# Proximate and Fiber Composition of Different Parts of *Tephrosia bracteolate* as Affected by Phosphorus Application Rate and Sowing Date

**Oluwafemi Okukenu, Ph.D*; Peter Dele, Ph.D.; Bolanle Akinyemi, Ph.D.; Abiola Olajide, Ph.D. (in-view); Olufemi Onifade, Ph.D.; Oluwatoyin Ogunrombi, M.Agric.; Aanuoluwapo Adekale, M.Agric.; and Michael Kolade, M.Agric.**

Department of Pasture and Range Management, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria.

E-mail: femi_okukenu@yahoo.co.uk

**ABSTRACT**

This study was carried out to evaluate the effect of phosphorus application rate and sowing date on proximate composition of different parts of *Tephrosia bracteolata*. The experiment was a laid out in a 3 × 4 × 3 factorial arrangement comprising three (3) sowing dates (May, June, and July), four (4) phosphorus rates (0. 15, 30, and 60kgP/ha), and three (3) plant parts (leaf, stem and whole) in a split plot design with three replicates.

Results showed there was a significant ($p < 0.05$) difference on the proximate composition of *T. bracteolata* as affected by sowing date. *T. bracteolata* sown in May had the highest value (96.69%) for DM and *T. bracteolata* sown in June recorded the highest value (14.45%) for CP with the least value of 6.75% for EE observed in *T. bracteolata* sown in May.

The effect of application rate on the proximate composition of *T. bracteolata* was significant ($p<0.05$) except for DM, EE, and ash contents. *T. bracteolata* fertilized with 60kgP/ha recorded the highest value (16.60%) for CP with the lowest value (11.89%) in unfertilized *T. bracteolate*. Results also shows there was a significant ($p<0.05$) difference on the proximate composition of different part of *T. bracteolate*. The stem part of *T. bracteolata* recorded the highest value (96.92%) DM with the lowest value (94.50%) observed in the leaf part of *T. bracteolata* while the leaf part of *T. bracteolata* had the highest (15.65%) CP content and the lowest value (13.07%) recorded in the stem. Whereas, the stem part of *T. bracteolata* the highest content (7.72 and 9.75%) for EE and Ash and the lowest content (6.42 and 6.69%) was observed in the whole part of *T. bracteolata* while the highest (17.71%) NFC content was also recorded in the whole part.

Neutral detergent fiber (NDF), acid detergent fiber (ADF) and cellulose contents were highest (55.56, 35.11, and 25.00%, respectively) in *T. bracteolata* sown in June. *T. bracteolata* sown with 30kgP/ha application rate recorded the highest (55.63%) NDF content while *T. bracteolata* sown with the application rate of 15 and 30kgP/kg had the highest value (10.30%) of ADL content.

The results also showed that the NDF, ADF, ADL and cellulose contents of the *T. bracteolata* were highest (56.78, 36.11, 10.83, and 25.27%, respectively) in stem part of harvested *T. bracteolata*. It was therefore concluded that seeds of T. bracteolata sown in July had relatively low NDF and ADF contents, 15kgP/ha application rate on *T. bracteolata* recorded least NDF and ADF contents and the leaf part of harvested *T. bracteolata* recorded the least fiber fractions and also, phosphorus fertilizer can improve $N_2$ fixation, growth and quality of forage legumes which is recommended as feed for ruminant animals.

(Keywords: *Tephrosia bracteolata*; phosphorus fertilizer; application rate; plant parts)

## INTRODUCTION

The practice of growing legumes has always been a part of crop rotations dating back to ancient times (John *et al*., 2010). Legumes play an important role in sustainable farming because of its ability to increase soil fertility (Mugendi *et al.*, 2011). Legumes have a mutual symbiotic relationship with some bacteria in the soil that can improve levels of nitrogen fixation (Jim, 2015).

