INFLUENCE OF SPECIFIC GRAVITY OF SEEDS ON EARLY SEEDLING GROWTH AND DEVELOPMENT IN CACAO[1] /

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Resumen

Las semillas de cuatro tipos forasteros de cacao fueron asignadas a seis grupos en función de su gravedad específica (g.e.) utilizando un sistema agua-azúcar (sacarosa). Tales grupos fueron g.e. menor de 1.00; de 1.00 a 1.03; de 1.03 a 1.06; de 1.06 a 1.09; de 1.09 a 1.12; y superior a 1.12. Las semillas de cada grupo fueron estudiadas en relación a su influencia sobre la germinación, desarrollo del tallo y la raíz, producción foliar, y peso fresco y peso seco de tallos y raíces. Se tomó nota de las variaciones entre los tipos respecto a la distribución de semillas por cada grupo de gravedad específica, así como por su influencia en las características de las plántulas. Así, un incremento en gravedad específica fue altamente correlacionado con un incremento en desarrollo y en producción de materia seca. Debido a esta relación, el método puede ser utilizado en la selección masal de semillas de cacao para mejor desarrollo de las plántulas y posiblemente también para una mayor habilidad en llegarse a establecer. La selección a favor de semillas de elevada gravedad específica asegurará una mayor uniformidad de plántulas vigorosas y puede resultar beneficiosa en promover una mayor habilidad en llegarse a establecer así como tolerancia a la sequía durante el período crítico inicial de crecimiento.

Introduction

Mass selection based on seed weight and specific gravity is being used in selection programmes in soybeans (6, 7, 14). Seed weight and density are known to influence germination, seedling growth and vigour and later performance in rice (15), wheat (12), barley (4), rye (7) *Phalaris* (19), *Lolium* (16) and *Bromus* (17). Seed characters were reported to be influencing establishment ability also (1, 12, 20). Mc-Daniel (9) has shown that seed weight was positively associated with seedling vigour and mitochondrial metabolism. Heavy seeds have got greater growth potential than light seeds and this was shown by enhanced mitochondrial protein synthesis, greater enzyme production and higher respiratory rate.

The available literature on the subject mostly are related to annuals or perennial grasses and only very few studies are made on perennial tree species. Heavier seeds were reported to influence the quality and vigour of seedlings in arecanut (3, 4) cashew (11, 18) and rubber (13). Menon, Ravindran and Nair (10) recently showed that in cashew specific gravity of seeds has got significant influence on germination rate, germination period and seedling vigour. The present work was undertaken to study whether specific gravity differences have any bearing on seedling growth and vigour in cacao. A major limiting factor for cocoa cultivation in India is the long spell of drought for about 5-6 months. This in turn leads to poor establishment of seedlings under field conditions. Hence it became necessary to explore the possibilities to identify seedlings that have got better establishment ability and greater vigour. This was the aim to initiate this work which forms part of a long term programme on breeding for drought resistance in cocoa.

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Materials and Methods

In the present study more stress was given to specific gravity (sg.) of seeds than seed weight because the latter might be influenced by moisture content. Specific gravity of seeds has been defined as the ratio of the weight of a given volume of seed to that of an equal volume of another substance used as a standard (6). A graded series of sugar solutions with increasing sg. were used for classifying seeds of four forastero cocoa genotypes. The material for the study came from the seedling progenies of cocoa genotypes introduced from Malaysia and maintained at the CPCRI Regional Station at Vittal. The seeds from mature pods were cleaned and were grouped into different sg. classes by immersing them in distilled water and sugar solutions of increasing sg. The seeds were kept for 4-5 minutes before taking them to the next higher sg. solution. After each, the seeds were blotted dry. Six sg. groups were recognized: (1) below 1.00; (2) 1.00-1.03 (3) 1.03-1.06 (4) 1.06-1.09 (5) 1.09-1.12 and (6) above 1.12.

