A METHODOLOGICAL STUDY ON ESTIMATION OF STRAW TO GRAIN RATIO IN WHEAT CROP

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SUMMARY

Straw production is normally obtained as the product of grain production and straw to grain ratio. However, although appropriate sampling technique is available for estimation of grain production by conducting crop cutting experiments in randomly selected fields, no reliable technique is yet available for estimation of straw to grain ratio. With the development of high yielding varieties for which the straw to grain ratio may vary from one variety to the other, there is an urgent need to develop appropriate survey methodology to estimate the straw to grain ratio with a good precision. In this paper different procedures for estimation of straw to grain ratio for wheat crop have been investigated. The effect of agronomic factors on straw to grain ratio is also studied. The methodology developed has also been illustrated with the help of empirical data.

INTRODUCTION

1.1 One of the main sources of cattle feed in India is straw obtained mostly as a by-product of foodgrains. In view of the large cattle population in the country and the requirement of straw as cattle feed round the year, it would be important to develop a reliable estimate of straw production for planning of cattle feed programmes on realistic basis. However, straw production is normally obtained as the product of grain production and straw to grain ratio. The need for developing a technique for estimating straw to grain ratio with a reasonable precision thus assumes significance particularly when it is known to vary not only from one crop variety to another but also for defferent levels of management and cultural practices as well as under different agro-climatic conditions.

PRELIMINARY INVESTIGATIONS

Estimates of straw to grain ratio based on conventional ratio estimator (ratio of mean straw yield and mean grain yield) have been worked out for indigenous varieties of rice, wheat, maize, jowar, bajra, barley, ragi, small millets, gram and groundnut, by the National Sample Survey Organisation [6]. Similar estimates for some of these crops have also been worked out by the Indian Agricultural Statistics Research Institute. The NSSO estimates were based on data collected through enquiry during 1950-51 to 1952-53 (5th, 6th and 7th rounds) and those of IASRI on data pertaining to the control plots yields of straw and grain in the coordinated model agronomic experiments conducted by the ICAR during 1957-58 to 1961-62 which were obtained by direct weighment. However, these estimates suffered from a number of limitations. The NSSO estimates were subjected to serious non-sampling errors based as they were on data collected by oral enquiry only. The IASRI estimates were based on data obtained from control plots alone and thus did not reflect a representative picture in so far as plots where fertilizers or other treatments were applied were left out. It was, therefore, not very surprising that there were wide discrepancies between the two sets of results, underlying the serious limitation of the estimates of straw to grain ratio obtained in the above survey. Further, in both the investigations, no attempt was made to study the methodological aspects of working out straw to grain ratio with improved precision.

3. OBJECTIVE

The present study was taken up with the main objectives of developing appropriate estimator of straw to grain ratio for wheat crop using different types of estimators. The effect of factors like variety, soil, fertilizer use, rainfall etc. was also investigated. Effect of irrigation on this ratio could not be studied since almost all fields for which data were available both on high yielding and local varieties were reported irrigated. Similarly, there were hardly any fields where crop was grown without application of fertilizers. The straw to grain ratio was therefore examined at different levels of ferstilizer.

4. MATERIAL AND METHOD

4.1 For the present study, data relating to crop estimation suryeys conducted by IASRI under the project "Sample surveys for methodological investigation into HYVP" in Jalgaon district of

Maharashtra during the two years 1976-77 and 1977-78 were utilised [7]. The data were available for 75 and 82 crop cutting experiments on the Kalyan Sona (HYV) and 50 and 48 crop cutting experiments on the indigenous varieties during the two years respectively.

4.2 As the main objective of the present study was to develop a suitable estimator so as to provide reliable estimate of straw to grain ratio, 5 different estimators were studied for the purpose. Some of the others estimators like that based on regression approach were not included in the study since they were too combursome and therefore not commonly used. The 5 estimators investigated and the estimates of their variances are discussed below.

