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Experimental studies on seed production of tropical grasses in Kenya. 7. The breeding for improved seed and herbage productivity

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Summary

The history and characteristics of the Kitale grass varieties and the practices of seed multiplication are described.

Spaced-plant populations of various varieties of *Setaria sphacelata* and *Chloris gayana* were studied with a view to selecting suitable plants for developing varieties with better seed and herbage productivity. It was observed that these populations were heterogeneous in heading time, growth habit and vigour, and head number per plant. In most varieties there were 5 - 6 weeks between the dates of the first and the last 5% of the plants to head. Heading time was largely determined by vigour. The more vigorous the plants, the earlier they began heading. More heads were found in the early-heading plants.

In 18 clones, grouped together on the basis of even and early heading, good vigour and high head number, great variation was observed in the yield of Pure Germinating Seed (PGS) per plant, head number and seed setting per plant. Three outstanding clones had average PGS yields three times as high as the average of all 18 clones. Heritability for PGS yield and its components was invariably high.

It is concluded that breeding should have the following major objectives: even heading date, good plant vigour, potentially high head number, high seed setting, persistence and high nutritive value.

Introduction

There can be little doubt that the seed yield responses to the management factors described in the previous papers of this series were limited by the genetic make-up of the current Kitale varieties. It was shown that both intraplant and interplant heading are spread over so many weeks that shedding is commonly observed long before head emergence is completed. Similarly, flowering and shedding can occur simultaneously within single heads (Boonman, 1971a, 1971b). Seeds shed readily but the shedding and flowering of spikelets depend largely on the history of the heads they are on. Hence, heading patterns are of overriding importance.

Griffiths (1965) has summarized literature on selection for seed production in grasses. He concluded that such selection could be carried out successfully without prejudice to herbage productivity.

To achieve real progress by breeding it is imperative to know the characteristics of the varieties already in use. Of equal importance is a sound practical appreciation of the type of grass required in future.

The history of the present Kitale varieties and their multiplication

Most of the early work has been documented by Bogdan (1959, 1965, 1966) and it suffices here to mention the main events and the developments after 1966.

Out of some 4000 introductions collected from eastern Africa and elsewhere two superior species emerged: *Chloris gayana* (Rhodes grass) and *Setaria sphacelata*. The Nandi ecotype of *S. sphacelata* was introduced by D. C. Edwards as far back as 1935 while the Masaba and Mbarara ecotypes of *C. gayana* were introduced in the 1950's by R.Strange and A. V. Bogdan. These three varieties, all early heading and released without individual plant selection, quickly replaced the old farmers' varieties such as Nzoia Rhodes and Molasses grass and have had a great impact on ley farming in Kenya. In the early 1960's, individual plant selection led to the development of Pokot Rhodes, a late-heading variety. A late-heading Nandi II was developed through mass selection from the original Nandi variety, subsequently renamed Nandi I (Bogdan, 1965). Out of Nandi II, an even later heading variety was developed, Nandi III, through family selection. The view was held that early-heading varieties were necessarily stemmy and of inferior nutritive value. As a result, the planting of new multiplication fields of Nandi I was discontinued in 1967 and the same was about to happen with Mbarara Rhodes, so that late-heading varieties would have remained only.

The primary objective of the early work at Kitale was to multiply promising material quickly, and tribute must be paid to A. V. Bogdan and R. Strange for their effort. Demand for seed of the new varieties was understandably high. Consequently, efforts were directed to the rapid building up of seed stocks, but little attention was paid to maintaining material close to its original constitution. Varieties were multiplied from generation to generation and seed issues were made to the seed industry for further bulking and trade. In the process of multiplication attention was confined to isolation and weeds.

