GENERAL SUMMARY AND CONCLUSIONS

This paper records the results of studies conducted over a period of several years on certain seed problems, which have presented themselves in the course of endeavours towards the more profitable utilization of indigenous grasses. These studies deal largely with the question of suitable methods for the overcoming of delayed germination (III and IV), but also, in a preliminary way, with the seed-setting propensities of a number of these grasses and of selections (I). Moreover, the extent and the apparent causes of delayed germination were studied. In addition, certain results obtained from studies conducted on the actual germination of seed during the condition of delayed germination, are given (I). For the sake of a better appreciation of the problem, an effort has been made to present the scope thereof as revealed by the literature.

The seed-setting studies were, as far as possible, made under conditions of natural pollination, but owing to early shedding in the panicums in general, the individual heads had to be covered shortly after anthesis of the earlier flowers, thus necessitating daily shakings of enclosed heads. The results, based on heads enclosed on small demonstration plots, show, on the whole, great variability in the seed-setting ability of individual ecotypes and selections. The N'Gamiland

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Digitaria ecotypes included, were selected for good seed-setting and the values recorded, therefore, do not reflect the true position within this genus, the ecotypes of which are, on the whole, poor seeders, the majority setting seed sparingly, while a few apparently set no seed. General experience would indicate that seed-setting ability is not restricted to species boundaries. On the other hand, the best seeders in this genus would appear to originate from the drier regions, which fact is, to some extent, brought out in the data presented, although ecotypes from the same geographical region may vary very considerably in this respect. Some excellent seeders have been revealed, though in the majority of cases extreme variability is displayed within the ecotype, which is not readily accounted for. The "makarikari" selections (*Panicum coloratum* ?) exhibit great differences in seed-setting between individual selections, varying from 1 - 71%, indicating that much scope for improvement exists. On the whole, variability within this series is reasonably low, which is also somewhat the case with the 10 *Chloris gayana* ecotypes, of which one shows a very low value for seed-setting. The variability in the *Cenchrus* ecotypes is extreme, both as regards individual ecotypes and within the group as a whole. Judging from the data on *Digitaria Smutsii*, it would appear that season may have a very big influence on seed-setting, which agrees with experience in the field. In contrast to the *Panicum* selections, those within the *D. Smutsii* group show little variation in seed-setting ability. Disease is a very important factor in the seed-setting of native grasses.

Germination studies were so far only possible with seeds which were in a condition of delayed germination. Under these conditions it has been found that alternating temperatures may produce considerable increase in germination, as compared with even temperatures, which in no case have been

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able to effect complete germination of any kind of seed, still in the condition of delayed germination. The requirements of various kinds of seed, in regard to alternating temperatures, varied with the kind and age (i.e. condition of after-maturation) of the seed. Under the conditions of the present tests, it was found that certain kinds of seed could not be stimulated by any of the temperature combinations employed. Lack of response in this connection was not restricted to genus or species, so far as the results go. Even after certain treatments had given fairly successful stimulation, alternating temperatures could still induce further stimulation in certain kinds of seed, though not in others.

Low temperatures of 15°C or 20°C so far appear not to be of any value, for the improvement of germination capacity, even when the moisture content of the sand was varied with the 15° temperature and, as far as experience goes, this also applies to even temperatures of 35° and 40°C. Pre-cooling at ca. 5°C for various periods induced favourable response in one of the two kinds employed, the most favourable period appearing to be about 2 weeks. Within reasonable limits, the moisture-content of the quartz sand used during pre-cooling, had no distinct effect on the course of germination.

Light (diffused) may have an influence on the germination of certain kinds of seed and this may be quite appreciable. Of the several lines of seed examined for light requirements, the larger number appears not to be sensitive to it. As regards the light-sensitive types, the majority so far germinate better in the dark than in the light, but on the other hand, light was favourable to a <u>Setaria</u> (A.296) ecotype. KNO_3 may have a favourable influence on certain kinds; for others it was found harmful. In the last-mentioned species the favourable effect is, however, only obtained in light, not in the dark,

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with which the effect is harmful, whereas in certain others the reverse seems to be the case. With the same concentration of $MgCl_2$, $MgSO_4$ and $NaNO_3$, the last appeared to be harmful in light, the others giving responses about equal to water, both in light and in dark.

A very large percentage of seed-setting ecotypes were under observation for the progress of their delayed germination and everyone so far has exhibited this characteristic, which was found to vary from less than 2 months in the "Peddie" ecotype (Digitaria), to over 3½ years for other ecotypes of this genus. After the latter period it was still found that certain ecotypes were showing a germinability of only 1 - 10%. Resistance to germination does not seem to be restricted to certain genera or to ecotypes from a particular geographical or ecological region, and ecotypes of the same species, as for example Chloris gayana, may exhibit extreme differences. Under the conditions of storage employed (both outdoor and indoor), the course of delayed germination is seldom a smooth curve, Sudden rises and falls may be experienced, the former occuring mainly with the advent of summer. Recovery, partial or complete, is often obtained. On the whole, delayed germination is protracted.

