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Grain number estimation, regression model and grain distribution pattern in sorghum (*Sorghum bicolor*) genotypes

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ABSTRACT

Crop yields in physiological models are determined as a product of their yield components like the grain numbers/ plant times the average kernel weight at maturity. The grain numbers are calculated as a function of the above ground biomass growth during the panicle initiation phase. Biomass production of sorghum [*Sorghum bicolor* (L.) Moench] is influenced by genotype and management interaction, while transformation from vegetative to reproductive phase is influenced by genotype by environment, i.e. photoperiod of a given season. The grain weight in all the models is calculated as a function of the cultivar specific optimum growth rate multiplied by the duration of grain filling. Grain growth dynamics is thus a function of management, environment and genotype. Plant breeder's objective of enhancing the grain yield potential was achieved through improved translocation of dry matter produced into grain, that varies from 30 - 40%, in the newly developed hybrids. Increase in productivity brought about by genetic improvement is related to grain number and kernel weight. Grain number estimation is a tedious process and this paper attempts a simplified application of a regression model that relates grain number (dependent variable) with the spikelet weight (independent variable). A regression equation, Y = 24.626 X + 9.7136 derived using pooled dataset was used to predict the grain number. The rigor of the regression fit is validated using both predicted and observed grain number, based on the derived regression coefficient, which ranged from 0.97 to 0.99.

Key words : Grain number, Regression model, Sorghum, Spikelet weight

Sorghum (*Sorghum bicolor* (L.) Moench) is one of the nutritious cereals, popular among the most food insecure population in the semi-arid tropics of the world. The crop is highly adaptable to the hot and dry agro-ecological regions as compared to other fine grain cereals which require more congenial environment. In India, the crop is grown during *kharif* (rainy), *rabi* (post-rainy), and summer seasons across different states. The All India Coordinated Sorghum Improvement Project (AICSIP) has the national mandate of improving sorghum productivity across different sorghum growing states in India (Kumar *et al.* 2010).

Crauford *et al.* (1999) in a detailed study of time to flowering in sorghum landraces of diverse origin, used a photo-thermal model fitting approach for rate of development and found intrinsic earliness and responsiveness to photoperiod (critical photoperiod and slope) to be the major factors explaining genotypic variation in time to flowering. The *kharif* season is typically characterized by longer photoperiod, while in *rabi* (Oct-Feb) season a cultivar experiences shorter photoperiod (< 11.5 hr) with the annual phenomenon of equinox falling on 21 September. Ravi Kumar *et al.* (2010) while modeling the environmental factor influence on sorghum phenology found that *rabi* cultivars CSH 13R and M 35-1 matured more rapidly than the other 3 genotypes (AT × 623/RT × 430, Buster and QL41/QL36). This may have been associated with the smaller number of much larger grains produced by the sorghum genotypes (van Oosterom and Hammer 2008).

Yield differences in cereal crops are associated with kernel number (the product of panicles per square meter and kernels per panicle) and kernel weight. Potential for yield compensation occurs early in the plant life cycle through adjustment in the number of panicles per square meter and kernels per panicle (Nouri Maman *et al.* 2004). Variation in kernel weight allows for a degree of yield compensation late in the life cycle. Increases in kernels per panicle and in kernel weight may help compensate for low plant populations or limited tillering. As a result of this compensatory power, grain yield in cereals is relatively insensitive to plant population (Anderson 1986); however this compensation is less than perfect in grain sorghum (Kiniry 1988).

A better understanding of the developmental processes determining kernel number and their distribution pattern in

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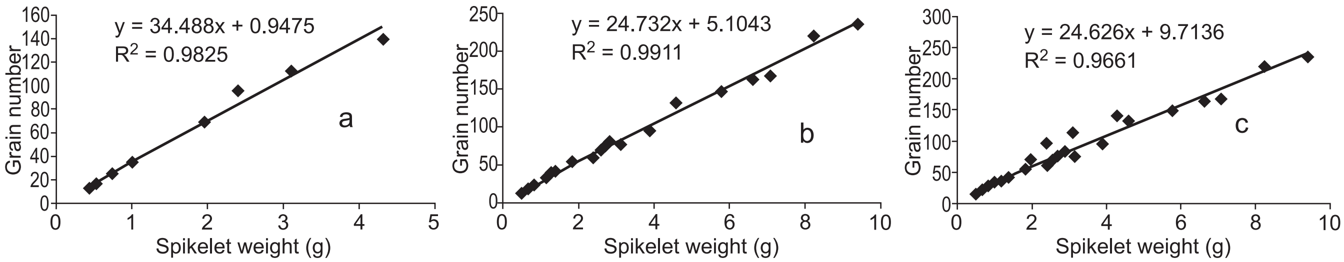

