EVALUATING THE POTENTIAL OF *TRIDAX PROCUMBENS* FOR LIVESTOCK FEED. 1. MORPHOLOGICAL STAGE OF DEVELOPMENT AND CHEMICAL COMPOSITION

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ABSTRACT

A quantitative method of specifying the morphological stage of development in *Tridax procumbens* was used for evaluating the chemical composition of the plant at specified canopy ages. An eight-stage classification system was defined and assigned numerical values from 1 to 8 in a sequential order of increasing maturity. The mean stage of total herbage (MSW) at a specified age of canopy was calculated as the average of the individual stages present and weighted for the dry weight in each stage. For the individual morphological stages present in a herbage samples, quality components measured by leaf percentage, crude protein (CP), *in vitro* true digestibility (IVTD), progressively decreased with maturity. From the vegetative to the mature seed stage, decreases were from 90% to 26% for the leaf proportion; 28% to 14% for CP; and from 82% to 53% for IVTD. Corresponding increases in fibre composition were from 26% to 59% for the total cell wall or neutral detergent fibre (NDF); 22% to 40% for ligno-cellulose or acid detergent fibre (ADF); and from 2.5% to 9% for lignin. Older canopies reached significantly higher mean stage (MSW) values than younger canopies. Associated with these were lower leaf percentage, CP, and IVTD; higher NDF, ADF, and lignin at higher MSW values. The implications of these findings are fully discussed.

INTRODUCTION

The problem of feed supplies and availability on sustained basis has been the major concern of the livestock industries in Nigeria. This problem has been made more critical by the prevailing high competition existing between man and animals for plant products which form

food for both. The need to minimise high import costs on grain and protein concentrates (F.O.S., 1976; World Bank, 1984) while still sustaining the livestock industry in Nigeria led to research explorations on alternative sources from locally available high quality feedstuffs (Njike *et al.* 1974, 1975; Njike, 1979, 1980; Tewe *et al.*, 1979). Little attention has been given to assessing the nutritive quality of the different weed species that grow in association with field crops (Adu *et al.*, 1977; Obioha and Ndukwe, 1976; Saleem *et al.*, 1979; Olubajo, 1977). A typical example of such weeds is *Tridax procumbens*, a common tropical weed which is well adapted to a wide range of environmental conditions.

The nutritive quality of any herbage could be fairly assessed from its chemical composition. These are dependent on the stage of maturity of the herbage at the time of harvest (Van Soest, 1973, 1982; Smith, 1972; Kalu and Fick, 1981, 1983). Such an assessment should therefore take into account the interrelationship.

Various stage classification systems have been used for grasses (Metcalf, 1973), and legumes (Nelson, 1925; Dotzenko and Ahlgren, 1950; Winch *et al.* 1970; Fehr *et al.* 1971, Gengenbach and Miller, 1972; Metcalfe, 1973; Kalu and Fick, 1981, 1983), and for cotton (Elsner *et al.* 1979). A quantitative stage classification system that adequately defines the morphological stages of *Tridax procumbens* would be needed for accurately and adequately

relating maturity stage with chemical composition.

The objectives of this study were (i) to develop a stage of maturity rating system for *Tridax procumbens*, and (ii) determine the chemical composition and quality components measured by leaf percentage, crude protein, *in vitro* true digestibility; and cell wall composition (fibre) at the different stages of development or maturity.

MATERIALS AND METHODS

Plant Materials and Treatments

The herbage samples used in this study were collected from established stands of *Tridax procumbens* seeded in April 1985 at the University Crops Research Farm. The experiment was carried on a two year fallow land previously cropped to maize. Seeds of *Tridax procumbens* were collected from wild stands growing in the locality. The field was ploughed, harrowed, and the seeds sown on the flat by broadcast method with no fertilizer treatments before or after sowing.

A randomized complete block design with four replications was used. Each replicate consisted of five canopy ages (14, 28, 42, 56, and 70 days) and seventeen harvest dates starting from April 29 to December 9. Herbage samples were collected from random locations within the replications at two-weekly intervals.

Age of the first growth herbage was calculated from the estimated date of 50% emergence after seeding. In the regrowth, the age of a sample was calculated from the date of the last harvest of the main treatment plot. The field layout and harvest sequence (table 1) were designed to provide herbage materials with a range of ages on each sampling date. Different ages were obtained by completely harvesting a treatment plot measuring 3.5 x 15.5m in each replication with a scateur every

14 days. For the first 14 weeks of the trial, a plot of the first growth material was mowed every two weeks. Thereafter, regrowth that was 10 weeks was mowed. From July onward, materials from 2 to 10 weeks (14 – 70 days) of age were sampled every 14 days.