4.3 Let $y_1, y_2 \ldots\ldots, y_n$ denote the straw yield of a random sample of n fields drawn from a population of N fields and $x_1, x_2, \ldots\ldots, x_n$ be the corresponding grain yield for the sampled set of fields.

4.3.1 The conventional ratio estimator (biased) *i.e.* the ratio of arithmetic means (1) denoted by $\hat{R}_1$ is given by

$$\hat{R}_1 = \frac{\bar{y}}{\bar{x}} \text{ where } \bar{y} = \frac{1}{n} \sum_i^n y_i$$

$$\text{and } \bar{x} = \frac{1}{n} \sum_i^n x_i$$

and an estimate of its variance by,

$$\hat{V}(\hat{R}_1) \frac{1-\frac{n}{N}}{n\bar{x}^2}(s_y^2 + \hat{R}_1^2 s_x^2 - 2\hat{R}_1 s_{xy})$$

$$\text{where } s_y^2 = \frac{1}{n-1} \sum_i^n (y_i - \bar{y})^2$$

$$s_x^2 = \frac{1}{n-1} \sum_i^n (x_i - \bar{x})2^2$$

$$s_{xy} = \frac{1}{n-1} \sum_i^n (y_i - \bar{y})(\bar{x}_i - \bar{x})$$

4.3.2 Arithmetic mean of ratios (biased) denoted by R_2 [4] is given by

$$\hat{R}_2 = \frac{1}{n}\sum_{i}^{n} r_i \qquad \text{where} \qquad r_i = \frac{y_i}{x_i}$$

and an estimate of its variance by,

$$\hat{V}(\hat{R}_2) = \frac{1}{n(n-1)}\sum_{i}^{n}(r_i - R_2)^2$$

4.3.3. Geometric mean of ratios (biased) denoted by $\hat{R}_3$ is given by

$$\hat{R}_3 = \left(\prod_{i}^{n} r_i\right)^{1/n}$$

For finding out the estimate of variance of $\hat{R}_3$, the following result [5] has been used

$$V\{g(x)\} = \left[\frac{dg}{dx}\right]^2 V(x)$$

Where $g(x)$ is a funci.on of random variable x and $V(x)$ is the variance of x.

Taking $x = \hat{R}_3$ and $g(x)$ as $\log(\hat{R}_3)$, we have

$$V(\log\hat{R}_3) = \left(\frac{d}{d\hat{R}_3}\log\hat{R}_3\right)^2 V(\hat{R}_3) = \frac{V(\hat{R}_3)}{\hat{R}_3^2}$$

$$\text{Now } V(\log\hat{R}_3) = V\left[\frac{1}{n}(\log r_1 + \log r_2 + \ldots + \log r_n)\right]$$

$$= \frac{1}{n^2}\left[\frac{V(r_1)}{r_1^2} + \frac{V(r_2)}{r_2^2} + \ldots + \frac{V(r_n)}{r_n^2}\right]$$

$$= \frac{1}{n^2}\left[\frac{nV(\hat{R}_2)}{r_1^2} + \frac{nV(\hat{R}_2)}{r_2^2} + \frac{nV(\hat{R}_2)}{r_n^2}\right]$$

$$= \frac{V(\hat{R}^2)}{n}\sum_{i}^{n}\frac{1}{r_i^2}$$

$$\text{hence } V(\hat{R}_3) = \hat{R}_3^2\frac{V(\hat{R}_2)}{n}\sum_{}^{n}\frac{1}{r_i^2}$$

and its extimate is given by

$$\hat{V}(\hat{R}_3) = \frac{\hat{R}_3^2}{n}\,\hat{V}(\hat{R}_2)\,\sum_i^n \frac{1}{r_i^2}$$

4.3.4. The harmonie mean of ratios denoted by $\hat{R}_4$ is given by

$$\hat{R}_4 = n\left[\sum_i^n \frac{1}{r_i}\right]^{-1}$$

The estimate of variance of $\hat{R}_4$ is obtained by a procedure similar to that for $V(\hat{R}_3)$ and is given by

$$\hat{V}(\hat{R}_4) = \frac{\hat{R}_4}{n}\,\hat{V}(\hat{R}_2)\left(\sum_i^n \frac{1}{r_i^2}\right)^2$$