Fig 1 Linear relation between spikelet weight and grain number in a.372A × CB 135, b. CSH 16 and c. Pooled data.

the earhead could enhance the efficiency of breeding programs aimed at improving grain yield. Data pooled over two *kharif* seasons across different sorghum hybrids and varieties have been utilized to generate a regression model. A generic model based on the mean values of sorghum cultivars and a specific model based on individual hybrid, have been developed. The paper attempts to substantiate the importance of grain number in sorghum and as well compare the distribution pattern across sorghum genotypes.

MATERIALS AND METHODS

Kharif sorghum experimental hybrids of 50 nos. involving various female and male parents were grown during *kharif* 2010 and 2011, in a RBD layout. They were initially established by irrigation at sowing and later allowed to grow under rainfed conditions so as to quantify their relative performances. At harvest in both the above experiments, the grain number and spikelet weights across individual earheads in selected test hybrids were recorded so as to fit a regression model. Individual datasets within a given hybrid as well as pooled data across hybrids were utilized to derive the regression equations.

The hybrids 372A × CB 135 and CSH 16 were harvested and the grain number and spikelet weights were recorded across the earheads. A linear regression equation was derived using the individual data over a range of spikelet weights (0-10g) of the said hybrids (Fig 1 a & b) and a pooled equation with their combined data (Fig 1 c).

The respective equations were as follows:

i. $Y = 34.488 X + 0.9475$ with an R^2 value of 0.98

ii. $Y = 24.732 X + 5.1043$ with an R^2 value of 0.99

iii. $Y = 24.626 X + 9.7136$ with an R^2 value of 0.97

The rigor of the procedure was validated by interpolating both predicted (using the above equations) and observed grain number (manual count) so as to draw valid conclusions.

RESULTS AND DISCUSSION

Validation of individual and pooled equations

The equations derived individually within each hybrid when used to predict the grain number showed a better fit between predicted and observed grain number with a regression coefficient of 0.99 (Fig 2a). The grain number predicted using a pooled equation across hybrids, showed a scatter from the trend line with a regression coefficient of 0.97.

