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GENOTYPIC VARIABILITY IN SEED AND SEEDLING GROWTH IN *SESBANIA* SPECIES

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SUMMARY

Twenty six genotypes of *Sesbania aculeata* and *Sesbania rostrata* were examined for variability in seed characters and seedling growth under field conditions. Though the smaller seeds had faster seedling emergence, the relative growth rate and rate of increase in seedling height was higher for larger and heavier seeds. The larger seeds also showed faster leaf emergence, *i.e.* lower phyllochron. In contrast to the field germination, all the *Sesbania rostrata* genotypes failed to imbibe moisture at room temperature indicating physical dormancy due to seed coat impermeability. These seed attributes can be useful in maintaining uniform crop stand (by selection of genotypes and seed treatment) for achieving faster biomass production in *Sesbania* species for green manuring in rice-wheat cropping system.

Key words : **Relative growth rate, seed moisture uptake, seed weight, seedling emergence, *Sesbania aculeata, Sesbania rostrata*.**

INTRODUCTION

India ranks third in fertilizer consumption and the demand is going to rise further due to increased demand for food. In crop like rice, green manuring provides an indispensable means to reduce fertilizer consumption and sustaining soil fertility. Green manuring is important for soil fertility in various rice ecosystems (Buresh and De Datta 1991). The pre-rice fallow period of 45-60 days can be used for fast growing leguminous green manure crops like *Sesbania aculeata* and *Sesbania rostrata* (commonly known as Dhaincha). Green manuring with *Sesbania* improves soil fertility by improving soil physical, chemical and microbial status. Green manuring can meet the nitrogen requirement of the rice crop in the early growth period of up to 40-50 days after transplanting. The vigorous root system of *Sesbania* utilizes significant amount of sub soil phosphorus and transfers it to the surface soil when incorporated (Meelu *et al.* 1991). To improve the green manuring potential of *Sesbania*, a good crop stand and faster biomass production is therefore, required. It depends to a certain extent upon the seedling emergence, establishment, growth and the seed characteristics. The seed coat characteristics of legumes affect the seedling emergence (Gardner *et al.* 1985). Several *Sesbania* species have seed coat impermeability (Cook *et al.* 1974). The seed size and weight are also important traits affecting the seedling growth. Bolder seed size is advantageous for initial seedling vigour (Gardner *et al.* 1985). The present study was therefore, undertaken to examine seedling growth and its association with related characters in *Sesbania aculeata* and *Sesbania rostrata* species.

MATERIALS AND METHODS

Twenty six accessions of *Sesbania* which include sixteen *S. aculeata* genotypes viz. LJ-29, LJ-31, LJ-32, LJ-33, LJ-34, LJ-35, LJ 36, LJ-37, MD(S)-1, Ses Pant-1, NDAU(S)-1, Rajendra Dhaincha, Hisar Local, PDCSR-local, Pant Ses-1A, EC 435738) and ten genotypes of *Sesbania rostrata* viz. EC 178342, EC 391970, EC 331973, EC 223312, EC 218472, EC 95553, EC 213472 A, EC

213473, IC 75625 and CO-1) were obtained from NBPGR, New Delhi. Seeds were sown in field conditions in Randomized Block Design with two replications on June 2nd 2000 at Research Farm of Project Directorate for Cropping Systems Research, Modipuram (29°4'N, 77°46'E), Meerut (U.P.). Fifteen gram seeds of each entry were sown in 3m row length at 45 cm row spacing. Fertilizers were applied @ 60 kg P_2O_5 ha^{-1} and 40 kg K_2O ha^{-1} at the time of sowing.