A sample of seeds from each sg. group was sown in washed river sand in polybags, kept in uniform shade in a polyethylene-roofed house, and under uniform conditions. Germination, growth, and other characters were recorded for a sample of 25 seedlings from each treatment. On the 40th and 80th days a 2% solution of an NPK fertilizer mixture (Suphala) was given at the rate of 250 ml per bag. On the 100th day the seedlings were taken out by cutting open the polybags and immersing them in water so that the root system could be obtained without damage. Shoot length, root length, number of leaves, fresh and dry weight of root and shoot were recorded. Dry weight was recorded after drying the roots and shoots at 100°C for 48 h.

Results and Discussion

The distribution of seeds in the various sg. groups was found to differ in the four genotypes studied (Figure 1). In one, the distribution was almost normal while in others it was very much uneven and the majority of the seeds were concentrated in one or two sg. groups. Only one type gave a few seeds having sg. above 1.12. In all the types the highest number of seeds were in the 4th sg. group (1.06-1.09). In one case the first group (below 1.00) was also absent. In three out of four, the percentage of seeds falling in different sg. groups increased sharply as the sg. increased from the third (1.03-1.06) to fourth (1.06-1.09) group.

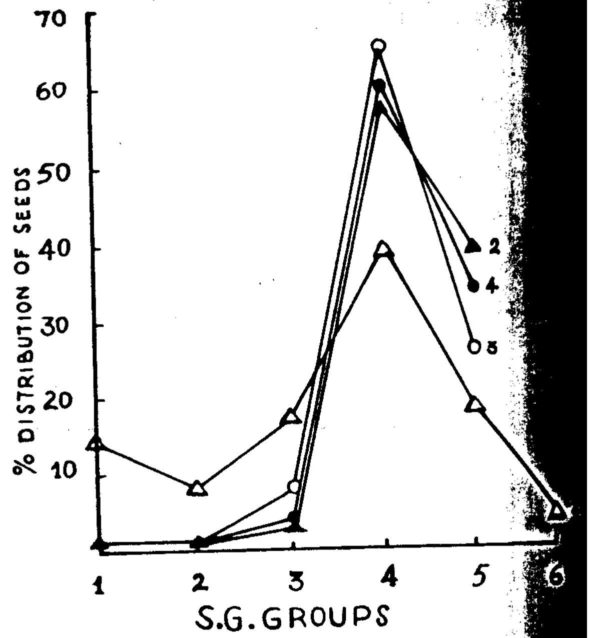

Fig. 1. Distribution of seeds in different sg. groups in four cacao cultivars.

Certain amount of variability could be expected in cocoa because of its heterogenous nature. Still the distribution pattern of sg. groups was probably an inherent character because the same pattern was noticed when seeds were collected from different trees of the same genotypes and studied. Seed weight was found to be not influenced by sg. in two types while in other two, seeds of higher sg. had higher seed weight.

Germination rate and the time required for germination (germination period) were not very much affected by the sg. differences. Reduction in germination rate was noted only at the two lower sg. groups. The seeds with sg. below 1.00 gave only 36% germination and the second group (sg. 1.00-1.03) gave only 72%. All the other sg. groups gave uniformly high germination. The reduction in germination noted in low sg. might be due to the improper development of the embryo or cotyledons or both. In cashew significant differences were recently reported (10) in germination rate and germination period among the different groups of seeds. They calculated a vigour index based on these parameters that could be of use in seed selection. Such marked differences were not found in the case of cacao. Differences between the two species could be expected because of the difference in their physiological condition; in cocoa the seeds were fresh and physiologically active and the process of germination started immediately after sowing while in cashew the seeds were dormant and dry.

Though growth rate was recorded after 30 days and 100 days, only the final observation was analysed. After 100 days, shoot length was significantly different in the various sg. groups. In all the types, there was general increase in shoot length as the sg. increased, reaching the highest values in fourth and fifth groups (Figure 2). Deviation from this general relationship was noted only in the last sg. group of type 1. This deviation could not be explained, but here the sample was too low (only six plants) for a reliable estimation. In the other cases high correlation was noted between sg. and shoot length (Table 1). The coefficient of correlation was highly significant in one of the types, but not so in the others. Similar results were also obtained in the case of cashew (10). The results also indicated that if the two lower sg. groups were discarded it could be possible to produce vigorous seedlings of uniform stand.

