Maize Yield Forecast Based on Cob Size

Bal B.P.S. Goel

Indian Agricultural Statistics Research Institute

ABSTRACT: This paper gives a method of maize yield forecasting from cob size. There is almost a linear relationship between grain weight and size of a fully developed maize cob. Harvesting of maize is done normally 6-8 weeks after the cobs are fully developed. Its length, thickness and fullness determine size of a cob. A linear relationship between grain weight and cob size can be easily estimated on the basis of these measurements along with moisture content of grain from a representative sample of cobs. An estimate of number of cobs per hectare, average cob size and the relationship between grain weight and cob size give a forecast of maize yield about one month before harvest. The method was developed in collaboration with the National Early Warning Unit (NEWU) for Food Security and the Bureau of Statistics (BOS) in Lesotho. It was successfully used for forecasting maize yield in Lesotho for the 1992-93, 1993-94 and 1994-95 crop seasons and in Swaziland for the 1994-95 crop season. The yield forecast obtained by this method was remarkably close to the final yield estimate based on objective crop cutting surveys in both countries.

1. Introduction

Maize is the most important crop in the Southern Africa Development Community (SADC) region of Africa. An advance estimate or forecast of maize production is therefore of much interest to SADC authorities, governments of member states, trade, industry and international community for food security monitoring and other purposes. The final estimate of maize production is obtained as a product of the estimate of maize area and its yield from a crop survey. The estimate of area becomes available in March/April, about 2 months after planting of the crop. A yield estimation survey is done at the time of harvesting in May/June and a yield estimate becomes available in October/November. At that late stage, the estimate is of not much use. Therefore, a method of maize yield forecasting which is simple, objective and which can provide a yield forecast before harvesting of the crop is of much value to all concerned.

2. Background

For obtaining a maize yield forecast in Lesotho, the approaches followed earlier were (1) subjective judgement by agricultural extension staff, (2) FAO water balance model and (3) counting of maize grains in a sample of cobs. The first method is obviously subjective and is therefore not reliable. The second method also has several limitations. The third method consists in counting grains on all cobs on a 10 meter row of maize plants in a sample of fields to estimate the number of grains, and then multiplying it by 0.3 gram (assumed to be weight of one grain) to get average yield per hectare. The method is tedious, time consuming and uses an arbitrary factor 0.3 to forecast yield. The method given here was developed with this background in view.

3. Choice of Independent Variable

Any objective method of forecasting yield involves estimating a relationship between yield and a suitable independent variable(s) which influences the yield and which is easy to measure before harvest. The various independent variables investigated in the past for forecasting crop yields were climatic variables, weather variables, and biometrical or plant characteristics. All these variables have a strong impact on crop yields. In the present study, cob size, which can be easily measured 6-8 weeks before harvest and which has very high positive correlation with yield, was chosen as the independent

variable. A study of the simple correlations between (a) grain weight and count, $\rho 1$, (b) grain weight and cob length, $\rho 2$, and (c) grain weight and cob size, $\rho 3$, on a sample of cobs revealed that $\rho 1$, $\rho 2$ and $\rho 3$ were highly positive with values 0.8 or more. Further, it was also seen that $\rho 3 > \rho 2 > \rho 1$. Thus, it was concluded that the cob size was the most appropriate independent variable for maize yield forecasting. It was interesting to note that $\rho 3$ remained high (around 0.95) even for a combined sample of hybrid and open pollinated varieties of maize. These findings were used to evolve the methodology given in Section 4 for forecasting maize yield.

4. Methodology

$$\text{yield} = \text{average number of cobs} \times \text{average grain weight per cob}$$

4.1 Number of cobs

Number of cobs per hectare was estimated from a subsample of crop-cutting plots selected in the annual yield estimation survey in Lesotho (circular plots of 25 square meter area). All effective (non-empty) cobs in the sample plots were counted and the numbers averaged out.

4.2 Average grain weight

Average grain weight was estimated as a product of average cob size and grain weight per unit size. Length and maximum circumference of all effective cobs on a sample of 5 plants selected out of all the plants in the selected plot were measured with an ordinary measuring tape. The size of a cob is determined in terms of its length and diameter. However, for the sake of convenience, maximum circumference instead of diameter was measured. In order to adjust the size for damaged or partially filled cobs, the extent of fullness (%) was also recorded for the cobs which were not full.

$$\text{cob size (x)} = \text{cob length} \times \text{maximum circumference} \times \text{fullness}/\pi$$

Average cob size was estimated for all cobs. For estimating the relationship between grain weight and cob size, a subsample of 2 cobs was selected out of all the cobs measured above. For these two cobs weight of wet maize grain (in grams) and its moisture content, m (%) was also recorded. Dry weight of grain was determined from the wet weight as follows:

$$\text{dry weight (y)} = \text{wet weight} \times (100\text{-m}) / (100\text{-}14)$$

where "m" is the observed moisture content and "14" is the moisture content in dry grain.

On the basis of the available y and x values as above, the following relationship was estimated between grain weight and cob size for forecasting maize yield:

$$y = \alpha + \beta x + e \, .$$

Average cob weight was estimated from the above by substituting average cob size in the above equation.

5. Results and Conclusions

The forecast of maize yield by this method was obtained in Lesotho for the 1992-93, 1993-94 and 1994-95 crop seasons and in Swaziland for the 1994-95 crop season. In both countries the forecasts were remarkably close to the final yield estimates. Data for these forecasts were collected in

collaboration with NEWU and BOS in Lesotho and in NEWU and Central Statistics Office in Swaziland as a part of the annual crop estimation survey. It may be mentioned that these forecasts were made from a much smaller sample than the one used in the final estimates. Thus, this method could be used as a substitute for the method of crop-cutting. The regression coefficient appeared to be stable over years under normal weather conditions. This, however, needs to be further studied.