Days taken to seedling emergence were recorded under field conditions. Germination percentage was recorded in terms of score i.e. poor (less than 40 %), fair (40 to 60 %), good (61 to 80 %) and very good (81 to 100 %) germination. The absolute growth rate of seedlings (g day^{-1}) up to 25 days after sowing (DAS), rate of increase in height of seedlings up to 25 days from emergence, relative growth rate (g g^{-1} day^{-1}) from 25 to 50 DAS (Blackman 1919) and Phyllochron, *i.e.* the time interval between same developmental events between successive leaves (Rickman and Klepper 1995) was measured as growth dgree-days taken per leaf emerged up to 25 DAS. The base temperature for growth of *Sesbania* was assumed as 10°C on the basis of similarity in growing season to other warm season crops, e.g. rice, maize, sorghum etc that have a base temperature of 10°C (Krug 1997). The leaf area was taken with the help of Leaf Area Meter (*Li-COR* Model 3100). The volume of *Sesbania* seeds was determined by water displacement method by taking 200 seeds in a 10 ml measuring cylinder. The seed surface area was estimated as per the formula for surface area of a cylinder, because the *Sesbania* seeds appear closely similar to cylindrical shape as evident from photograph (Plate 1). Surface area: volume ratio was then obtained. Seed weight $seed^{-1}$ was calculated from sample of 200 seeds. The moisture uptake of seeds was estimated by taking fresh seed weight initially and after 3, 6 and 9 hours of soaking on moist filter paper in petriplates at room temperature. Results are reported only for 6 hrs of seed moistening and expressed as per cent water absorbed per initial seed weight.

The mean values were used to calculate the correlation coefficient between two variables. Regression equation and R^2 value has been provided along with the graphical illustrations with the help of Microsoft Excel programme.

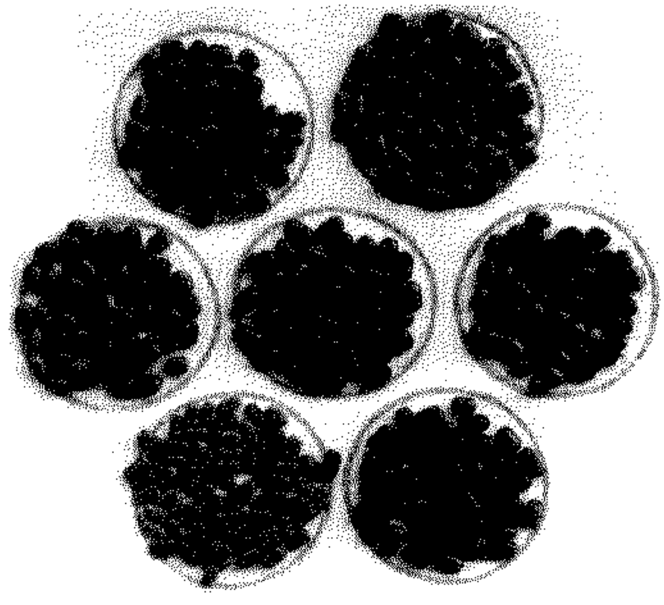


Plate. 1. Variability in seeds of *Sesbania* species

RESULTS AND DISCUSSION

The days taken for seedling emergence under field conditions were positively correlated with seed weight per seed (r=0.423, Fig. 1), i.e. the larger seeds taking more time for emergence. Marshall (1986) also observed in some species including *Sesbania drummondii*, higher percentage germination of small seeds than large ones under natural condition. Small and medium sized seeds of *Glycine max* emerged from soil more rapidly than large ones (Edward and Hartwig 1971). The larger seeds have larger cotyledons, which encounter a greater soil resistance to emergence (Gardner *et al.* 1985). This cold also be due to the lower surface area: volume ratio of the larger seeds (r = -0.795, Fig. 2). Lower surface area: volume ratio may be related to lesser rate of moisture uptake and thus