Similarly as the sg. increased, a proportionate increase in root length was noted. This relationship was most evident in type 2, less evident in 3 and 4 and least in 1. In all the cases the higher sg. groups gave considerably higher root growth, the maximum being in 4th and 5th groups. In cashew it has been reported that sg. differences did not affect root growth significantly. This lack of effect has been explained by the authors to be due to the spatial constraint imposed by the container bag.

Fresh shoot and root weights increased with the increasing sg. of seeds. In the case of shoot weight the increase was proportionate, deviation observed only in one case (Figure 4). The highest values were obtained in the highest sg. class (1.09-1.12). In all the types the weight increases were very sharp between the lowest and other sg. groups. Correlation between sg. and shoot growth was high in all the cases

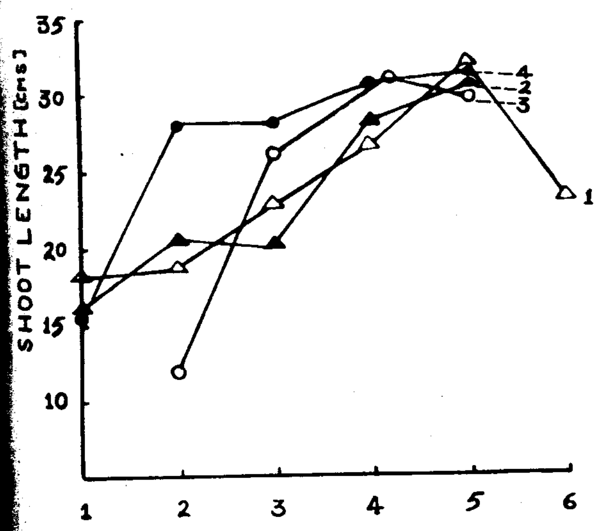

Fig. 2. Influence of sg. of seeds on length of shoots in four cacao cultivars.

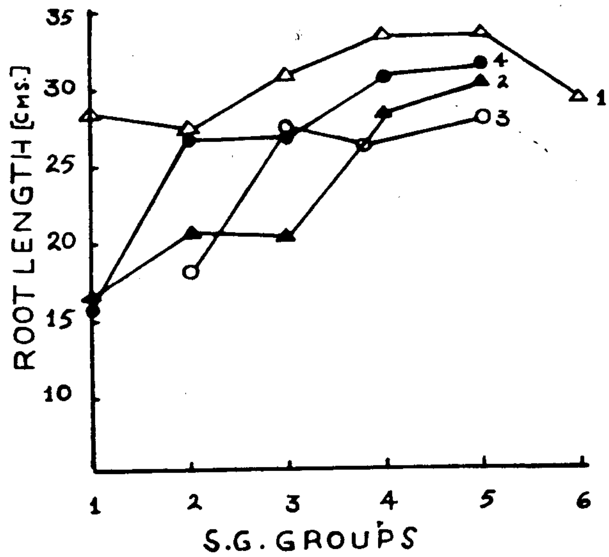

Fig. 3. Influence of sg. of seeds on root length in four cacao cultivars.

Table 1. Correlation coefficients of different sg. groups and their early growth characters.

Variety	Shoot length	Root length	Fresh shoot weight	Fresh shoot weight	Dry shoot weight	Dry root weight
1	0.60	0.44	0.66	0.65	0.48	0.66
2	0.98**	0.77**	0.97**	0.90*	0.97**	0.96**
3	0.84	0.77	0.76	0.75	0.62	0.60
4	0.74	0.41	0.78	0.88*	0.83	-0.98*

* Significant at P = 0.05 level.

