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INTRODUCTION OF ANTHEPHORA SPECIES TO THE TROPICAL RAIN FOREST: IMPLICATIONS FOR GRAZING PROPAGATION AND BREEDING OF THE SPECIES

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ABSTRACT

Three species of *Anthephora* of derived savanna origin were introduced into the tropical rain forest environment and their adaptability to the region was determined through morphological and seed yield studies. The three species, *A. ampulacea* (file grass), *A. nigritana* and an induced autotetraploid of *A. ampulaca* designated as *A. ampulacea* (4x) maintained, to a large extent their biological description, but a more luxuriant growth was recorded compared to reports from the areas of origin. Leaf measurements (length and with), leaf and tiller numbers were greater than twice the values reported in literature at 50% heading. This implies that the species exhibit phenoplasticity. Seed production was however low in all three species and the seeds when produced were to a large extent sterile. Grasses of the genus *Anthephora* can therefore be used as both wet and dry season pasture in southern Nigeria. The problem of sterile seed can be overcome by breeding the species for seed production in the savanna region of the country where the grass is indigenous and seed production is not hampered, while growing it in the rain forest region purely for pasture and hay-making.

Key words: Breeding, *Anthephora ampulaca* 2x, *A. nigritana* 4x, *A. ampulacea* 4x, phenoplastic, pasture.

INTRODUCTION

The genus *Anthephora* comprises good forage grasses which are well adapted to near dry regions of the tropics. Three, out of the six species of this genus reported in literature are found in Nigeria (Stanfield, 1970, Ene-obong and Omaliko, 1985a). The three species found in Nigeria are *A. ampulacea* (Stapf and Hubb), *A. nigritana* (Stapf and Hubb) and *A. cristata* (De Wild and Dur). In West Africa the file grass *A. ampulacea* is used extensively as a dry season herbage for direct grazing by livestock in parts of the derived savannah zones of Nigeria (Ene-Obong and Ani, 1988 and Ene-Obong and Mba, 1994). The use of the species for this purpose arises as a result of its ability to grow under near drought conditions. Although there are several species of forage grasses that are already well adapted to the tropical rain forest of the south there is still the need to introduce grass species which could endure the dry seasons given the advancing phenomenon of global warming and its attendant prolonged dry periods. Studies of plant performance over a range of environments in the field and under controlled condition are used to identify patterns and mechanisms of adaptation. Such studies also help to define appropriate target areas for plant exploration. The present study on the introduction of *Anthephora* species to the tropical rain forest area was carried out to identify the species pattern of adaptation, and also to explore the possibility of providing adequate dry season herbage for livestock as they are brought southwards by pastoralists.

MATERIALS AND METHODS

Whole potted plants of the three genotypes of *Anthephora* were obtained from the University of Nigeria, Nsukka. The Three genotypes and their descriptions are listed in Table 1.

Tillers of these three species were planted out in the botanical garden of the University of Calabar, in a field experiment set out in randomized block design plots with three replications. There were three plots per block and the genotypes randomized in these plots. Each plot measured 1x 1.5m. Thirty stands each of the three genotypes were planted on

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TABLE 1: EXPERIMENTAL PLANTS AND THEIR GENOTYPES

S/NO	SPECIES	GENOMIC CHROMOSME NO	REMARKS
1	*Anthephora ampulace* 2x	2n = 2x = 18	diploid
2	*Anthephora nigritana*	2n = 4x = 34	natural allopolypoid
3	*Anthephora ampulacea* 4x	2n = 4x = 36	induced tetraploid from A. *ampulacea* 2x

each of these three plots, 30cm apart, giving a total of ninety stands per genotype. The plants were established in February 1994.

A blanket NPK treatment (15N:15P: 15K compound fertilizer) at a rate equivalent to 150kg N/ha was applied to the soil two weeks after planting. The plants were mugged and watered daily until onset of wet season. The plants were reared to maturity, and forage and seed yield attributes were determined as follows:

(a) Plant height, measured as height from the soil to the tip of the spike of the main tiller.

(b) Leaf length, measured as length from base of leaf to the leaf tip.

(c) Leaf breadth, taken midway along leaf length

(d) Number of tillers per plant.

(e) Leaf area, determined as a product of leaf length, leaf width and a factor 0.905 (Kemp 1960).

(f) Number of leaves per tiller.

(g) Dry matter yield (leaves).

(h) Dry matter yield (Stem).

(i) Number of spikes/plant.

(j) Number of spikelets/spike

(k) Number of florets/spike.

(l) Number of seeds/spike.

(m) Number of seeds/plot.

(n) Seed weight/100 seeds.

(10) Pollen Stainability.

Pollen Stainability Test: This was carried out by squashing mature anthers in methyl blue stain on microscope slides. The slides were then observed under the microscope and the number of round pollen grains that were stained counted, and expressed as a percentage of the total number of pollen grains counted.