When evidence became available that this system of continuous multiplication led to considerable shift the decision was taken to stabilize the current varieties (Boonman, 1971a). Spaced-plant populations were established from which subsequent multiplications were to originate. In 1968 and 1969 plants were collected at random from multiplication fields of known name and history. Some 4000 plants for Nandi I and Nandi II, and 1000 each for the other tufted grasses, *Panicum coloratum* cv. Solai, *Panicum maximum* cv. Makueni and *Brachiaria ruziziensis*, were planted 1 m apart. Of the 3 Rhodes grass varieties, Mbarara, Masaba and Pokot, 1000 plants of each were set out 4 m apart so that each plant could form a little sward. Varieties were grown in isolation and the seed harvested was issued to a local seed company for further multiplication under official certification. This superseded the previous system of uncontrolled multiplication, from 1970 onwards.

In these spaced-plant populations considerable plant-to-plant variability was subsequently noticed in major characters such as heading date, vigour and general plant type. This offered an opportunity to start a breeding programme on the basis of intravarietal variation.

Characteristics of present Kitale varieties

The evidence now available on existing varieties offers some help in defining the breeding objectives for future varieties. Table 1 summarizes the main features, assembled together from published (Boonman, 1971b, 1973) and unpublished data.

The Guinea grasses are the first to head but they are low in herbage yields. Coloured Guinea, however, produces the highest PGS yields of all grasses, whereas Makueni is

Table 1. The major characteristics of Kitale varieties (after Boonman, 1971b, 1972c and unpublished data).

	Sequence in week of Initial Head Emergence (IHE)	Number of tillers at IHE per m²	Weight per tiller at IHE (mg)	Yield of dry matter (tons/ha), 8 weeks after cleaning cut	Yield of dry matter (tons/ha) at advanced heading	Maximum head number per m²	Maximum percentage heading tillers	Culm length at optimum seed harvest (cm)	1000-grain weight (mg) at optimum seed harvest	PGS-yield per crop (kg/ha) at optimum seed harvest
	1968-1971	1969	1969	1969	1969	1969	1969	1969	1968-1971	1968-1971
Setaria sphacelata cv. Nandi I	3	950	260	6.0	8.1	350	25	150	420	32
Setaria sphacelata cv. Nandi II	4-5									22
Setaria sphacelata cv. Nandi III	5-6	980	220	5.0	7.7	170	9	135	420	15
Chloris gayana cv. Mbarara	2	1550	210	7.0	7.7	320	20	132	280	44
Chloris gayana cv. Masaba	4-5	1290	190	6.3	7.1	230	13	130	260	40
Chloris gayana cv. Pokot	6	1260	260	5.7	7.5	160	12	130	310	24
Panicum coloratum cv. Solai	1	1530	200	4.0	7.1	520	34	115	460	52
Panicum maximum cv. Makueni	1	1150	280	4.2	4.9	130	10	144	540	25
Brachiaria ruziziensis (Congo Signal)	9	1240	280	5.0	7.4	470	37	126	1930	23

relatively low. Congo Signal *(Brachiaria ruziziensis)* is an extremely late-heading variety and only produces one seed crop a year, of rather low yield. In spite of its high percentage of heading tillers, Coloured Guinea is persistent in leys, in contrast with Makueni and Congo Signal, under Kitale conditions. These three species are not widely used in Kenya. Most of the seed grown of Makueni and Congo Signal is exported to other countries where they are reported to be doing well under warmer conditions.

As noted earlier, the species receiving most attention at Kitale are Rhodes grass and setaria. Broadly speaking, Rhodes grass varieties are popular with the average farmer because of their ease of management and wide adaptation, whereas more sophisticated farmers in the medium altitudes (above 1700 m) tend to favour Nandi, which is more persistent. It is evident from Table 1 that the early-heading varieties excel in both herbage and seed yield. The PGS yields of the early-heading varieties are nearly twice as high, although Masaba Rhodes, a medium-early variety, produces almost as much as Mbarara Rhodes.

Varieties can be distinguished on the basis of tiller numbers and weights at Initial Head Emergence (IHE, 5-10 heads per m^2). In Rhodes, the late-heading Pokot has fewer but heavier tillers and produces heavier seeds. The late-heading Nandi III, however, has more and finer tillers and shorter culms than Nandi I.