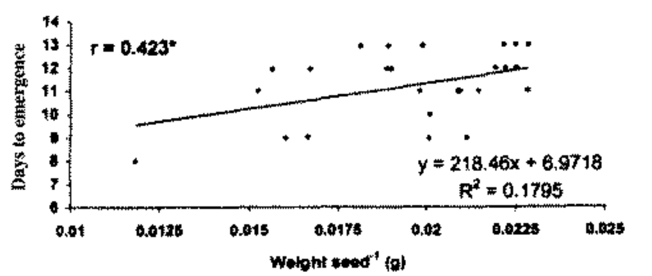


Fig. 1. Relation of seed weight with days to seedling emergence

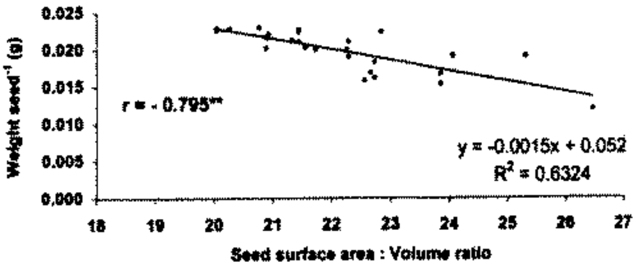


Fig. 2. Relation of seed surface area: volume ratio with seed weight in *Sesbania* genotypes

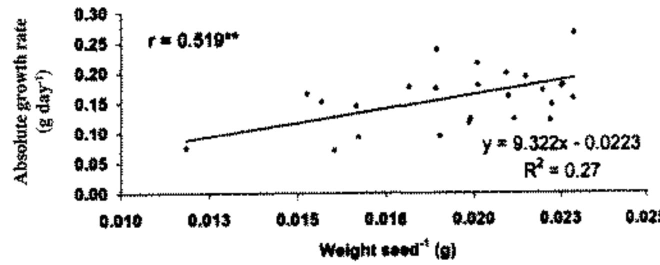


Fig. 4. Absolute growth rate of seedlings from emergence to 25 DAS

resulted in late emergence of larger seeds of *Sesbania.* However, the rate of moisture uptake of seeds after 6 hrs was negatively correlated with surface area: volume ratio (i.e. larger seeds having higher moisture uptake rate) (r = -0.667, Fig. 3) but this was only for *S. aculeata* species. The EC genotypes, mostly, *S. rostrata*, have

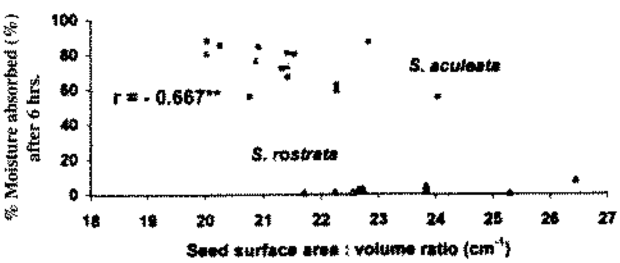


Fig. 3. Moisture uptake by *Sesbania* seeds in relation to seed surface area: volume ratio

smaller seeds as compared to LJ series belonging to *S. aculeata* (Table 1). Irrespective of size variation these seeds take longer time to germinate due to seed coat impermeability. The observed correlation between seed size and germination rate is, therefore, not understood properly. Other factors may also be contributing to the late seedling emergence of larger seeds. Under natural or simulated habitat temperature, large seeds of many species including *S. macrocarpa* and *S. vesicaria* showed higher percentage germination than small ones (Marshall 1986, Baskin and Baskin 1998). In other species germination is either rapid for smaller seeds or is independent of seed size (Baskin & Baskin 1998). After emergence, the absolute growth rate of seedlings up to 25 DAS had significant and positive association with seed weight seed^{-1} (r = 0.519, Fig. 4). This may be attributed to the greater storage of seed reserves in larger seeds that can be used by the seedling in the early stages of growth than in the small one. The larger seed cotyledons have a higher specific leaf weight and a greater initial photosynthesis (Black 1959, Gardner *et al.* 1985). Leishman *et al.* (1995) also suggested that seed size is a major determinant of absolute growth rate (g day^{-1}) of seedling. Similarly, the increase in height of seedlings (cm day^{-1}) was positively correlated with individual seed weight (r = 0.386, Fig. 5). The faster leaf emergence as indicated by lower