RESULTS

Summaries of the results obtained in this study are tabulated in Tables 2 to 5. Of the three species, the tetraploids, *A. nigritana* and *A. ampulacea* (4x) were consistently superior to the diploid in all characteristics except leaf number/tiller, number of seeds per plot and number of tillers per plant. The mean height of *A. ampulacea* 2x (diploid) was 139.2 ± 1.26cm while the height for the tetraploids were 185.4 ± 0.84cm for *A. nigritana* and 184.33 ± 1.35 cm for *A. ampulacea* (4x). Analysis of variance of these plant heights showed a high significant difference between the heights of the species ($P < 0.001$). The diploid, (Table 3), *A. ampulacea* 2x plants were prostrate in habit than the *A. nigritana* and *A. ampulacea* 4x. There was no significant difference between the heights of A. *nigritana* and *A. ampulacea* 4x.

On tiller numbers, *A. ampulacea* 4x produced the highest tiller number with a mean of 59.9 ± 1.86, followed by *A. nigitana* (48.6 ± 1.95) and then *A. ampulacea* 2x with a mean of 40.8 ± 2.1 tiller per plant. There was high significant difference ($P < 0.01$) between the species in their tiller number.

Leaf measurements (leaf length, breadth and area) were greater for the tetraploids than the diploid. Analysis of variance (ANOVA) showed significant differences between *A. ampulacea* 2x and the tetraploids ($P < 0.05$) while the tetraploids showed no significant differences among themselves. (LSD at $P < 0.05$). Number of leave counted for each tiller were 37.0 ± 2.78 for *A. ampulacea* 2x, 24.2 ± 1.53 for *A. nigritana* and 26.4 ± 1.80 for *A ampulacea* 4x.

Seed Yield Attributes

The number of spikes per plant was

TABLE 2: FORAGE YIELD ATTRIBUTES OF 3 SPECIES OF *ANTHEPHORA* IN CALABAR.

GENOTYPE	PLANT HEIGHT (cm)	TILLER NUMBER	LEAF LENGTH (cm)	LEAF WIDTH (cm)	LEAF AREA (m)^2	NO. OF LEAVES/TILLER	DRY MATTER WEIGHT (LEAF) (g)	DRY MATTER WEIGHT (STEM) (g)	DRY MATTER WEIGHT (WHOLE) (g)
A. ampulacea 2x	139.2 ±1.26 a	38.8±2.10 a	35.1±2.03 a	0.75±0.01 a	23.6±0.58 a	37.0±2.78 a	11.2±0.61 a	19.70±1.40 a	30.6±2.51 a
A. nigritana	185.4±0.84 b	48.6±1.95 b	55.0±1.33 b	0.87±0.02 b	42.7±1.75 b	24.2 ±1.53 b	11.2±0.98 a	45.8±4.40 b	55.0±0.51 b
A. ampulacea (4x)	184.3±1.35 b	59.87±1.86	51.4±1.62 b	09 ±0.02 b	41.4±1.58 b	26.4±1.80 b	11.2±0.89 a	51.3±2.50 b	63.0±2.40 b
Overall Mean X	169.6	49.1	47.2	0.84	35.9	29.2	11.2	38.9	49.5

Means with identical alphabets (a,b,c) are not significantly different while those with different alphabets are significantly

TABLE 3: MEAN SQUARES AND VARIANCES FOR FORAGE YIELD ATTRIBUTES OF 3 SPECIES OF *ANTHEPHORA*

		PLANT HEIGHT		TILLER NUMBER		LEAF LENGTH		LEAF WIDTH		LEAF AREA		NO OF LEAVES/ TILLER		WHOLE DRY MATTER YIELD (g)	
SOURCES OF VARIATION	DF	MS	VR	MS	VR	MS	VR	MS	VR	MS	VR	MS	VR	MS	VR
TOTAL	44														
BLOCKS	2	6.628	0.3350ns	128.956	2.680ns	3.182	0.120ns	0.0016	0.359ns	4.99	0.233ns	2.88.2	4.268*	32.1	1.62
GENOTYPES	2	10431.810	527.28***	1488.956	30.998***	1619.602	61.142***	0.083	19.128***	1715.456	79.993**	36121.382	534.926	384.1	26.89
BLOCK X GENOTYPE	4	26.394	1.33	66.556	1.386ns	4.205	0.159ns	0.01.2	2.359ns	35.190	1.641ns			28.9	1.52ns
ERROW	36	19.784		48.033		26.489		0.0043		21.445		67.526		19.2	

n.s. = Not significant; * = significant at P < 0.05; ** = significant at P < 0.01: *** = signicant at P < 0.001.