Legumes are nodulated plants that play an important role in nitrogen fixation (Schulze, 2004). Nitrogen fixation is a process of changing atmospheric nitrogen to ammonia or other molecules needed by living organisms (Badri *et al*., 2009). Nitrogen fixation is an important process for agriculture and for the manufacturing of fertilizers (Jim, 2015).

In legumes, atmospheric nitrogen ($N_2$) fixation happens in the nodules (Broughton *et al.*, 2003) and nodules grow in the roots that are produced by $N_2$-fixing rhizobial bacteria (Broughton *et al*., 2003). Most of these bacteria belong to the genera of *Bradyrhizobium*, *Mesorhizobium*, *Rhizobium*, and *Sinorhizobium* (Fauvart *et al*., 2008). While nitrogen fixation is a sustainable way of producing nitrogen (N) which is important in making chemical fertilizers, several factors cause some limitations (Andres *et al*., 2012). Some biotic and abiotic factors affect the mutual interaction between legumes and their micro-symbiont partner (Andres *et al.,* 2012; Lira, *et al*., 2005).

Legume productions are negatively impacted by several factors such as drought (Andres *et al*., 2012), low pH levels (Lin *et al.*, 2012), salinity (Abd-Alla *et al*., 2013), heavy metals (Schue *et al*., 2011), extreme temperatures, and low nutrient availability In the soil where legumes are grown (Wei *et al*., 2010). This also proves how climate change is gravely affecting legume production and decrease in the availability of phosphorus in soil also has an impact in legume production (Doi Sulieman and Tran, 2015). The mini-review focuses on the various researches that have looked into this situation and conducted tests to prove the relationship between phosphorus availability and legume growth and production.

Phosphorus (P) plays a vital role in the growth and development of plants and It is needed in the molecular structure of plants and it facilitates transformation of energy and regulation of several enzymatic activities as well (Schulze *et al*., 2006). Some molecules that contain phosphorus are nucleic acids, proteins, lipids, sugars and adenylate (Zhang *et al*., 2014). In adenylates, phosphorus is the main component required for most of the functions of plant cells (Zhang *et al*., 2014). Phosphorus is also essential in most metabolic processes that happen above the ground. These processes include: energy generation, nucleic acid synthesis, photosynthesis, respiration, glycolysis, membrane synthesis and integrity, enzymatic activation or inactivation, redox reactions, signaling and carbohydrate metabolism (Vance *et al*., 2003). Therefore, inadequate phosphorus in soil gravely affects the growth and development of plants. For instance, lack of phosphorus affects a leaf's development and ability to carry out photosynthesis therefore causing the plant not to produce sufficient food to support optimal growth (Doi Sulieman and Tran, 2015).

## MATERIALS AND METHODS

The field experiment was carried out at the Teaching and Research Farm unit of the Directorate of University Farms (DUFARMS), while the laboratory analysis was carried out at the laboratory of the Department of Pasture and Range Management, Federal University of Agriculture, Abeokuta (FUNAAB), Ogun State, Nigeria. The land was cleared, followed by ploughing after which the land was allowed to rest for a period of two weeks before harrowing. The experimental land measuring 1,470 $m^2$ were mapped out after harrowing. After land preparation and before planting, soil samples were randomly collected from the plots at the depth of 0-15 cm using soil auger to represent the topsoil. The samples were bulked per replicate, mixed thoroughly and sub-samples were taken for analysis to determine the pre-planting nutrient status of the soil.

Seeds of *Tephrosia bracteolata* were sourced around the vicinity of Federal University of Agriculture, Abeokuta, in the year 2016. A day before planting, the legume seeds were scarified, using hot water method. The seeds were placed in a cloth bag and immersed in the hot water ($80^0C$) for 3 minutes. The seeds were thereafter be air-dried before sowing. The seeds were sown by drilling method and which was achieved by sowing the seed along each row within the plots at spacing of 75 cm apart at a seed rate of 7 kg/ha.