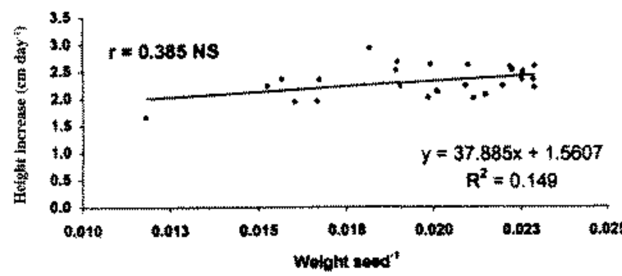


Fig. 5. Rate of increase in seedling height from emergence to 25 DAS in relation to seed weight

phyllochron (Rickman and Kelpper 1995) was also observed in case of larger and heavier seeds (r = -0.737, Fig. 6). The RGR of plants between 25 DAS and 50 DAS was not correlated with the seed size in both the species of *Sesbania* (r = 0.132, Fig. 7) but the plant height at 50 DAS

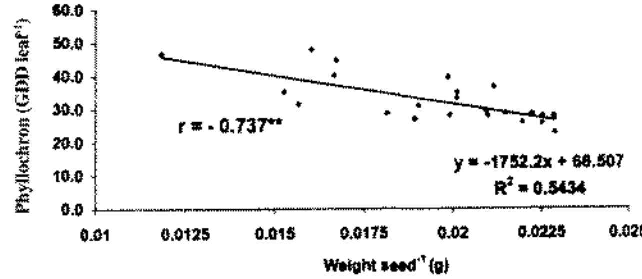


Fig. 6. The Phyllochron in relation to seed weight in *Sesbania* genotypes

Table 1. Variation in the seed weight and field germination of *Sesbania* genotypes.

Accessions	*Sesbania* species	1000 Seed weight (g)	Field germination score
EC 178342	*S. rostrata*	15.25	Fair
EC 391970	*S. rostrata*	16.64	Fair
EC 331973	*S. rostrata*	11.83	Very good
EC 223312	*S. rostrata*	15.66	Fair
EC 218472	*S. rostrata*	16.02	Poor
EC 95553	*S. rostrata*	16.71	Very good
EC 213472A	*S. rostrata*	18.93	Fair
EC 213473	*S. rostrata*	19.90	Good
IC 75625	*S. rostrata*	19.84	Poor
CO-1	*S. rostrata*	18.14	Good
LJ 29	*S. aculeata*	22.84	Very good
LJ 31	*S. aculeata*	22.53	Good
LJ 32	*S. aculeata*	22.18	Good
LJ 33	*S. aculeata*	20.10	Very good
LJ 34	*S. aculeata*	22.87	Good
LJ 35	*S. aculeata*	21.96	Good
LJ 36	*S. aculeata*	22.51	Good
LJ 37	*S. aculeata*	21.47	Fair
MD(S)-1	*S. aculeata*	20.90	Very good
PANT SES-1	*S. aculeata*	21.13	Very good
NDAU(S)-1	*S. aculeata*	20.97	Very good
RAJENDRA DHAINCHA	*S. aculeata*	19.02	Very good
HISAR LOCAL	*S. aculeata*	22.23	Very good
PDCSR LOCAL	*S. aculeata*	18.89	Very good
PANT SES- 1 A	*S. aculeata*	20.09	Very good
EC 435738	*S. aculeata*	22.87	Good
Mean	Overall	19.67	-
	S. rostrata	16.89	54% (score based)
	S. aculeata	21.41	80% (score based)
CD. (5%P)	-	1.548	-