No exactly comparable data for Nandi II are available. In view of the breeding history outlined above, it can be assumed that the characteristics of Nandi II are intermediate between those of Nandi I and Nandi III. If data from comparable trials and seasons are used, the estimated PGS yield of Nandi II can be put at 22 kg (Table 1). Data collected on PGS yields obtained from commercial fields grown at the National Agricultural Research Station in Kitale between 1964 and 1968, the period when all three varieties were in production, showed that the average annual yields of PGS were 30, 18 and 12, respectively, which correspond well with the yields given in Table 1. The important conclusion arises that PGS yield is increased by about 50% from Nandi III to Nandi II and again from Nandi II to Nandi I, with increased earliness.

Breeding objectives

Clearly defined objectives and the correct choice of source material are of paramount importance in a breeding programme. The basic aim is to improve both the seed and herbage productivity, including nutritive value, of the existing Kitale varieties.

The major objectives are to include (1) high seed yield and (2) long-lasting (persistent) and well-distributed production of a large quantity of nutritious herbage. In view of the scope of the present series of studies, priority is here given to breeding for seed yield, but it is essential to know how this affects herbage characteristics. Information is needed to see if simultaneous improvement is feasible.

Close matching of the basic clones as regards heading date is a prerequisite not only to attain maximum seed yield but also to guarantee proper interplant fertilization and to prevent shift in subsequent cycles of multiplication. A bred variety must be sufficiently uniform for authenticity and stability.

To improve seed yield further, there are various breeding possibilities, such as increasing head number, seed setting or seed weight on the one hand, or improving the efficiency of components to bring about more even maturation on the other.

For herbage breeding, persistence and a good seasonal distribution of production are important. In mixed-farming areas where cereals and short-term leys alternate, persistence is less of a problem. In milk-economy areas, however, farmers are tending to specialize more and more in dairy production and going out of cereal production. These farmers need persistent grasses. Good seasonal distribution of growth is difficult to tackle from the breeding side. Growth rate is highest at the onset of the rains (Boonman, 1972c) and lowest in the dry season. Management is the best way for the farmer to reconcile the fluctuations in supply and demand. Conservation of surplus growth in the form of hay or silage is becoming popular, as this enables farmers to bridge the gap in the dry season without having to devote extra land to the growing of special fodder crops. Irrigation, already practiced in some areas, will become more widespread. In many areas of Kenya, and elsewhere in the tropics, stocking rates are high in relation to grass growth, even in the rainy season. To date, no compatible, productive legume is available and the reliance on nitrogenous fertilizer is steadily increasing, helped by the favourable ratio of milk/nitrogen prices.

Under good growing conditions, Kitale grasses are capable of achieving high dry matter yields. Growth rates of over 140 kg DM ha^{-1} day^{-1} were reported (Boonman, 1971b). In contrast nutritive value, measured in terms of digestibility, is low. Breeding for higher nutritive value is therefore essential and could be conducted along two lines: (1) to obtain a higher digestibility at a given yield capacity and (2) to improve the yield capacity, i.e. vigour of (re)growth which would enable the farmer to graze more often at a desirable level of digestibility.

The studies reported here were carried out to examine the material available in the spaced-plant populations referred to above. In view of the past experience with breeding it was thought necessary to examine some parameters and their relationships before defining a breeding policy.

Phenotypic selection is commonly used to reduce large source populations to manageable sizes. At this stage a distinction is made between what is believed to be good or bad and the ultimate success of the breeding programme depends on the correctness of this decision. It is therefore of paramount importance to have a good knowledge of the material that is to be carried forward.

Materials and methods

After preliminary observations in 1969 and 1970 more detailed studies were made in 1971 as follows.