** Significant at P = 0.01 level.

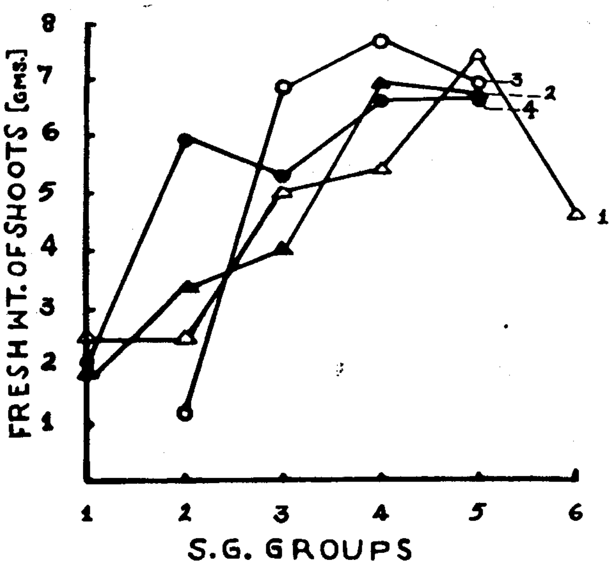

Fig. 4. Influence of sg. of seeds on fresh weight of shoots in four cacao cultivars.

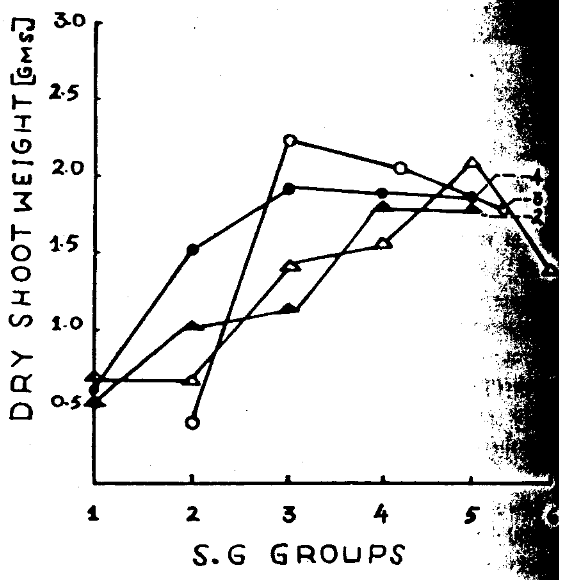

Fig. 6. Influence of sg. of seeds on dry shoot weight i four cacao cultivars.

(Table 1). Similarly root weight was also found to have high correlation with sg. (Figure 5, Table 1). Similar results were also recorded for cashew (10) for shoot weight while for root weight the differences were not significant.

Dry matter production as noted from dry weight of shoot and root was significantly more in the higher sg. groups (Figures 6, 7). High coefficient of correlation was observed in all the cases except i type 1 (Table 1). This increase in dry matter produc tion could be the cumulative effect of better roo and shoot system development, better assimilatio rate and enhanced mitochondrial activity. Studie (9) have shown that heavier seeds have enhance enzyme production, respiratory rate and mito chondrial protein synthesis. The net result of the effects is reflected in greater dry matter accumula

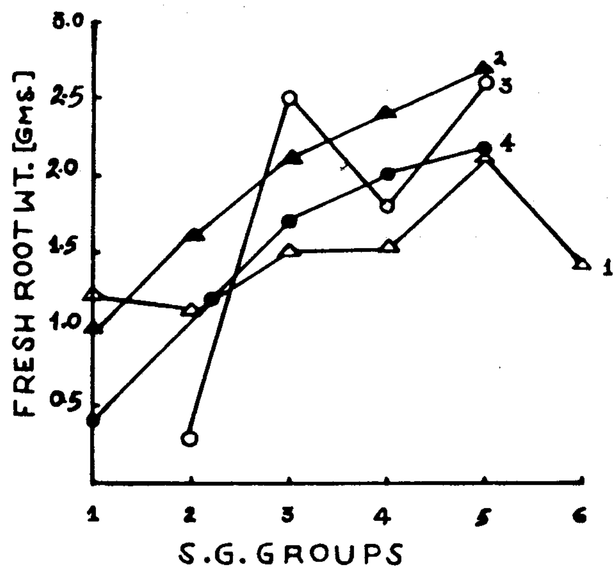

Fig. 5. Influence of sg. of seeds on fresh weight of roots in four cacao cultivars.