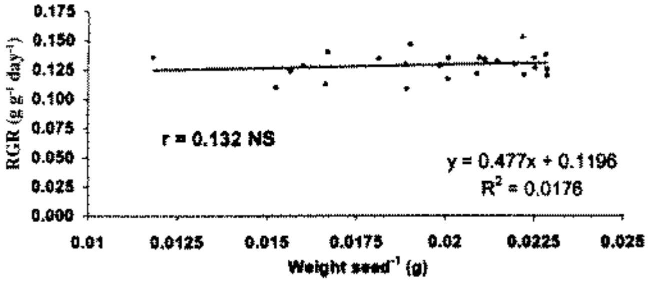


Fig. 7. RGR of *Sesbania* plants between 25 to 50 DAS in relation to seed weight

was positively correlated with the seed weight (r = 0.549, Fig. 8). Choe *et al.* (1988) also reported that the RGR of adult plants of *Raphanus raphanistrum* from different

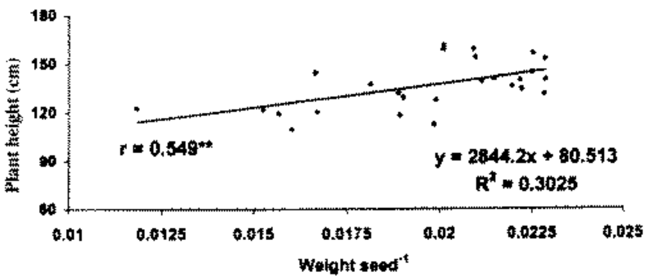


Fig. 8. Plant height of *Sesbania* genotypes at 50 DAS in relation to seed weight

seed sizes was similar but the size of adult plants was three times higher from the larger seeds (Stanton 1985, Choe *et al.* 1988). Larger plants usually have higher leaf area, as observed from the positive correlation between plant height and leaf area per plant (r = 0.622, Fig. 9). Thus it is logical to assume that the larger sized plants having higher leaf area can support a larger seed size.

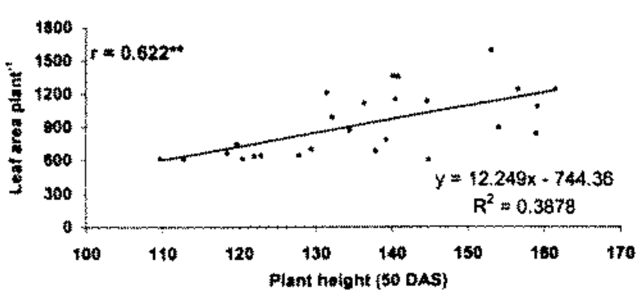


Fig. 9. Leaf area per plant of *Sesbania* genotypes in relation to plant height at 50 DAS

The percentage moisture absorbed by *Sesbania* seeds (Fig. 10) indicates physical dormancy due to seed coat impermeability in *S. rostrata* species. The moisture uptake