An analysis of the apparent causes of delayed germination has revealed that both seed-coats and "embryos" play a part in all the genera so far studied, the repsective roles, however, varying markedly in different kinds. In Echinochloa, Chloris gayana and Digitaria, as well as certain Panicum ecotypes studied, the "embryos" soon take the lead in the discontinuation of inhibition, the seed-coats retaining their resistance for much longer periods. In the seed of the ecotypes of the Brachiaria, Sporobolus and the majority of those of the Paspalum under observation, the inhibition of the "embryos"

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is only gradually discontinued. Rarely, apparently, do the two factors cease to inhibit germination simultaneously. In the Urochloa, the embryos apparently continue to remain a hindrance to germination, even after about 9 months or more, when the removal of the caryopses (with breaking of seed-coats) gave 88% germination. Embryo retrogression, as indicated by declines in percentage germinability, occur with the advent of spring and summer and seems to be a fairly general phenomenon with a number of the ecotypes studied.

The seed-coat factor would, therefore, seem to be a much more important one than the "embryo" factor in the resistance of these seeds to germination. In fact, it was found that 3½ years old Digitaria seed, germinating under 15%, had already lost about 30% viability; that is, when apparently 85% of the seed-coats were still unready. Such an analysis is considered to be of great value in the study of methods for the promotion of delayed germination.

A large number of organic and inorganic chemicals, including two growth substances and certain of those compounds which has been found effective by other investigators for the breaking of "dormancy" and for root formation, were tested out. The gas and vapour treatments included both short and long periods (up to 2 months). The majority of these chemicals produced stimulation at certain concentrations and periods. Usually only one or two ecotypes were under observation. Several of these chemicals showed excellent stimulation. For example, CO_2 gave 59% increase over its control after 2 months, with Panicum minus F.14. HNO_3 vapours similarly secured a 53% increase with Digitaria seln.24-3. In the same way a 41% increase was registered by Digitaria C.1 with O_2 treatment. At 45°C these gases were very harmful after the second month.

Vapours of thioacetic acid, carbon tetrachloride and

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ethyl thiocyanate gave 40, 43 and 35% stimulation respectively, with the resistant seeds of Digitaria 24-3. NO_2 yielded over 40% increase with Panicum F.14. Soaking in alpha naphtalene acetic acid and beta indolyl acetic acid, though giving good stimulation with the one kind, was, if anything, harmful with the other. On the whole, gas and vapour treatments seem to offer better chances of success than solutions.

Extensive studies were made of physical methods for the hastening of delayed germination, particular attention being given to temperature effects. It was found that continuous exposure of seed (dry) outdoors (sunlight), gave marked stimulation with certain lines after several months, the amount and the period for maximum stimulation depending upon the kind and, so far as can be ascertained, on the age of the seed, but, no doubt, on other conditions as well, such as the time of the year. Germinability may, however, deteriorate very rapidly, even before full stimulation could be attained. The favourable effect does not appear to be one of wavelength only, if at all, since with the use of various "filters", yellow and "darkness" treatments gave far better stimulation than red, for the Setaria seed used, and since, moreover, another treatment outdoors, without direct exposure, realized equally good stimulation. In shade, 0 and 50% humidity proved of little value, the 90% appearing very deleterious. Exposed to sunlight, the 0 humidity was apparently also of no value, whilst 50% humidity, though initially beneficial for certain kinds of seed, brought decline of germinability to all seeds after 4 months. On the whole, restriction of both, aeration and humidity, at the degrees used, were apparently far less beneficial, or even harmful, as compared with free aeration and unregulated humidity, both in shade and in sun, outdoors. The more resistant seeds were, on the whole, stimulated less than

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the less resistant seeds. Aeration would seem to be an important factor.

Storing seed at 0%, 50% and 90% humidity, as well as under conditions of complete aeration and in a sealed atmosphere, inside a refrigerator, indicated rather variable responses for different kinds of seed, so that the relative merits of these treatments remain somewhat obscure, although distinctly harmful effects were discernible in the case of the less resistant kinds of seed after four or more months.

When, however, these conditions are repeated at higher temperatures of 25°, 35° and 45°C respectively, the harmful effect of 0%- and 90%-humidities are clearly demonstrated, particularly the latter, under which seeds loose germinability in a few months' time. The 50%-humidity, though still having some stimulation value at 35°C, has a deleterious effect at 45°C, the seeds loosing their germinability after 2 to 3 months. A sealed atmosphere appears to be more favourable than any of the controlled humidities, but the best stimulation was realized with seeds receiving aeration, there being, apparently, little to choose between 35°C and 45°C. A few of the lines employed - the Urochloa and ecotypes of Panicum and Digitaria - were very resistant and were, moreover, not at all or only very slightly influenced by these treatments. The use of extreme alternating temperatures (25° and 45°C; and 28° and 65°C) appeared to be no more favourable for the hastening of delayed germination than the higher temperatures, employed continuously.