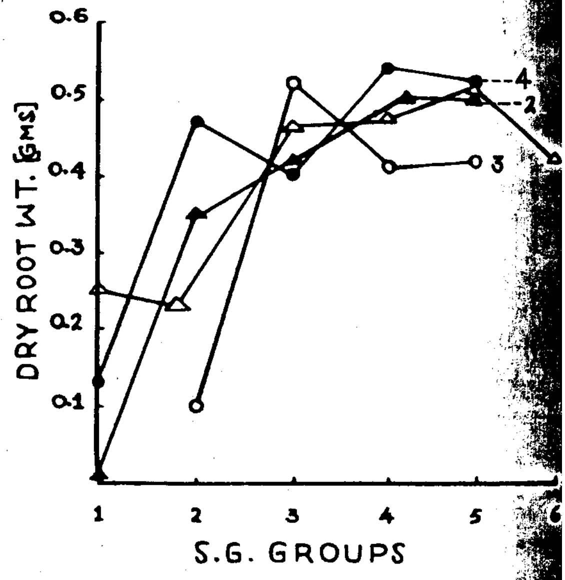

Fig. 7. Influence of sg. of seeds on dry root weight in fo cacao cultivars.

tion and more vigorous growth of seedlings. Similar results were also reported in cashew (10).

Leaf production was not significantly different in any of the cases. Interestingly leaf production was found to have no correlation with any other seedling characters in cashew too, and leaf number was found to be not influenced by the sg. differences of seeds (10). This perhaps indicates that the greater shoot growth can be due to an enhancement in cell elongation rather than an accelerated cell cycle leading to more leaf production, which in turn is related to endogenous levels of growth factors such as gibberellic acid.

The results indicated variability between types both in regard to distribution of seeds in the various sg. groups and in their influence on seedling characters. In type 2, all the characters were significantly correlated with sg. and in other types the coefficients of correlation were high for many of the characters studied. In general, growth and vigour increased with an increase of sg. At least in the case of many annuals and perennial grasses the available evidences show that a positive association exists between seed weight and seedling vigour during both germination and early growth stages. Mac Daniel (9) has shown that heavier seeds have got greater growth potential and that this was shown by enhanced mitochondrial protein synthesis, greater enzyme production and higher respiratory rate. The higher root and shoot development and dry matter production may be indicating a better efficiency of the root system and assimilatory organs, an accelerated cell growth which in turn is related to endogenous levels of growth factors. All these may be important in the successful establishment of the seedling in the early critical period of growth.

Seed vigour is an indication of its potential and for a tree crop like cocoa, selection of seed is of primary importance. Specific gravity of seeds can be employed as an easy mass selection criterion for selecting vigourous seeds that can give seedlings of greater vigour, and may prove beneficial in enhancing establishment ability and drought tolerance in the initial critical period of growth. Since selection can shift the population mean, selecting for higher sg. could be useful in raising the population mean of the progenies with respect to the character. It has been shown in the case of soybean that sg. is related to protein and fat contents of the seeds. If such a relationship exists in cocoa, which is very likely, then sg. selection becomes useful in raising the population mean with respect to fat or protein contents. This character is thus worth including in the future breeding programmes.

In India at present no high yielding selections or hybrids are available; and no selection of parent trees or seeds is being practiced. Under these circumstances the results of the present study assume greater significance as it suggests a method of selecting cocoa seeds, that could lead to more vigorous seedlings, better establishment ability and subsequently more robust tress.

Summary

Seeds from four cacao forastero types were grouped into six specific gravity (sg.) groups using a water-sucrose system. The groups were as follows: sg. below 1.00; 1.00-1.03; 1.03-1.06; 1.06-109; 1.09-1.12; and above 1.12. The seeds from each group were studied in relation to their influence on germination, shoot and root growth, leaf production, fresh and dry weight of shoots and roots. Variations among the types were noted both in respect to the distribution of seeds in the various sg. groups, as well as in their influence on seedling characters. An increase in sg. was strongly correlated with an increase in growth and dry matter production. Because of the relationship existing between high sg. and growth and dry matter production, this method could be used in mass selecting cocoa seeds for better seedling growth and possibly also for better establishment ability. Selection for high specific gravity seeds will ensure uniformly vigourous seedlings, and may prove beneficial in enhancing establishment ability and drought tolerance in the initial critical period of growth.

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