Single Super Phosphate (SSP) fertilizer was used as the desired phosphorus sources in this study. The fertilizer was source from a reputable agrochemical store in Abeokuta, Ogun State. The rate of application for fertilizer were 0 (i.e., control), 15, 30 and 60kg P/ha.

The study was laid out in a 3 × 4 × 3 factorial arrangement comprising three (3) sowing dates (May, June and July), four (4) phosphorus rates (0. 15, 30 and 60kgP/ha) and three (3) plant parts (leaf, stem and whole) in a split plot design with three replicates. The inter-plot spaces were weeded as at when due throughout the experimental period by hoe. Forages were harvested at 8 weeks after planting by using a $1m^2$ quadrat which was thrown three times. Sub samples were taken, weighed and oven–dried at 65 $^0$C to constant weight and stored for analysis.

Proximate composition (contents of dry matter, crude protein, ether extract and ash) were determined according to AOAC (2000) while non-fiber carbohydrate was calculated as NFC = 100 - (CP + Ash + EE + NDF). Fiber fraction (Neutral detergent fiber (NDF), Acid Detergent Fiber (ADF) and Acid Detergent Lignin (ADL) were determined with the procedure of Van Soest *et al*, (1991). Cellulose content was taken as the difference between ADF and ADL while hemicellulose content was calculated as the difference between NDF and ADF. Data collected were subjected to Two-way analysis of variance and the treatment means were separated using Duncan's Multiple Range Test using SAS (1999) package.

## RESULTS

There was a significant ($p< 0.05$) difference on the proximate composition of *T. bracteolata* as affected by sowing date except for ash and NFC. *T. bracteolata* sown in may had the highest value (96.69%). for DM and *T. bracteolata* sown in June recorded the highest value (14.45%) for CP and *T. bracteolata* sown in May recorded the lowest value (6.75%) for EE. The effect of application rate on the proximate composition of *T. bracteolata* was significant ($p<0.05$) except for DM, EE and Ash contents. *T. bracteolata* fertilized with 60kgP/ha recorded the highest value (16.60%) for CP with the lowest value (11.89%) in unfertilized *T. bracteolata* and unfertilized *T. bracteolata* had the highest value of 17.80% for NFC. Also there was a significant ($p<0.05$) difference on the proximate composition of different part of *T. bracteolate*. The stem part of *T. bracteolata* recorded the highest value (96.92%) for DM with the lowest value (94.50%) observed in the leaf part of *T. bracteolata* while the leaf part of *T. bracteolata* had the highest (15.65%) CP content and the lowest value (13.07%) recorded in the stem. Whereas, the stem part of *T. bracteolata* the highest content (7.72 and 9.75%) for EE and Ash and the lowest content (6.42 and 6.69%) was observed in the whole part of *T. bracteolata* while the highest (17.71%) NFC content was also recorded in the whole part (Table 1).

The effect of sowing date and P application rates on fiber composition of different parts of *T. bracteolata* was significantly ($p<0.05$) different. There was a significant ($p<0.05$) difference on fiber composition of *T. bracteolata* as affected by sowing date except for Acid detergent lignin (ADL) and Hemicellulose. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and cellulose contents were highest (55.56, 35.11 and 25.00% respectively) in *T. bracteolata* sown in June and least value (54.50, 33.61 and 23.56%) recorded in *T. bracteolata* sown in July. The effect of P application rates on fiber composition of *T. bracteolata* was significant ($p<0.05$) except for ADF and hemicellulose. *T. bracteolata* sown with 30kgP/ha application rate recorded the highest (55.63%) NDF value with least value (54.37%) observed with the application rate of 15kgP/ha while *T. bracteolate* sown with the application rate of 15 and 30kgP/kg had the highest value (10.30%) of ADL content and lowest (9.41%) was recorded when 60kgP/ha application rate was used. However, the cellulose content of *T. bracteolate* was highest (25.04%) when 60kgP/ha rate of application was used and least value (23.11%) was observed when 15kgP/ha rate of application was used (Table 2).