4.3.5 The Hartley-Rose unbiased ratio type estimator [2,3] denoted by $\hat{R}_5$ ls given by

$$\hat{R}_5 = \hat{R}_2 + \frac{n(N-1)}{N(n-1)\bar{x}N}\,(\bar{y} - \hat{R}_3\,\bar{x})$$

where $\bar{x}_N = \frac{1}{n}\sum_{i=1}^{N} x_i$

and the estimate of variance of $\hat{R}_5$ is given by

$$\hat{V}(\hat{R}_5) = \frac{s_r^2}{n} + \frac{2C'}{(n-2)\bar{x}_N} + \frac{(n-1)s_r^2 s_x^2 + (n-3)C^2 + (1-\frac{2}{n})(n-1)K_{22}}{(n^2-n-2)\bar{x}_N^2}$$

where $s_r^2 = n\,\hat{V}(\hat{R}_2)$

and C, C' and K_{22} (Fisher's K statistics) are given by

$$n(n-1)C = n\sum_i^n y - \left(\sum_i^n x\right)\left(\sum_i^n r_i\right)$$

$$(n-1)\,C' = \sum_i^n y_i\,r_i - 2\sum_i^n y + \hat{R}_2^2 \sum_i^n x_i - (n-1)\bar{x}\,s_r^2$$

$$K_{22}=\frac{n}{(n-1)(n-2)(n-3)}\,(n+1)\sum_i^n y_i^2-\frac{2(n+1)}{n}$$

$$\sum_i^n y_i x_i \sum_i^n r_i-\frac{2(n+1)}{n}\sum_i^n y_i r_i \sum_i^n x_i$$

$$-\frac{(n-1)}{n}\sum_i^n x_i^2\sum_i^n r_i^2-\frac{2(n-1)}{n}\Big(\sum_i^n y_i\Big)^2+\frac{8}{n}\sum_i^n y_i$$

$$\sum_i^n x_i\sum_i^n r_i+\frac{2}{n}\sum_i^n x_i^2\Big(\sum_i^n r_i\Big)^2+\frac{2}{n}\sum_i^n r_i^2\Big(\sum_i^n x_i\Big)^2$$

$$-\frac{6}{n^2}\Big(\sum_i^n x_i\Big)^2\Big(\sum_i^n r_i\Big)^2$$

5. Results and Discussion

5.1 The estimates of straw to grain ratio alongwith the estimates of their variances as obtained for different estimators studied are presented in Table-1 for both high yelding and local varieties of wheat for 1976-77 and 1977-78. Considering the precision of the various estimators R_4, the Harmonic mean of ratios and R_5, Harltey Ross estimator proved quite poor compared to the remaining three, the variances being much higher than those of the other three estimators. It was also seen that of the other three estimators R_2, the arithmetic mean of the ratios was more efficient than R_1, the conventional ratio estimate and R_3, the Geomatric mean of the ratios, Further, this was true for both the high yielding as well as the local varieties and also for both the years which showed that of all the various estimators studied, this estimator namely the arithmetic mean of the ratios (R_2) was consistently the most efficient estimator of the straw to grain ratio. The grain in efficiency in R_2 was of the order of 10-24 percent compared to R_1 and of the order of 5-12 percent compared to R_3 over the two years as well as over the varieties.