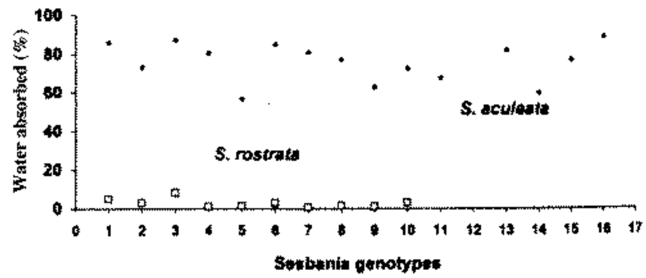
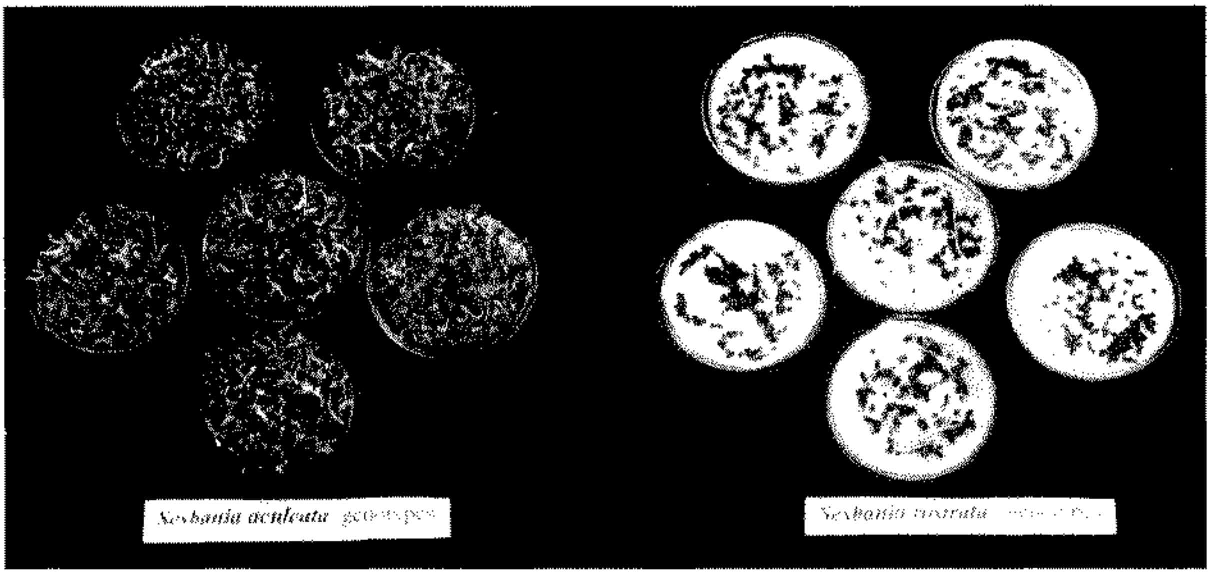


Fig. 10. Moisture absorption by seeds of different *Sesbania* genotypes

(% water absorbed per initial seed weight) after 6 hrs of seed soaking on mosit filter paper ranged from 55.8 to 88.4% in the sixteen *S. aculeata* genotypes whereas in *S. rostrata* it ranged from 0.8% to 8.4%. The poor germination of *S. rostrata* as compared to *S. aculeata* seeds after 4 days on moist filter paper at room temperature provides further evidence about seed coat impermeability (Plate 2). The *S. rostrata* species is reputed to be hydrophytic i.e. having high water requirement and bear aerial stem nodules (Tomakpe *et al.* 1991). Other aquatic *Sesbania* species eg *S. bispinosa*, *S. hististyla* and *S. sesban* also have physical seed dormancy due to seed coat impermeability (Cook *et al.* 1974). Seed coat softening treatments eg boiling water treatment (98°C for 30 sec.) to *S. punicea* seeds (Graaff and van Staden 1983) and concentrated sulphuric acid treatment for 4 hrs.to *Sesbania drummondii* are required for maximum germination (Eastin 1984). In the present experiment no seed treatment was given for softening the seed coat. There was no difference in days to emergence of *S. aculeata* and *S. rostrata* seedlings under field condition; both taking about 8-13 days for emergence. However, the overall germination score was 54% and 80% for the *rostrata* and *aculeata* species respectively. In contrast to the poor moisture uptake and very poor or no germination under room conditions (where the diurnal temperature fluctuations are minimized, Fig. 10, Plate 2), the field germination percentage was 54%. This may be attributed to the high soil temperatures of about 45-50°C and diurnal variation during end of May to early June under north Indian conditions. This might have disrupted



(A) (B)

Plate 2. Germination of *Sesbania* genotypes 4 days after seed soaking at room temperature. (A): *Sesbania aculeata* (B): *Sesbania rostrata*

seed coat impermeability and helped in the emergence of *S. rostrata* genotypes in field conditions. Taylor (1981) also reported the loss of physical dormancy of *Trifolium subterraneum* seeds due to exposure to high daily temperature fluctuations during summer and suggested the role of physical expansion and contraction of seed.