Also, there was a significant ($p<0.05$) difference on the fiber composition of different parts of harvested *T. bracteolata* except hemicellulose. The NDF, ADF, ADL and cellulose contents of the *T. bracteolata* were highest (56.78, 36.11, 10.83 and 25.27% respectively) in stem part of harvested *T. bracteolate* and lowest values (53.22, 32.89 and 22.72) was recorded in leaf parts of harvested plant while the leaf and whole parts had the least value (9.67%) of ADL (Table 2).

**Table 1:** Effect of Sowing Date and Application Rate on the Proximate Composition (%) of Different Parts of *Tephrosia bracteolata.*

| Factors | DM | CP | EE | Ash | NFC |
|---|---|---|---|---|---|
| **Sowing Date** | | | | | |
| May | 96.69$^{a}$ | 14.18$^{b}$ | 6.75$^{b}$ | 8.25 | 15.82 |
| June | 95.28$^{b}$ | 14.45$^{a}$ | 6.92$^{ab}$ | 7.89 | 15.19 |
| July | 95.58$^{b}$ | 14.21$^{b}$ | 7.31$^{a}$ | 8.06 | 15.93 |
| SEM | 0.34 | 0.36 | 0.21 | 0.28 | 0.73 |
| **Application Rate (kgP/ha)** | | | | | |
| 0 | 95.59 | 11.89$^{d}$ | 6.96 | 8.15 | 17.82$^{a}$ |
| 15 | 95.96 | 13.78$^{c}$ | 7.19 | 7.96 | 16.70$^{a}$ |
| 30 | 95.56 | 14.85$^{b}$ | 6.82 | 8.04 | 14.67$^{b}$ |
| 60 | 96.30 | 16.60$^{a}$ | 7.00 | 8.11 | 13.40$^{b}$ |
| SEM | 0.41 | 0.23 | 0.24 | 0.33 | 0.80 |
| **Parts** | | | | | |
| Leaf | 94.50$^{c}$ | 15.65$^{a}$ | 6.83$^{b}$ | 7.75$^{b}$ | 16.55$^{a}$ |
| Stem | 96.92$^{a}$ | 13.07$^{c}$ | 7.72$^{a}$ | 9.75$^{a}$ | 12.68$^{b}$ |
| Whole | 96.14$^{b}$ | 14.12$^{b}$ | 6.42$^{b}$ | 6.69$^{c}$ | 17.71$^{a}$ |
| SEM | 0.31 | 0.30 | 0.19 | 0.19 | 0.65 |

$^{a, b, c}$ :Means in same column with different superscripts are significantly ($p<0.05$) different.

SEM = Standard Error of Mean
DM = Dry matter
CP = Crude protein
EE = Ether extract
NFC = Non fibre carbohydrate

**Table 2:** Effect of Sowing Date and Application Rate on the Fiber Composition (%) of Different Parts of *Tephrosia bracteolata.*