Setaria sphacelata

The spaced-plant populations of Nandi and Nandi II, each consisting of over 4000 plants planted 1 m apart, were allowed to develop two consecutive seed crops in 1971 and observations were taken as follows:

- week of heading (W_i): the week in which the plant had developed 10 fully emerged heads, W_1 being the week when the first 1 - 5% of all plants had 10 heads;
- growth habit: at W_1 all plants were classified as tall, short or poor;
- vigour: plants were ranked on a 1 - 5 scale for vigour of regrowth 1 month after the cleaning cut, where 5 represents the greatest vigour; this observation, ancillary to that of growth habit, was carried out in the late-season crop;
- head number, shedding, lodging and diseases.

In August 1971, 18 Nandi plants were selected on the basis of early heading, even heading date, adequate head production and tall growth habit. They were subsequently planted out in clones of 4 replicates, at a spacing of 75 × 50 cm. This made it possible to estimate genotypic variances and heritabilities for seeding properties.

The spaced-plant populations of Mbarara, Masaba and Pokot Rhodes, each consisting of about 1000 plants set out 4 m apart with paths between the plots, were allowed to develop two consecutive seed crops in 1971 and observations were taken as follows:

- week of heading: when heads began emerging evenly over the whole plot;
- vigour: when 1 - 5% of the plants had reached W_1, all plants were ranked on a 1 - 5 scale for vigour of regrowth;
- head number, shedding, lodging and diseases.

In all above plant evaluations about 100 kg N $ha^{-1}crop^{-1}$ was applied as a top dressing.

Results

The relationship between growth habit and week of heading in Nandi is borne out in Fig. 1. The proportions of tall, short and poor plants are shown for each heading week.

As heading week proceeded tall plants decreased whereas poor plants increased as a percentage. The highest percentage of short plants was observed at W_4. W_8 consisted almost entirely of poor plants. Consequently, early heading was closely associated with tall plants. Although Fig. 1 refers to the first crop of Nandi I of 1971 only, the same was confirmed for consecutive crops, also those of Nandi II.* The latter contained more short plants, fewer poor plants and appeared to be more uniform than Nandi I. In the Rhodes grass varieties, a predominant proportion of plants in the early-heading groups grew erect after planting and it took them a longer time to cover a given area with stolons (data not presented).

Classifying Nandi plants for growth habit may be more suited to the later stages of a selection programme, but in the early stage with its great variability it was found easier to rank individual plants on a 1 - 5 scale for vigour of regrowth.

An important finding corroborating the evidence presented in Fig. 1 is that both in Nandi and in Rhodes grass heading week was negatively correlated with vigour (Table 2).

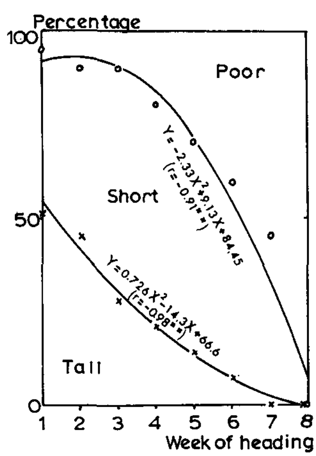

Fig. 1. Relationship between growth habit and week of heading.

* To pool the data of all crops and varieties formulas were devised which will be published elsewhere.

Table 2. Correlation coefficients between heading week and vigour (varieties pooled per species).

	df	r	P
Nandi	4244	-0.14	0.01
Rhodes	5559	-0.12	0.01

Thus the more vigorous a plant the earlier it heads. Late-heading, vigorous plants do occur but there are very few.

The heading patterns of the spaced-plant populations of Nandi I, Nandi II, Mbarara, Masaba and Pokot Rhodes are shown in Fig. 2. The interval between the dates of the first and the last 5% of the plants to come into head varied from 4 weeks in Mbarara and Nandi II to 6 weeks in Masaba and Pokot.

The herbage was usually cut back at W_9 or W_{10}, when over 99% of the plants had commenced heading. At this time plants were observed for head number. Early-heading plants were naturally at a disadvantage because many had collapsed by then. Nevertheless, it was found in Nandi that plants with many heads were more frequent within the group of tall plants (Table 3).