Seed germination in *Sesbania* has been a problem because of physical dormancy. There are many factors responsible for seed germination, establishment and growth. The cause of delay in germination in *Sesbania* accessions haveing higher seed weight, observed in the present study, needs to be further investigated. The larger seeds however, showed higher seedling growth and vigor (in term of high RGR, faster increase of height and lower phyllochron). The selection of suitable genotypes based on traits such as seed weight, seed surface area: volume ratio, seedling growth rate, days to emergence, moisture absorption pattern would therefore help in better seedling establishment, faster growth and finally higher biomass production for green manuring.

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REFERENCES

Baskin, C.C. and Baskin, J.M. (1998). Seeds, Ecology, Biogeography, and Evolution of Dormancy and Germination. Academic Press, California, USA.

Black, M. and Naylor, J.M. (1959). Prevention of the onset of seed dormancy by gibberellic acid. *Nature* **184**: 468-469.

Blackman, V.H. (1919). The compound interest law and plant growth. *Ann. Bot.* **33**: 353-360.

Buresh, R.J. and De Datta, S.K. (1991). Nitrogen dynamics and management in rice—legume cropping systems. *Adv. Agron.* **45**: 1-59.

Cook, C.D.K., Gut, B.J., Rix, E.M., Schneller, J. and Seitz, M. (1974). Water Plants of the World. A Manual for the Identification of the Genera of Freshwater Macrophytes. Junk, The Hague.

Choe, H.S., Chu, C., Koch, G., Gorham, J. and Mooney, H.A. (1988). Seed weight and seed resources in relation to plant growth rate. *Oecologia* **76**: 158-159.

Eastin, E.F. (1984). Drummond rattlebox (*Sesbania drummondii*) germination as influenced by scarification, temperature, and seedling depth. *Weed Sci.* **32**: 223-225.

Edwards, C.J., Jr. and Hartwig, E.E (1971). Effect of seed size upon rate of germination in soybeans. *Agron. J.* **63**: 429-430.

Gardner, F.P., Pearce, B.R. and Mitchell, R.L. (1985). Physiology of Crop Plants, 209-245. Iowa State Univ. Press. Ames.

Graaf, J.L. and van Staden, J. (1987). The relationship between storage conditions and seed germination in two species of *Sesbania*. *S. Afr. J. Bot.* **53**: 143-146.

Krug, H. (1997). Environmental influences on development, growth and yield. In: H.C. Wien (ed.), The Physiology of Vegetable Crops, pp. 101-180. CAB International.

Leishman, M.R., Westoby, M. and Jurado, E. (1995). Correlates of seed size variation: A comparison among five temperate floras. *J. Ecol.* **83**: 517-530.

Marshall, D.L. (1986). Effect of seed size on seedling success in three species of *Sesbania* (Fabaceac). *Am. J. Bot.* **73**: 457-464.

Meelu, O.P., Singh, Y. and Singh, B. (1991). Adoption and successes of using green manuring crops in rice farming. In: S.K. Dutta and Charles Sloger (eds.), Biological Nitrogen Fixation Associated With Rice Production, pp. 315-327. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.

Rickman, R.W. and Klepper, B.L. (1995). The phyllochron: where do we go in the future. *Crop. Sci.* **35**: 44-49.

Stanton, M.L. (1985). Seed size and emergence time within a stand of wild radish (*Raphanus raphanistrum* L.): The establishment of a fitness hierarchy. *Oecologia* **67**: 524-531.

Taylor, G.B. (1981). Effect of constant temperature treatments followed by fluctuating temperatures on the softening of hard seeds of *Trifolium subterraneum* L. *Aust. J. Plant. Physiol.* **8**: 547-548.

Tomekpe K., Dommergues Y., Gillsis, M., Holsters, M. and Dreyfus B. (1991). Stem-nodule forming Rhizobia and *Sesbania* green manure crop. In: S.K. Dutta and Charles Sloger (eds.), Biological Nitrogen Fixation Associated Wtih Rice Production, pp. 17-24, Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.