TABLE 4: MEAN VALUES (WITH S. E.) OF SEED YIELD ATTRIBUTES OF 3SPECIES OF ANTHEPHORA IN CALABAR

GENOTYPE	No of Spikes/plant	Spike length (cm)	No of Spikes/Spike	No of Florets/Spikelet	No of Seeds/Spikelet	no of seeds/spike	No. of Seeds/Plots	Seeds Wt./100 Seeds (g)	Pollen Staninability (%)
A. ampulacea (2x)	68±3.40 a	15.9±0.35a	44.8±1.20a	4.7±0.12a	0.6±0.21a	1.6±0.46a	26.0±182a	0.4a	82.6±0.52
A. nigritana (2x)	72.40±2.8 a	18.2±0.13a	51.5±0.52b	6.6±0.21b	0.44±0.19b	0.7±0.27b	10.6± 22.1b	0.62b	78.2±1.21
A. ampulacea (4x)	75.5±2.10 a	1.0± 0.41a	48.1±1.50b	5.4±0.21b	0.33±1.6b	0.6±0.27b	10.2 ±2.70b	0.58b	72.6±0.33
Overall Mean X	72.2	17.4	48.1	5.6	0.4		15.6	2	77.8

Means with identical alphabets (a,b,c) are not significally different while those with different alphabet are significantly different ($p<0.05$)

TABLE 5: MEAN SQUARES AND VARIANCES FOR GORAGE YIELD ATTRIBUTES IN 3 SPECIES OF *ANTHEPHORA*

		NO OF SPIKES/PLANT		SPIKE LENGTH (CM)		NO. OF SPIKLES/SPIKE		NO. OF SEEDS/SPIKELET		NO. OF FLORETS/ SPIKELET		NO OF SEEDS/ SPIKE	
SOURCES OF VARIATION	DF	MS	VR	MS	VR	MS	VR	MS	VR	MS	VR	MS	VR
TOTAL	44												
BLOCKS	2	80.067	0.776ns	63867.61	1.005NS	42.022	2.051	0.4222	0.5NS	0.867	1.733NS	0.0222	0.0111NS
GENOTYPE	2	122.6	1.188ns	64996.02	1.023NS	163.489	7.979***	0.2889	0.7308NS	12.6	25.2***	4.6889	2.3444**
BLOCKS X GENOTYPE	4	24.267	0.235ns	63310.5	0.997NS	3.989	0.195NS	0.2222	0.3846NS	0.467	0.933NS	1.1222	0.5611NS
ERROR	36	130.233		63532.47		20.489		0.5778		0.5		2	

n.s. =Not significant.* significant at $p<0.01$;*** significant at $p<0.001$

greatest in the induced tetraploid followed by *A. nigritana* then *A. ampulacea* 2x (75.5 ± 2.10, 72.4 ± 2.80, 68.6 ± 3.40 respectively (Table 4) Analysis of variance however showed no significant differences between the species in their spike numbers.

The spike lengths as well as the number of spikelet per spike for the tetraploids were higher than those of the diploid but the diploid *A. ampulacea* 2x produced more seeds per spike than the tetraploids (1.6 ± 0.46; 0.67 ± 0.27; and 0.6 ± 0.27 for *A. ampulacea* 2x, *A. nigritana* and *A. ampulacea* 4x respectively). *A. ampulacea* 2x had a pollen stainability of 82.61 ± 9.52%, *A. nigritana* had pollen stainability of 78 . 21 ± 1.92% while for *A. ampulacea* the value was 72.6 ± 0.33%.

The seed weight per 100 seed was 0.40g in *A. ampulacea* 2x; 0.62g in *A. nigritana* and 0.58g in *A. ampulacea* 4x (Table

4). On dry matter production, the tetraploids *A. nigritana* and *A. ampulacea* (4x) produced total dry matter weight of 55.0 ± 5.1g and 63.0 ± 2.4g respectively. The diploid *A. ampulacea* 2x had a dry matter weight of 30.6 ± 2.51g. Analysis of variance for dry matter yield of whole plants as well as for leaf and stem portions showed significant differences between the diploid and tetraploids, ($P < 0.05$). There was no significant difference between *A. nigritana* and induced tetraploid *A. ampulacea* 4x.

Correlation and regression analysis of the results showed a positive relationship between dry matter yield and plant height, and tiller number, number of leaves, and spike number, although these values were not significant.

DISCUSSION

The morphology of the filegrass *A. ampulacea* (2x) had been described by Omaliko and Ene-obong (1987). The file grass introduced and cultivated in the botanical garden of the University of Calabar maintained most of the descriptions offered but showed more luxuriant growth, which resulted in longer mean leaf length, plant height and longer spike length. The forage yield was greater than that reported by Omaliko (1984), and Ene-obong and Omaliko 1985a) probably due to high soil moisture and high soil nutrient availability. It is known that crop yield is at its maximum at high level if nitrogen fertilizer and appropriate soil moisture status. (Russel 1973).