In 85 unreplicated plants of the spaced-plant population of Nandi II, heads were counted weekly in three consecutive seasons. One plant failed to produce heads at all. Only 15 plants produced more than 200 heads in all three seasons. Some of these produced this number more rapidly than others. Nearly all plants with many heads belonged to the early-heading groups, even though later-heading plants had had ample time to show this character.

An additional positive feature of early heading was its apparent correlation with drought tolerance. The Nandi I crop produced some vigorous plants with many heads in March 1972, even though this was right at the end of a severe dry season. It was subsequently found that 75% of these plants were those which had belonged to W_1 and W_2 in the first crop of 1971. This suggests that early, vigorous plants were also more drought-tolerant

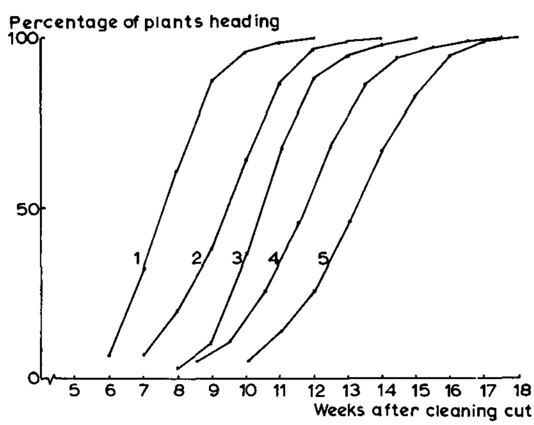

Fig. 2. Heading patterns in spaced-plant populations of Nandi and Rhodes varieties; averages over 3 seasons.
1 = Mbarara Rhodes; 2 = Nandi I; 3 = Nandi II; 4 = Masaba Rhodes; 5 = Pokot Rhodes.

Table 3. Percentage per growth habit (Nandi I, early-season crop).

	Growth habit		
	tall	short	poor
In original population	28	49	23
In plants with many heads (20% of original population)	40	51	9

Table 4. Correlation for heading week and vigour over two consecutive crops (varieties pooled per species).

	df	r	P
Heading week			
Nandi	2038	0.41	0.01
Rhodes	2908	0.63	0.01
Vigour			
Nandi	1033	0.40	0.01
Rhodes	2828	0.30	0.01

probably because they had formed more regrowth when the dry season began.

If selection is envisaged, heading date and vigour must be consistent over consecutive seasons. Table 4 shows that the correlation coefficients were highly significant, indicating that there was good consistency.

Seeding properties of some selected Nandi clones

The characteristics of 18 clones which had been selected from the Nandi populations on the basis of early and even heading date, adequate head production and tall growth habit, are presented in Table 5.

The mean of all 18 clones is compared with the mean of the group of 3 outstanding clones which differed significantly from subsequently ranked clones. The values of heritability (clones) are given, which when multiplied by the selection differential give an estimate of the genetic gain obtained in the top group of 3.

It is evident from Table 5 that the genetic gain of + 178% was high for yield of PGS. With the opted selection differential, yield of PGS was increased threefold. This increase was only partly due to the small increase observed in 1000-grain weight. The main yield components causing the said increase were head number and seed setting per head even though heads were shorter in the top group. The degree of shedding was considerably higher in the top group. apparently because they began heading about 1 week earlier. It was suggested in a previous paper, however, that early shedding does not necessarily mean the loss of valuable seed (Boonman, 1973).

As regards the effect of selection for seed yield on herbage properties, it can be seen from Table 5 that the top group was more vigorous both in the first growth and the regrowth. The fresh weight of herbage at seed harvest was not significantly different between clones. Its heritability was low. These findings are hardly surprising because at the advanced stage of seed harvest poor clones have normally caught up with the better ones. The top group was less prone to lodging at seed harvest.

Table 5. The genetic variation in 18 early heading plants of *Setaria sphacelata* cv. Nandi.