| Factors | NDF | ADF | ADL | HEM | CELL |
|---|---|---|---|---|---|
| **Sowing Months** | | | | | |
| May | 55.50$^{ab}$ | 33.89$^{b}$ | 10.00 | 21.11 | 23.89$^{b}$ |
| June | 55.56$^{a}$ | 35.11$^{a}$ | 10.11 | 20.44 | 25.00$^{a}$ |
| July | 54.50$^{b}$ | 33.61$^{b}$ | 10.06 | 20.89 | 23.56$^{b}$ |
| S E M | 0.52 | 0.45 | 0.26 | 0.52 | 0.45 |
| **P Application Rates (kgP/ha)** | | | | | |
| 0 | 55.19$^{ab}$ | 34.44 | 10.22$^{a}$ | 20.74 | 24.22$^{ab}$ |
| 15 | 54.37$^{b}$ | 33.41 | 10.30$^{a}$ | 20.96 | 23.11$^{b}$ |
| 30 | 55.63$^{a}$ | 34.52 | 10.30$^{a}$ | 21.11 | 24.22$^{ab}$ |
| 60 | 54.89$^{ab}$ | 34.44 | 9.41$^{b}$ | 20.44 | 25.04$^{a}$ |
| S E M | 0.61 | 0.45 | 0.29 | 0.60 | 0.52 |
| **Plant Parts** | | | | | |
| Leaf | 53.22$^{c}$ | 32.89$^{c}$ | 9.67$^{b}$ | 20.83 | 22.72$^{b}$ |
| Stem | 56.78$^{a}$ | 36.11$^{a}$ | 10.83$^{a}$ | 20.67 | 25.77$^{a}$ |
| Whole | 55.06$^{b}$ | 34.11$^{b}$ | 9.67$^{b}$ | 20.94 | 24.44$^{a}$ |
| S E M | 0.48 | 0.38 | 0.24 | 0.50 | 0.43 |

$^{a, b, c}$ :Means in same column for each factor with different superscripts are significantly ($p<0.05$) different.

SEM = Standard Error of Mean
NDF = Neutral Detergent Fibre
ADF = Acid Detergent Fibre
ADL = Acid Detergent Lignin
HEM = Hemicellulose
CELL = Cellulose

## DISCUSSION

The most effective and practical method to increase forage production is adequate fertilization. The result for NDF content in this present study was supported by the report of Karachi (1997) who reported lower NDF contents of legumes than grass at the same stage of growth. Increasing dietary NDF concentration most often has a negative impact on the amount of DM consumed by animals (Allen, 2000). However, legume fibers ferment more rapidly in the rumen which is a reason for ruminants to consume larger amounts of legumes than grasses (Hinders, 1995).

The soil fertility treatments resulted in reduced fiber contents of the forage. Decrease in NDF, ADF and ADL contents of *T. bracteolata* might be due to the soil treatment which contributed to the concomitant improvement in the rumen soluble plant cell constituents. The results of previous studies on the effect of fertilization on fiber contents are not consistent while some studies reported a positive effect (Daşçı, 2008), others reported negative or no effect (Daşçı, 2008).

The values recorded in this present study from all factors were higher than that reported by Yetimwork *et al*. (2011). Singh and Oosting (1992) pointed out that roughage feeds containing NDF values of less than 45% to be classified as high, those with values ranging from 45 to 65% as medium and those with values higher than 65% as low quality. Thus, taking into consideration the criteria of Singh and Oasting (1992) based NDF composition, *T. bracteolata* grown using soil fertility treatments can be classified as medium quality roughages.

The NDF content of the current study fell within the mentioned range signifying the good nutritional value of the forage in the present study which the findings of Albayrak *et al*. (2009), Turk *et al*. (2007) and Bell *et al.* (2001) who reported that P is the most important fertilizer nutrient required for the growing of forage legumes. ADF is the percentage of highly indigestible and slowly digestible material in a feed or forage. Lower ADF indicates more digestible and desirable forage. It is a highly determinant factor for the digestibility of forage and intake of the animals. Kellems and Church (1998) indicated that roughage with less than 40% ADF is categorized as high quality and those with greater than 40% as poor quality. The ADF content of the present study fell within the range (28.30 – 37.02) reported by Turk *et al.* (2011) when the rates of 0 – 120kgP/ha were used which make it a digestible and desirable forage as reported by Kellems and Church (1998). Lignin is a component that gives strength and resistance to plant tissue thereby linking the ability of rumen microorganisms to digest the cell wall polysaccharides, cellulose and hemicellulose (Reed *et al*., 1988). Generally, the presence of insoluble fiber, particularly lignin, lowers the overall digestibility of the feed and limits nutrient availability (Mustafa *et al*., 2000). The ADL content of the present study is similar to that reported by Negash *et al*. (2017) and lower (10.62) than that reported by Sisay (2012). The variation in the fibre contents of different parts of harvested *T. bracteolata* are related to the leaf to stem ratio of the plant whereby, leaves are lesser in fiber contents than stems (Tan *et al*., 1997). The fiber contents of the forage plant decreases with increase in the proportion of leaves and increases with the increase in the proportion of stem.