5.2 Taking the estimate of straw to grain ratio, it was obserservd that this estimate was significantly higher for the indigenous varieties compared to that for the high yielding varieties for both the years which may, infact, be expected. However, the difference

TABLE 1

Estimate of straw to grain rrain ratio and estimate of its variance under different estimators

Year	*Variety*	*Number of observations*	*Estimate of straw to grain ratio*					*Estimate of variance*				
			$\hat{R}_1$	$\hat{R}_2$	$\hat{R}_3$	$\hat{R}_4$	$\hat{R}_5$	$\hat{R}_1$	$\hat{R}_2$	$\hat{R}_3$	$\hat{R}_4$	$\hat{R}_5$
1976-77	Kalyan Sona	76	2.72	2.77	2.74	2.70	2.72	0.0033	0.0027	0.0029	0.2900	0.9200
	Locol	50	3.15	3.25	3.19	3.14	3.15	0.0110	0.0100	0,0110	0.2300	2.0000
1977-78	Kalyan Sona	83	2.56	2.67	2.60	2.55	2,56	0.0049	0.0043	0.0048	0.2500	0.7700
	Local	48	2.83	2.87	2.82	2.78	2.83	0.0077	0.0062	0.0065	0.5200	1.6200

between two ratios declined from 15 to 10 percent in the second year.

The variation in the estimate of straw to grain ratio for different intensity of rainfall is presented in Table-2. It was observed that the ratio was the lowest for the above normal rainfall during both the years and also for both high yielding and local varieties indicating thereby that adequate moisture availability during the crop growth period was essential for maximising the grain component of crop.

5.3 To study the variation in the straw to grain ratio for different levels of fertilizer use sample correlations were worked out between levels of N, P & K and corresponding ratios for the two years separately for high yielding and local varieties. None of these correlations was found significant indicating that different levels of fertilizer use in the range of observations available in the data did not have a significant effect on straw to grain ratio both for the high yieldtng and indigenous varieties.

6. Approach for Future

6.1 The development and introduction of new varieties of crops and for that matter the various recommendations regarding the extent and intensity of adoption of associated improved agricultural practices is a continuous and dynamic process. This process is bound to have its impact on agricultural production including straw to grain ratio. Hence, it would be desirable to work out straw to grain ratio of a crop at ragular/appropriate intervals of time along with the yield estimation surveys, if possible, in order togather information on the change in this ratio under the changing agriculture as well as to built up reliable estimates of production of straw.

6.2 Data for estimating grain yield are colleted in the State series of crop cutting experiments as well as under other surveys conducted by various Central and State agencies. Data on straw yield can also be collected alongwith those for grain yield and as such no separate planning of the experiments or the selection of field/plots would be needed for this purpose. However, from operational point of view, taking into account the quantity and volume of the straw involved as well as the difficulty of its weighment, the cost and efforts involved would rise codsiderably apart from the cumber some nature of work. The collection of data on straw yield, therefore, may be limited to 25-50% of the experiments planned on a crop in a district depending on the resources

TABLE 2

Straw to grain ratio according to intensity of rainfall under different estimators

Year	Rainfall	*Kaiyan Sona*					*Local*				
		$\hat{R}_1$	$\hat{R}_2$	$\hat{R}_3$	$\hat{R}_4$	$\hat{R}_5$	$\hat{R}_1$	$\hat{R}_1$	$\hat{R}_3$	$\hat{R}_4$	$\hat{R}_5$
1976-77	Below Normal	2.57	2.57	2.57	2.56	2 57	2.78	2.79	2.79	2.79	2.78
	Normal	2.75	2.81	2.77	2.73	2.75	3.19	3.29	3.23	3.18	3.19
	Above Normal	2.51	2.47	2.45	2.43	2.52	2.61	2.69	2.69	2.68	2.53
1977-78	Below Normal	2.81	2.81	2.81	2.80	2.81	—	—	—	—	—
	Normal	2.82	2.89	2.84	2.80	2.82	3.12	3.10	3.06	3.03	3.13
	Above Normal	2.30	2.38	2.32	2.29	2.29	2.59	2.66	2.62	2.59	2.59

available. This will no doubt affect the precision of the estimate of straw yield. For obtaining straw yield with a high degree of precision, suitable estimators can be developed with the help of double sampling approach by using straw to grain ratio based on the experiments from which data on both these aspects have been collected and using the overall average yield of grain which is based on a larger sample. Considerable saving of time and effort could be achieved and the estimate of straw yield obtained with a high precision by following the above procedure.

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