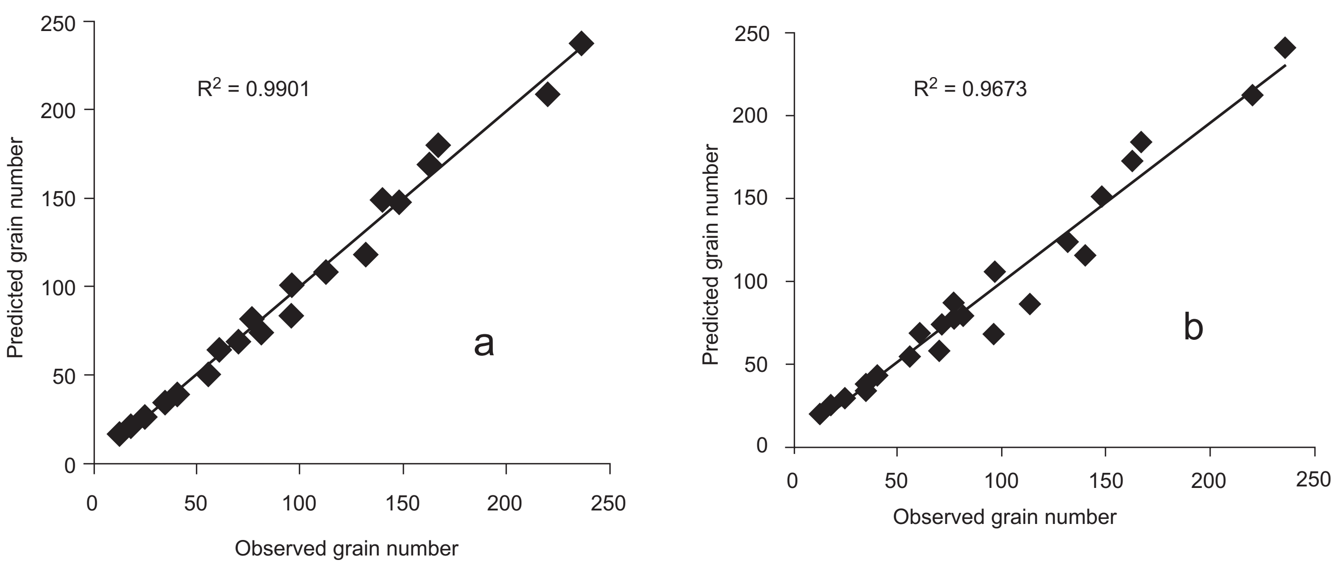

Fig 2 Predicted versus Observed grain number a. using equation i & ii, b. using iii.

Pooled regression equation Y = 24.626 X + 9.7136, can be used to estimate sorghum grain number (Y), using an independent variable as spikelet weight (X).

Grain distribution pattern across earhead

Grain number and test weight (1000 seed weight) are two important criteria used by plant breeders in the selection process, since they contribute significantly to the increased yields in potential hybrids of sorghum. About 11 best performing genotypes were selected from the 50 test experimental hybrids which were derived from female parents like 27A, 151A, 161A, 372A, 415A, 455A. Some of the crosses involved the following male parent like CB 131, 132, 133, 134, 135, 137, 138. The grain number and spikelet weight when plotted as a function of primary rachis number indicated a distinct distribution pattern with more grain concentrated at the bottom of the earhead.

The physiological analysis of cereals indicate that, for a given species and environment, allocation of resources during the panicle development phase allows for a high plasticity in seed number, while grain filling phase provides a relatively narrow range of seed size, that results from breeding and agronomic selection. Predicting grain number based on spikelet weight provides for a quick estimate, which could be utilized as a basis for selecting potential hybrids in sorghum. Among the experimental hybrids evaluated during *kharif* season, those based on the following female parental lines like 151A and 415A showed greater potential in terms of grain number which was derived as a function of spikelet weight. A regression equation Y = 24.626 X + 9.7136, can be used to estimate sorghum grain number (Y), using an independent variable, i.e. spikelet weight (X). Since weighing individual spikelet is faster than manual count of the grain number, the regression equation provides an alternative approach to estimate sorghum grain number.

REFERENCES

Anderson W K. 1986. Some relationships between plant population, yield components and grain yield of wheat in a Mediterranean environment. *Australian Journal of Agricultural Research* **37**: 219–33.

Crauford P Q, Mahalakshmi V, Bidinger F R, Mukuru S Z, Chantereau J, Omanga P A, Qi A, Roberts E H, Summerfield R J, Hammer G L. 1999. Adaptation of sorghum: Characterization of genotypic flowering responses to temperature and photoperiod. *Theoretical and Applied Genetics* **99**: 900–11.

Kiniry J R. 1988. Kernel weight increase in response to decreased kernel number in sorghum. *Agronomy Journal* **80**: 221–26.

Kumar S R, Ramanjaneyulu A V and Krishna A 2010. A decadal analysis of improved sorghum (*Sorghum bicolor*) cultivar response to fertilizer application in rainy season and a hypothetical grain production model. *Indian Journal of Agricultural Sciences* **80**: 786–90.

Nouri Maman, Stephen C Mason, Drew J Lyon, and Prabhakar Dhungana. 2004. Yield components of pearl millet and grain sorghum across environments in the central great plains. *Crop Science* **44**: 2 138–45.

Ravi Kumar S, Graeme L Hammer, Ian Broad, Peter Harland, and Greg McLean. 2009. Characterising environmental effects on phenology and canopy development of diverse sorghum genotypes. *Field Crops Research* **111**: 157–65.

van Oosterom, E J, and Hammer G L. 2008. Determination of grain number in sorghum. *Field Crops Research* **108**: 259–68.