A sample consisted of all herbage above a 3cm stubble height that fell within a sampling quadrat of 30cm² area.

Morphological stage classification

Individual stems were separately examined and grouped into stage categories as modified by Kalu and Fick (1981). The stages are defined in table 2, and allowed for the recording of the progression in development over 1 to 2 weekly intervals for the first growth (uncut) and the aftermath (table 3). The stage categories were assigned numerical values from 1 to 8 from the youngest to the oldest shoots.

Each fraction of the total sample occurring in each morphological stage category was dried in a forced - draught oven to constant weight at 65°C. The dry weights were used to calculate the mean stage of development for canopies from each plot sampled on each harvest date. Mean stage was calculated using the equation developed by Kalu and Fick (1981) and modified to accommodate the developmental sequence of *Tridax procumbens* as follows:

$$MSW = \sum_{S=1}^8 \frac{S \times D}{W}$$

Where MSW = Mean stage by dry weight
S = Stage number, 1 to 8.

- D = dry weight of shoots
in stage S
W = total dry weight of
shoots in all stages.

In this equation, the mean stage by weight (MSW) was the average of the individual stages present in a sample of the harvest date, and weighted for dry weight of the herbage in each stage.

Dried samples were separated into leaf and stem fractions and redried to constant weight at 65°C. The recorded dry weight of each of the leaf and stem fractions in each stage category was used to calculate the leaf percentage for the stage and for the total herbage on each harvest date as follows:

$$\text{Leaf percentage} = \sum_{\text{Stage 1}}^8 \frac{\text{leaf dry weight}}{\text{leaf dry weight} + \text{stem dry weight}} \times \frac{100}{1}$$

The leaf and stem fractions were each separately ground to pass a 1mm screen and immediately sealed in polythene bags for laboratory analysis.

Laboratory analysis

The kjeldahl method (AOAC, 1976) with nitric acid modification was used to estimate the crude protein. The fibre concentration represented by the following components: neutral - detergent fibre, acid - detergent fibre, lignin; and the *in vitro* true digestibility were determined according to Goering and Van Soest (1970). Each component was measured in percentage units on dry matter basis for each of the leaf and stem fraction. Herbage composition was calculated as follows:

$$\text{Herbage Composition} = \sum_{\text{Stage 1}}^8 \frac{(\text{SDM} \times \text{SC}) + (\text{LDM} \times \text{LC})}{\text{SDM} + \text{LDM}}$$

Where

- SDM = Stem dry matter
LDM = leaf dry matter
SC = Stem composition
LC = Leaf composition

and composition represented by

- CP = Crude Protein
IVTD = *In Vitro* true digestibility
NDF = Neutral detergent fibre
ADF = Acid detergent fibre
Lig = Lignin.

RESULTS

Leaf percentage

In this study, the leafiness of *Tridax procumbens* was highest at the vegetative stages for all the canopy ages (table 4). Leaf percentage decreased with both age and advancing stage of maturity in uncut and aftermath canopies. Leaf percentage ranged from 90% for young immature canopies to about 25% in very old and matured or senescing canopies. Stage-to-stage decreases in leaf percentage were generally higher in older canopies. For example in a 42 day old canopy, leaf percentage in uncut and aftermath decreased from 86% and 85% to 54% and 56% respectively at the late flower stage, while corresponding decreases in a 56 day old canopy was from 80% and 82% to 42% and 35% at the late flower stage for uncut and aftermath canopies respectively. It would appear that *Tridax procumbens* maintains high leaf concentration between ages of 28 and 42 days and before reaching the late flower stage.

TABLE 1.

Field layout and harvest sequence of the experimental plots

b. Harvest Sequence

Treatment number*	Age in weeks															
1	2	2	4	6	8	10	2	4	6	8	10	2	4	6	8	10
2	2	4	2	4	6	8	10	4	6	6	8	10	2	4	6	8
3	2	4	6	2	4	6	8	10	2	4	6	8	10	2	4	6
4	2	4	6	8	2	4	6	8	10	2	4	6	8	10	2	4
5	2	4	6	8	10	2	4	6	8	10	2	4	6	8	10	2
Date of harvest	29	13	27	10	24	8	22	5	19	2	16	30	14	28	11	25
	Apr	M	M	J	J	Jly.	Jly.	A	A	S	S	S	O	O	N	N

*Treatment numbers assigned to plots identifies plots to be mowed. Bold type numbers indicate ages of canopy to be mowed on the specified date of harvest to provide the subsequent ages of regrowth.