	Week of heading (weeks after cleaning cut)	Yield of PGS per plant (g)	PGS* (%)	Yield of clean seed per plant (g)	Head number per m^2	Mean head length (cm)	Number of germinating seeds per head	1000-grain weight (mg)	Fresh weight per plant (kg)	Shedding (1-5) 5 = no shedding	Lodging (1-5) 5 = no lodging	Vigour (1-10)	
												1st growth	regrowth
Mean of 18 clones	7	0.45	27.1	1.66	72	19.7	9.8	520	2.9	4.2	2.9	5	6
Mean of 3 selected clones	6	1.39	49.8	2.79	148	17.8	17.9	540	3.1	3.2	3.2	6	7
Heritability (clones)	0.47	0.85	(0.90)*	0.70	0.87	0.89	0.60	0.72	0.15				
Genetic gain (%)		+178	(+75)*	+48	+92	-8.6	+50	+2.8	+1.0				

* Means of clones based on weighted means; heritability and genetic gain based on straight means.

The above results refer only to one harvest and one location. More information is needed to verify these findings.

Discussion

The wide range in heading date (Fig. 2), the consistency of heading week over consecutive crops (Table 4) and the high heritability for week of heading (Table 5) indicate that considerable improvement in seed yield will result from grouping plants according to date of heading. Further improvement in seed yield can be achieved by utilizing the variation in seed yield components, namely seed weight, seed setting and head number (Table 5). All these characters had a high heritability so that mass selection is an appropriate method to pick out superior genotypes (Latter, 1964). Their responses to various husbandry measures such as fertilizer, planting density and harvesting time have been reported previously (Boonman, 1972a, 1972b, 1972c, 1973).

Differences in 1000-grain weight, though significant, were small. The three best-yielding plants produced a slight genetic gain of only 2.8%, in contrast with the genetic gain of 178% in yield of PGS. Improvement of the seed weight may have more significance if increased seedling vigour is sought than as a tool to increase seed yield, as the advantage of higher weight would be off-set by the need for higher seed rates.

Seed setting, i.e. the number of PGS per head, was observed to vary greatly from plant to plant (Table 5). Seed setting appears to be the single most important yield component requiring the attention of the breeder. It is however the most difficult to determine as it requires laborious testing. High yield of clean seed of clones is normally not accompanied by an equally high percentage germination ($r_{76} = -0.04$). The method in this study was to germinate a sample of the clean seed (Boonman, 1972b). Purity tests, i.e. the separation of full and empty spikelets (Gildenhuys, 1950), may produce quicker results but they give little indication as to whether the pure seed is ultimately going to germinate. Seed setting per head was certainly not positively correlated with head length, as head length was on average shorther in the top group of Table 5.

Seed setting is sometimes reduced by bunt *(Tilletia echinosperma* Ainsworth) in Nandi and *Panicum*. When an epiphytic occurs some plants are less affected than others (Boonman, unpublished data). Behaeghe and Blouard (1962) have shown that breeding for resistance against *Sphacelotheca setariae*, a similar if not the same disease, is possible.

Spikelets normally absciss upon maturation but there are indications that direct selection for better seed retention is feasible. Of specific importance is the need to develop varieties with consistently high seed setting so that the large season-to-season and year-to-year variation in seed yield might be reduced (Boonman, 1972a, 1972c, 1973).

An increase in head number, even more so if more heads are produced in less time, has a direct effect on yield of PGS (Boonman, 1972a). In the present study head numbers were found to vary from nil to over 600 per m^2 at seed harvest in well fertilized Nandi plants. However good the seed setting per head, this must be accompanied by a high number of heads if high PGS yields are to be achieved.

The negative correlation between vigour and heading week (Table 2) lends support to the contention submitted here that plants do not produce heads in any appreciable quantity until a minimum of herbage has accumulated. This is a crucial difference from grasses in temperate climates, where day length is the principal determinant of heading time. Therefore, certain concepts on quantity-quality relationships of herbage developed for temperate grasses do not apply to Nandi or other tropical grasses behaving similarly. In temperate climates, heading is rapid and accompanied by a sharp decline in digestibility In tropical grasses heads do not appear in any number unless a certain amount of vegetative growth has developed. Even then, heading is a gradual process and it takes abou six weeks after IHE until some 200 heads have emerged per m^2. At this stage it is stil possible to harvest over 50% of the dry matter in the form of non-heading tillers (Boonman, 1971b, 1972a). This may explain Minson's (1971) finding that tropical grasses do not drop in digestibility as rapidly as temperate grasses.

