nitrogen partitioning in relation to season and nitrogen content of the growth medium in two Nigerian occurring grasses *Andropogon gayanus* (Kunth) and *Schcizachyrium sanguineum* (Retz.) Alstom *Unpublished M.sc. Thesis. University of* Ife, *Nigeria.*

Pate, J.S. (1968). Physiological aspects of inorganic and intermediate nitrogen metabolism (with special reference to the legume, *Pisum arvense* L.). *In Recent Aspects of Nitrogen Metabolism in plants* pp 219-40. Academic press.

Plummer, A.P. (1943). The germination and early seedling development of twelve range grasses. *Journal of the American Society of Agronomy 35, 19-43.*

Puttens Vander W.H. (1990). Establishment of *Ammophila aenaria* (Marram grass) from culms, seeds and rhizomes. *Journal of Applied Ecology 27: 188-199.*

Ranwel, D.S (1972). *The Eccology of Salt Marshes and sand Dunes.* Chapman and Hall London.

Russel, J.S., Bourg, C.W. and Rhoades H.F. (1954). Effect of N-fertilisation on the Nitrogen, P, and cation contents of Bromegrass. *Soil Science Society American Proceeding. 18:292-296.*

Sokal, R.F. and Rohl, F.J. (1969). *Biometry. W.H. Freeman and Co. San, Francisco.*

Tel, A.O. and Rao, P.V. (1982). *Automated and semi-automated Methods for Soil and Plant Analysis.* Manual series No.7. International Institute for Tropical Agriculture, Ibadan.

Thornley, J.H.M. (1975). Comment on a recent paper by Hunt on shoot root ratio. *Ibid 39,1149-50.*

Waller, D.M. (1986). The Dynamic of Growth farm. *In Plant Ecology (Ed. M.J. Crawley) Blackwell. Scientific publications.* Oxford. London

Wareing, P.F. (964). The developmental physiology of rhizomatous and creeping plants. *Proceeding of the 7th British Weed control conference* British Crop protection council Croydon

Wilman, D., Ojuederie, B.M. and Asore, E. (1976). Nitrogen and Italian ryegrass:3: Growth up to 14th weeks; Yield, proportions, digestibilities and nitrogen contents of crop fractions, and tillers population. *J.Brit. Grassland. Sec.* 31:73-78.