TABLE 2.

Definition of Stages of Development for *Tridax procumbens*

Stage number	Stage Name	Stage Definition
1	Early vegetative.	Shoot length $\leq$ 10cm, no flower buds, flowers and seeds.
2	Mid vegetative.	Shoot length 11 to 15cm, no flower buds, flowers and seeds.
3	Late vegetative.	Shoot length $\geq$ 16cm, no flower buds, flowers and seeds.
4	Flower bud.	Shoots with $\geq$ 1 node with flower bud, no flowers or seeds.
5	Early Flower.	Shoots with $\geq$ 1 node with un open flowers.
6	Late flower.	Full bloom. Terminal and axillary nodes with open flowers, no papus.
7	Immature seed.	Shoots with $\geq$ 1 node with immature papus on seeds with open flowers on main axis and branches.
8	Mature seed.	Papus well formed, can be blown off the plant.

TABLE 3.

Progressive changes in morphological stage of development in a canopy of *Tridax procumbens*.

Morphological Stage	Numerical Value	Days to Morphological stage					
		First Growth (Uncut)			Aftermath*		
		Location I	Location II	Location III	Location I	Location II	Location III
Early vegetative	1	10	14	18	20	16	15
Mid vegetative	2	15	20	25	25	25	23
Late vegetative	3	25	30	31	31	35	30
Flower	4	35	40	38	40	40	42
Early flower	5	38	45	46	45	46	47
Late flower	6	47	50	53	55	50	52
Early seed	7	53	55	60	58	60	61
Late seed	8	70	75	72	65	70	70

TABLE 4

The effect of canopy age, morphological characteristics on leaf percentage.

Morphology		Age in Days									
Morphological Stage	Numerical Value	14		28		42		56		70	
		U*	A	U	A	U	A	U	A	U	A
leaf %											
Early Vegetative	1	90	95	85	91	86	85	80	82	92	84
Mid Vegetative	2	86	92	74	78	71	78	67	71	68	66
Late Vegetative	3	—	—	58	70	65	67	64	68	43	45
Flower	4	—	—	—	—	60	59	44	57	35	39
Early Flower	5	—	—	—	—	56	58	41	37	31	40
Late Flower	6	—	—	—	—	54	56	42	35	25	27
Early Seed	7	—	—	—	—	—	—	35	41	28	30
Late Seed	8	—	—	—	—	—	—	34	36	26	28

*U = Uncut

A = aftermath

Crude protein and in vitro true digestibility:

Changes in these quality components associated with, and for the different ages and stages of maturity followed the same patterns as those of the leaf percentage (tables 5, 6). At any canopy age and stage of maturity the CP of the leaf fraction was higher than that for the stem fraction. The leaf CP for young and immature canopies was in the range of 31 – 32% and decreased to about 20% in old and matured canopies (table 5). The stem fraction followed the same pattern but consistently had significantly lower %CP than the leaf fraction. Stem CP decreased from 18.5% at the immature and young age to about 6% in old and matured shoots. On total herbage basis, the protein content was high with 29.6% CP at the early vegetative stage to about 14% in an matured old canopy.

The IVTD response (table 6) was similar to that of CP, and both followed same pattern as did leaf percentage. The leaves were more digestible than stems. The percentage IVTD of the leaf for the different ages and stages decreased from 89% to about 70% (table 6). The stem fraction was generally low in IVTD. However, on the total herbage basis, the IVTD was high, ranging between 80 to 82 in young immature canopies to about 53% in aged and matured canopies.

Fibre (NDF, ADF, and lignin)

The NDF, ADF, and lignin concentrations increased with increasing stage of development (tables 7, 8, and 9) for all ages of the herbage. The leaf fractions were consistently lower in fibre at any specified age and stage of development. The stem fractions consistently maintained higher concentration of the fibre components. The **rate of increase** from one stage or age to the next was most pronounced in the stem than in the leaf fraction. On total herbage basis, NDF increased from a range of 25 to 29%

in young and immature canopies to 59% in old canopies (table 7). Values for ADF were about 22% in young canopies and increasing to about 40% in old canopies (table 8) and lignin concentration was 2.5 to 3.8% in young canopies and increasing to about 9% in old canopies (table 9).