The average plant height of this species in this experiment was 139.2cm (ranging from 130 to 148cm) as against an average height of 90cm reported by Ene-obong and Omaliko (1985). The mean spike length was 15.93cm compared to a spike length of 3.12cm reported. The number of spikelets also increased from 37 to 44.8 ± 45 spikelets. A leaf length of 50cm and width of 0.3-0.7cm was reported by Ene-Obong and Omaliko (1985a) but in this study, a mean leaf length of 35.13cm and a mean width of 0.75cm were observed. These measurements showed that *A. ampulacea* 2x grown in the rainforest area, with an average rainfall of 358.5mm and an average temperature of 23.8c actually grew into a bigger plant than described. The increase in size of the plant could also be attributed to the enrichment of the soil through fertilizer application and constant watering applied through-out the period of plant growth. Higher morphological yield of the species implies more dry matter yield available for feeding the livestock. It is therefore advantageous to grow the species in the south for livestock production. Ene-obong and Omaliko (1985b) found a high positive correlation between the number of fertile florets per head and seed yield. This was not the case in this study. Although the number of fertile florets counted was actually greater in this study than reported, the seed set was low.(1.6 ± 0.46 seeds per head). The poor seed production could be as a result of unfavourable environmental conditions during the pollinating period, such as constant rainfall, high humidity or unfavourable day -lengths. The latter is less likely to be a reason in this study because day lengths in the tropics do not vary drastically, although some plants such as Okro and *Telfairia* are very sensitive to photoperiods. High rainfall and high humidity are therefore advanced as the reasons for poor seed set in the *Anthephora* species grown in the Calabar area. The low seed in the tetraploid species could also be a direct result of irregularities in meiotic process since the seeds were predominantly non-fertile. To overcome the problem of seed production as a set-back in the use of *Anthephora* in livestock feeding in this region, it is suggested that commercial seed of the species be produced else where, where environmental condition for seed production are more favourable. This practice is not strange and has been in progress in the breeding of forage crops in Britain since many grass species are poor seed producers, or produce seeds of poor quality, e.g. in British native species such as buffalo grass, grama grass and bluestems. This technique is also applicable to some introduced species (Burton, 1951; Cooper, 1973).

The average leaf appearance rate in the species ranged from 3-6 days and tallies well with earlier reports by Ene-Obong and Omaliko (1985b). Leaf longevity within the species was observed to be approximately 50 days and increased towards flowering. The number of tillers per plant was also observed to range from 24-48, depending on the plant age and with no significant variation between the morphology of parent tillers and daughter tillers. Tillering was intravaginal as earlier reported by Ene-Obong and Omaliko (1985b).

The mean tiller numbers for *A nigritana* and *A . ampulacea* (4x) were 48.6 ± 1.95 and 59.9 ± 1.86 respectively. These results do not tally with those reported by Ene-Obong and Mba (1994) who reported 16.67 ± 2.11 for *A. ampulacea* (4x) and 19.67 ± 1.52 for *A nigritana*). These difference in tiller numbers could be a reflection of the age at which the counts were made, since the number of tillers produced per plant were found to be correlated positively with plant age. The increase in the observed tiller number in this study could also be a direct response to nutrient availability and favourable environmental conditions during growth.

On leaf area measurements, the two tetraploid species were not significantly different, *A. nigritana* having leaf area of 42.66± 1.25cm^2 and *A. ampulacea* 4x a mean leaf area of 41.37± 1.58cm. The number of leaves per tiller were, however, greatest in *A. ampulacea* (2x) - (37.0 ± 2.78). The number of leaves per tiller counted for *A. ampulacea* (4x) was 26.35 ± 1.80, while the count for *A. nigritana* was 24.18 ± 1.53. There exists a complex relationship between leaf number, size and photosynthetic rate in forage plants. In many forage species including perennial and Italian ryegrass, as reported by Cooper, (1973), genetic variation is detected in the maximum photosynthetic rate achieved at light saturation and this characteristic responds readily to selection. High photosynthetic rate per unit leaf area is usually correlated with small mesophyll cells and hence with a small leaf area. Therefore, a high photosynthetic rate of the individual leaf does not necessarily lead to a high photosynthetic rate of the whole plant or crop canopy (Cooper 1973). Based on this assessment, it would appear that within the *Anthephora* species studied, the *A. ampulacea* (2x) with smaller leaves and a more prostrate canopy for more light interception is more efficient in photosynthetic activity and therefore digestible dry matter production than the polyploids.

In general terms, apart from the problem of low seed set, the three species of *Anthephora* introduced and grown in this area were well established, growing more luxuriantly with greater morphological characteristics like plant height, leaf production, tiller numbers and length than those reported elsewhere. The *Anthephora* species are therefore said to be phenoplastic, showing variation in phenotype depending on the environment.

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