According to Singh and Oosting (1992) roughage diets with NDF of 45-75% and below 45% are generally considered to be medium to high quality feeds, respectively. The current results in NDF content are within the mentioned range signifying the good nutritional value of the forages of the current study. The differences observed in the dry matter contents in this presents study might be attributed to the differences in soil related factors, climate, plant parts and probably the physiological stage of the plant at harvest as reported by Mason *et al.* (1991). The CP content of *T. bracteolata* in this study was above the minimum level of 7.5% required for optimum rumen function (Van Soest, 1982). A review by Adugna and Said (1994) indicated that CP value less than 7.5% inhibits intake, digestibility and proper utilization of feeds. In addition, the CP content of the forage species under most of the treatments in this study could also satisfy the requirement for lactation and growth. Norton (1981) reported that a minimum of 15% CP is required for lactation and growth. The value for ash in this study was in line with the report of Jennings (2004) that herbaceous forage legumes have higher content of some minerals like calcium, sulfur and possibly phosphorus than grasses, and well nodulated legumes contain large amounts of calcium, magnesium and other essential elements. Concentration of minerals in forage varies due to factors like plant developmental stage, morphological fractions, climatic conditions, soil characteristics and fertilization regime (Jukenvicius and Sabiene, 2007).

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## ABOUT THE AUTHORS

**Dr. Oluwafemi Okukenu,** is a Registered Animal Scientist (RAS) and is a member of the Nigerian Institute of Animal Science. He is a Lecturer in the Department of Pasture and Range Management, Federal University of Agriculture, Abeokuta, Nigeria. He holds a Ph.D. in Pasture Production and Utilization and with keen interest in rural extension with regards to pasture science and forage conservation.

**Dr. Peter Dele,** is a Registered Animal Scientist (RAS) and is a member of the Nigerian Institute of Animal Science. He is a Lecturer in the Department of Pasture and Range Management, Federal University of Agriculture, Abeokuta, Nigeria. He holds a Ph.D. in Pasture Production and Utilization and with keen interest in forage conservation.

**Dr. Bolanle Akinyemi,** is a Registered Animal Scientist (RAS) and is a member of the Nigerian Institute of Animal Science. She is a Lecturer in the Department of Pasture and Range Management, Federal University of Agriculture, Abeokuta, Nigeria. She holds a Ph.D. in Pasture Production and Utilization and with keen interest in forage conservation.

**Abiola Olajide,** is a Research Demonstrator in the Department of Pasture and Range Management, Federal University of Agriculture, Abeokuta, Nigeria with keen interest in pasture breeding and technology.

**Prof. Olufemi Onifade,** is a Fellow and Registered Animal Scientist (RAS) and is a member of the Nigerian Institute of Animal Science. He is a Lecturer in the Department of Pasture and Range Management, Federal University of Agriculture, Abeokuta, Nigeria. He holds a Ph.D. in Forage Science and Utilization.

**Oluwatoyin Ogunrombi**, is an M.Agric. student in the Department of Pasture and Range Management, Federal University of Agriculture, Abeokuta, Nigeria with keen interest forage science and conservation.

**Aanuoluwapo Adekale**, is an M.Agric. student in the Department of Pasture and Range Management, Federal University of Agriculture, Abeokuta, Nigeria with keen interest forage science and conservation.

**Michael Kolade**, is an M.Agric. student in the Department of Pasture and Range Management, Federal University of Agriculture, Abeokuta, Nigeria with keen interest forage conservation and utilization.

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