DISCUSSION

This study was initiated to evaluate the nutritive value of *Tridax procumbens*. The quality components measured as leaf percentage, CP, IVTD, NDF, ADF, and lignin showed a consistent pattern of changes with herbage age and stages of maturity. The results of this experiment agreed with earlier established findings that chemical composition changes with age and stage of development (Obioha and Ndukwe, 1976; Heinrichs *et al.* 1969; Van Soest, 1982; Kalu and Fick, 1983). Herbage materials at any specified age or date of harvest is composed of individual shoots of varying stages of development. Since herbage quality is influenced by stage of development, less matured shoots harvested from a common aged canopy would be expected to differ in quality and chemical composition. This trend was clearly shown in a canopy of *Tridax procumbens* (tables 4 to 9). In the same manner, the field environmental factors represented by climatic, edaphic, and biotic factors in which the crop growth plays a major role in determining its composition (Bowman and Law, 1964; Macleod, 1965; Deinum *et al.* 1967; Snaydon, 1972a, 1972b; White and Wight, 1981), and the joint cumulative effects appear to be expressed by the maturity or stage of development at the time of harvest. In this experiment, both the first growth and the aftermath canopies of *Tridax procumbens* sampled from three different locations showed varying rates of progressive changes from one maturity stage to the next (table 3),

TABLE 5.

Effect of Canopy age and stage of maturity on Crude Protein Concentration of *Tridax procumbens*

Maturity Stage (Numerical Value)	Age in Days											
	14			28			42			56		
	L*	S	H	L	S	H	L	S	H	L	S	H
1	31.0	18.5	29.6	26.3	14.6	22.2	25.1	14.0	19.2	24.3	12.8	18.1
2	32.0	15.2	27.6	25.4	12.5	20.2	24.3	13.4	19.3	25.1	11.5	17.8
3	—	—	—	24.5	13.3	18.5	25.1	12.1	18.6	24.8	8.7	18.4
4	—	—	—	—	—	—	23.6	10.5	17.5	22.7	9.0	18.3
5	—	—	—	—	—	—	23.2	9.5	16.4	23.0	9.2	17.6
6	—	—	—	—	—	—	23.5	10.0	16.9	22.8	8.5	17.8
7	—	—	—	—	—	—	—	—	—	21.3	8.6	18.8
8	—	—	—	—	—	—	—	—	—	19.2	8.0	17.6

*L = Leaf fraction
S = Stem fraction
H = Total herbage.

TABLE 6.

Effect of Canopy age and stage of maturity on *In vitro* true digestibility (IVTD) in *Tridax procumbens*.

Maturity Stage (Numerical Value)	Age in Days											
	14			28			42			56		
	L*	S	H	L	S	H	L	S	H	L	S*	H
1	89	75	82	83	63	74	80	61	71	78	55	65
2	87	62	80	81	58	69	71	56	67	73	51	60
3	—	—	—	75	61	70	70	57	65	67	55	63
4	—	—	—	—	—	—	68	48	64	67	50	59
5	—	—	—	—	—	—	70	42	56	70	40	52
6	—	—	—	—	—	—	69	36	52	70	45	55
7	—	—	—	—	—	—	—	—	—	68	30	50
8	—	—	—	—	—	—	—	—	—	69	30	50

*L = leaf fraction
S = stem fraction
H = Total herbage

TABLE 7

Effect of Canopy age and stage of maturity on Neutral Detergent Fibre (DNF) in *Tridax procumbens*.

Maturity Stage (Numerical Value).	Age in Days.											
	14			28			42			56		
	L*	S	H	L	S	H	L	S	H	L	S	H
1	23.3	40.2	26.1	24.5	52.8	36.2	27.2	54.5	41.0	28.0	64.5	52.4
2	20.5	43.1	29.2	26.3	54.2	37.8	28.1	57.2	31.2	67.3	55.3	31.5
3	—	—	—	28.5	56.4	39.5	28.8	51.8	45.0	29.5	65.0	31.5
4	—	—	—	—	—	—	30.2	60.5	45.0	33.3	66.1	55.0
5	—	—	—	—	—	—	30.5	65.0	47.2	32.5	67.8	57.1
6	—	—	—	—	—	—	30.3	64.8	47.0	33.0	67.5	56.2
7	—	—	—	—	—	—	—	—	—	32.8	68.0	55.5
8	—	—	—	—	—	—	—	—	—	33.1	68.4	56.2

* L = Leaf fraction

S = Stem fraction

H = Total herbage.

TABLE 8.