The value of various warm temperatures (28°, 40° and 50°C) for the improvement of delayed germination of fresh seed of various kinds, when subjected to these temperatures for 1 - 2 months and thereafter kept at room temperature, was also studied. It was revealed that for the ecotypes of Digitaria, Panicum and the one species of Paspalum utilized, the

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method proved to be of little benefit with the periods tested out, even after about 9 months. The Paspalum notatum seed was, however, benefited by a 60 days' treatment at 40 and 50°C, so that a period of 30 days is perhaps too short for these resistant kinds. A 76 days' period at 50°C with one rhodesgrass ecotype gave about 70% stimulation 2 months after the heat treatment, the germinability dropping subsequently. Pre-treatment at 20°C would appear to be of no value and 28° after harvesting is, if anything, favourable for this ecotype.

Heat at 65°C gave fairly good and quick stimulation with the several ecotypes employed, the period needed for maximum stimulation varying with the ecotype. After about 70 days the germinability exhibited complete deterioration, which may, however, not necessarily signify loss of viability.

The value of heat (65°C), cold (3°C) and sunlight, in single combinations with each other, alternated for varying periods and also heat and cold, used as pre-treatment, for varying periods, with both outdoor (sunlight) and room storage were also investigated for the improvement of delayed germination. The responses obtained with the 3 kinds of seed used were very variable; stimulations of as much as 80 to 90% were, however, realized. The heat and cold alternations induced the best stimulation with the Digitaria and Setaria, but this was followed by sudden and complete deterioration of germinability. In all combinations with sunlight, the Panicum outdoor control eventually equalled the stimulation obtained with the treatments. Pre-cooling with both room and outdoor storage was of great benefit only to the Digitaria and particularly with room storage.

With soaking and drying as well as with soaking, fairly good stimulation was realized with certain kinds, but hot-water, soaking and freezing, ultra-violet light and radium

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oxide treatments were, so far as these studies go, of little or no value. Breaking the seed-coats mechanically, by means of rubbing, gave marked stimulation, but the small size of the caryopses of most of the native seeds and the close envelopment of seed coverings (bracts) would seem to be very unfavourable factors from a practical standpoint.

Though it has not been possible to standardize methods for overcoming delayed germination, as an outcome of these studies, valuable information has been accumulated, which should be very helpful not only in further studies, but also in our future needs, so far as the more practical aspects of our investigations are concerned. When seed supplies of useful ecotypes and selections become available, not only will it then be possible to undertake certain large-scale studies along the lines already indicated, but it will then become necessary to adopt suitable storage measures to bring about the desired ageing within reasonable time. If germination capacity is not high enough at the time of the first planting season, it will be desirable to keep the seeds over until the following season. Two or three months of outdoor exposure should contribute materially to the improvement of the germinability, without incurring much risk of loss of viability.

Although the problem is perhaps more complex than one would wish to think, particularly where seed in a condition of delayed germination may be looked upon as being composed of various physiological groups (the size of these depending upon the stage of after-maturation), it is nevertheless possible that it will eventually, in practice, solve itself.

Finally, the main results may be briefly summarized as follows :-

1. Seed production is very variable, the majority of the assembled ecotypes being low or poor seed-setters, but good scope for improvement would appear to exist.

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2. The germination of seed in a condition of delayed germination was largely or partly affected by such methods as alternating temperatures, pre-cooling at 5°C, regulation of light conditions, KNO_3, and breaking of the seed-coats, though so far not by temperatures of about 15°C or 20°C. Seed coverings (bracts) may form a hindrance to germination in certain ecotypes.

3. No species (ecotype) showed immediate germination, the duration of delayed germination varying from about 2 months to well over 3 years, and may be a good deal longer.

4. In all genera studied, both seed-coat restrictions and "embryo" inhibition were found to be responsible for the observed delayed germination, the former having shown itself to be the factor of longest duration.

5. For the purpose of overcoming delayed germination, CO_2, O_2, HNO_3-fumes, NO_2, CCl_4, thioacetic acid vapours and solutions of the growth substances alpha naphthalene acetic acid and beta indolyl acetic acid, were found to be the most effective chemical treatments.

6. Of the many physical treatments employed for overcoming delayed germination, outdoor exposure - insolation, as well as indirect exposure to sunlight -, heat, alternations of heat and sunlight and of heat and cold, and also soaking, produced marked stimulation.

In conclusion the view may be expressed that though the results appear to be contradictory, this is perhaps to be expected, not only in the light of the results of other workers, but also from the findings here reported in regard to the causes of delayed germination. It would thus seem that direct and indirect evidence lend support to the viewpoint that, within

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a single sample, seed - in a state of delayed germination - is composed of physiological classes, each, so to say, requiring different conditions for overcoming delayed germination.

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