As heading time is largely determined by vigour, selection for numerous heads should not necessarily lower the herbage quality, certainly not in the pre-heading stage. In fact, young stems are of higher digestibility than leaves (Raymond, 1969; Hacker, 1971).

It was pointed out earlier that varieties must consist of plants grouped according to heading time. If this grouping were done without due regard to the negative correlation observed between vigour and heading week (Fig. 1, Table 2) late heading groups would possess reduced vigour. They also produced fewer heads (Table 3) and are therefore likely to produce less seed as was found by Evans et al. (1960) in bred varieties of temperate grasses. Local evidence to support this contention can be seen from Table 1. Nandi II and Nandi III were developed out of Nandi I primarily for late heading (Bogdan, 1966). Nandi I produced not only higher yields of seed, but also of herbage. A recent Australian report (Hacker, 1972) confirmed that Nandi I (Commonwealth Plant Introduction (CPI) 28709) had a higher herbage yield than Nandi II (CPI 32232). At Kitale, Mbarara Rhodes was found to produce higher yields of dry matter and digestible organic matter than Masaba and Pokot Rhodes (Thairu and Sheldrick, unpublished data).

Preliminary evidence (van Wijk, unpublished data) indicates that early-heading varieties of either Nandi or Rhodes grass have similar if not higher in-vitro digestibilities than late-heading varieties, at a given time, let alone at heading date or at a given level of yield. Additionally, early-heading varieties appear to be more persistent under grazing than late-heading varieties (Boonman, unpublished data). Consequently, late-heading varieties have little to commend them. Varieties that do not run to head early may, however, have a role to play in systems of extensive grassland use, but it is then still important to have late heading combined with high vigour. Even in the very late-heading groups a small proportion of vigorous plants occurs (Fig. 1). However, it requires more effort to pick them out. More difficult may be the task of combining late heading with good seed yield. Masaba Rhodes is, however, an example of a variety that is a good seed yielder though not early-heading (Table 1).

Preliminary evidence (van Wijk, unpublished data) suggests that selection for higher in-vitro digestibility at a given level of dry matter yield may be successful. Conversely, a variety bred for more vigorous regrowth, even if early-heading and potentially high in head number, would enable the farmer to have more frequent grazings with a high level of digestibility. Thus, higher planes of nutritive value can be arrived at by two, possibly concurrent, lines of approach.

Breeding efficiency would be enhanced if the desired ideotype (Donald, 1968) could be discovered at an early stage. With the evidence presently available it can be assumed that seed yield is closely correlated with vigour and, in tufted grasses, a tall growth habit. If this assumption is valid, early detection of useful plants becomes feasible. In old leys, of progressively declining productivity, very few such plants occur (van Wijk, unpublished data). The dominant type appears to be of poor vigour, funnel-shaped or flat-growing, and is apparently of strong competitive ability in mixture with erect types which yield well when alone (Montgomery effect; de Wit, 1960). By developing varieties consisting of uniformly vigorous, erect plants persistence in leys may automatically be improved. Tillering characteristics at an early stage may also provide information about the ultimate value of a plant (Boonman, 1971b).

It has often been said that the performance of spaced plants bears little relationship to its potential in a community. This does not seem to be relevant to spreading species such as Rhodes grass as individual plants can only be evaluated in little swards of their own (Bogdan, 1964). As for the tufted grasses, tropical pastures in Kenya rarely form closed swards but consist of a community of individually recognizable plants. Consequently, plants may confidently be evaluated at close spacings that are convenient for handling.

It is concluded that the breeding of tropical grasses for the intensive pasture areas of Kenya should have the following major objectives: even heading date, good plant vigour, potentially high head number, high seed setting, persistence and high nutritive value.

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