Effect of canopy age and stage of maturity on Acid-Detergent Fibre (ADF) in *Tridax procumbens*

Maturity Stage (Numerical Value).	Age in Days.											
	14			28			42			56		
	L*	S	H	L	S	H	L	S	H	L	S	H
1	16.2	36.1	21.9	19.0	40.5	28.0	19.8	42.8	30.5	20.0	45.0	34.9
2	16.8	40.3	25.5	19.2	44.0	28.8	20.1	48.1	34.1	20.3	48.8	38.6
3	—	—	—	19.5	45.2	29.6	19.6	48.7	36.2	20.8	50.6	39.1
4	—	—	—	—	—	—	20.5	51.3	38.4	19.7	51.5	40.5
5	—	—	—	—	—	—	21.1	51.2	37.9	21.5	52.7	39.8
6	—	—	—	—	—	—	21.6	51.6	39.0	21.8	52.6	40.1
7	—	—	—	—	—	—	—	—	—	21.6	52.3	39.5
8	—	—	—	—	—	—	—	—	—	21.9	52.6	40.0

* L = Leaf fraction

S = Stem fraction

H = Total herbage.

TABLE 9.
Effect of canopy age and stage of maturity on lignin concentration in *Tridax procumbens*

Maturity Stage (Numerical Value)	Age in Days											
	14			28			42			56		
	L*	S	H	L	S	H	L	S	H	L	S	H
1	1.5	4.3	2.5	2.3	4.8	3.2	3.5	7.8	5.2	4.0	10.3	7.5
2	2.1	6.4	3.8	3.6	6.9	5.5	4.2	9.5	6.7	4.3	10.8	7.1
3	—	—	—	3.8	8.5	6.1	4.0	10.7	7.6	4.5	10.4	7.2
4	—	—	—	—	—	—	4.8	10.5	7.7	4.2	11.2	7.8
5	—	—	—	—	—	—	4.7	11.6	8.1	4.1	11.5	7.9
6	—	—	—	—	—	—	5.6	12.5	9.2	4.4	11.3	7.3
7	—	—	—	—	—	—	—	—	—	4.0	11.3	7.3
8	—	—	—	—	—	—	—	—	—	4.8	11.7	8.1
% Lignin												
1	—	—	—	—	—	—	—	—	—	4.6	9.5	6.5
2	—	—	—	—	—	—	—	—	—	3.9	8.3	6.0
3	—	—	—	—	—	—	—	—	—	4.2	11.8	7.5
4	—	—	—	—	—	—	—	—	—	4.1	12.1	7.7
5	—	—	—	—	—	—	—	—	—	4.3	13.2	8.5
6	—	—	—	—	—	—	—	—	—	3.2	12.5	7.0
7	—	—	—	—	—	—	—	—	—	4.5	13.6	8.2
8	—	—	—	—	—	—	—	—	—	4.4	12.9	8.9

*L = Leaf fraction
S = Stem fraction
H = Total herbage.

TABLE 10.
Relationship of canopy age, mean stage and quality components in total herbage of *Tridax procumbens*.

Canopy age at harvest	Mean Stage (MSW)	Leaf Percentage	Crude Protein	IVTD	Fibre		Lignin
					NDF	ADF	
14	1.03	87.75	28.10	80.90	26.80	22.85	2.92
28	2.50	78.50	19.50	71.25	37.50	28.21	4.50
42	4.12	70.20	17.32	62.10	44.20	35.30	6.40
56	5.86	55.90	17.50	55.86	54.70	39.20	7.25
70	6.75	61.20	15.95	56.30	56.40	37.75	7.46

indicating an environmental effect on stages of development. Maturity stage therefore appears to integrate the physiological and environmental history of the plant. If such an hypothesis is true, the maturity stage could be a good indicator of the herbage quality since both factors are environmentally controlled.

In this study, the stages of development were assigned numerical values and were related to the changes in quality with maturity for a given specific age of herbage at the time of harvest. But a canopy of any age is composed of individual shoots of different stages of maturity which also vary in chemical composition (tables 5 to 9). The MSW (table 10) represented the mean stage reached by the total herbage of any age at the time of harvest and hence integrated both age and environment. Older canopies reached significantly higher MSW values than younger ones (table 10). Associated with that was lower leaf percentage, CP, and IVTD; and higher NDF, ADF and lignin with increasing MSW values.

The results of this study indicated a good nutritive potential of *Tridax procumbens* particularly with a harvest management schedule that optimises the quality attributes.

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