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Variability study in sorghum (Bhal and Costal zone crop) field experiments and yardstick there of

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ABSTRACT

The data on C.V. % for sorghum crop yield along with other details of 87 field experiments conducted during 1989-90 to 2014-15 at Dhandhuka center (Bhal and Coastal zone crop), were collected and analyzed. The frequency distribution tables were prepared for various experimental factors. The upper fiducial limits (the yardstick) of C.V. % at 95% confidence based on non central 't' distribution were worked out for accepting the results of sorghum crop experiments which emerged as 17 %.

Key words: CV%, Fiducial limit, Plot size, Non central t distribution, Experimental variability

Statistics is used to interpret data and sometimes to determine whether data are suspect. Most researchers are familiar with the use of the least significant difference (LSD) needed to separate two or more means. Another statistical measurement familiar to many scientists and taught in most basic statistics course is the coefficient of variation (CV). This familiar measurement was created in the late 1800s as a measure of variability. However, ever since it was tacitly promoted as a measure of experimental validity by (Snedecor and Cochran, 1967). Its original purpose has been largely ignored. The experimental data provide information on controlled (treatment effect) and uncontrolled variation. The uncontrolled variation is expressed as experimental error, which could be quantified as an estimate called 'coefficient of variation (CV)'. Besides, fertility variation among experimental units (plots), the factors contributing toward uncontrolled variation are climatic and experimental. Therefore, CV of field experiments varies with the situation. Lower magnitude of CV is the reflection of reliability (precision) of the experimental results. The acceptable range of CV advocated by various workers is based on the experience with very limited number of experiments. There is a need to develop a yardstick (critical value) for CV based on theory and also on a large number of experiments conducted under different situations. The present paper deals with this aspect. Johnson and Welch, 1939 reported that for a normal distribution, the ratio of mean to standard deviation should be of the order of 3 or more. Further, they mentioned that 33% has often been stated as the permissible upper fiducial limit of CV. Tyagi *et al.*1973 and Patel *et al.*, 1978 pointed out that CV obtained for the crops under study was found to be considerably higher than those reported from the uniformity trials. They stated that the yardstick for accepting experimental results should be worked out using CV observed in the experiments rather than in the uniformity trials. Bajpai and Nigam, 1980 suggested a working rule for deciding the value of *W*2 (weight corresponds to precision of the experiment) and developed an index to evaluate agricultural field experiments statistically. Gomez and Gomez, 1984 reported that CV varies greatly with the type of experiment, the crop grown and the character measured. They opined that the acceptable range of CV is 6 to 8

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% for varietal trials, 10 to 12 % for fertilizer trials and 13 to 15% for insecticidal and herbicidal trials on rice. Patel *et al*. 2001, reported that the when the coefficient of variation in pulse experiments in RCBD exceeds 23%, the experimental findings should not be considered for any purpose. Consequently, the CV has been used as a measure of validity for many types of agricultural experiments, from fertilizer experiments to crop performance trials. The CV was created as a measure of relative variability by Kendall and Stuart, 1977. Aflakpui, 1995 state that "there is no such thing as a CV for an experiment, only for individual variates." However, a CV of 10 to 15% for yield in experiments is generally expected by most field crop researchers. This expectation probably originated from Cochran and Cox's, 1957 statement that "the coefficient of variation is often between 5% and 15%." The basis for the CV is the assumption that the variance increases as the size of the mean increases. Allen *et al.*, 1978 reported a positive relationship for several crops, and Gotoh and Osanai, 1959 reported a positive relationship for wheat. Masood and Javed, 2003 reported based on the coefficients of variation the optimum plot sizes for maize trials were estimated to be (14.06 m^2) with square shape. Khan and Mead, 1998 presented uniformity data from field trials for improving precision of agriculture field experiments in Pakistan. Darji *et al.*, 2010, developed the yardstick of CV % for forage crop experiment at 95 % confidence based on non central 't' distribution were worked out for accepting the results of forage crop experiments which emerged as 14%.

MATERIALS AND METHODS

The secondary yield character data of 87 sorghum field experiments conducted during 1989-90 to 2014-15. Information on plot size, number of treatments, replications, experimental design and disciplines was collected for each experiment.

The plot-wise yield data were subjected to statistical analysis and CV was estimated for individual experiments. The same was assumed as random variable in further analysis.

CV is a function of square root of mean square (S) and mean ($\bar{X}$).

$$CV = \frac{S}{\bar{X}} \qquad (1)$$

The distributions of $\bar{X}$ and S have simple forms and Student's t distribution provides complete solution for testing the hypothesis or estimating fiducial limits relating to either m or s, singly. But t distribution cannot be used for $CV = \frac{S}{\bar{X}}$ Mckay, 1932 used non-central t-distribution for providing fiducial limits of CV.

Let z be a quantity distributed normally about zero mean with unit standard deviation and let w be a quantity distributed independently as χ^2, with degrees of freedom of χ^2

Then, if t is defined by the equation:

$$t = \frac{\delta + Z}{\sqrt{W}} \qquad (2)$$

Where δ is some constant, then t is distributed in a manner depending only on d and f. This distribution is a non central t-distribution. When d equals zero, the distribution is the familiar Student's t.

Let an estimate of V be $v = S/\bar{X}$ the sample coefficient of variation.

Now, one may write

$$\frac{\sqrt{n}}{v} = \frac{\sqrt{n}\bar{X}}{S} = \frac{\sqrt{n}(\bar{X}\mu -)}{\sigma} + \frac{\sqrt{n}\mu}{\sigma} + \frac{S}{\sigma} \qquad (3)$$

It appears from comparison with eq. (2) that $\frac{\sqrt{n}}{v}$ is distributed as non-central t with $f = (n - 1)$ and $\frac{\sigma\sqrt{n}}{v}$. This distribution can be used for test of significance and for providing fiducial limits of V (i.e. CV), as is done for μ. Since the objective was to work out the yardstick based on CV, the upper fiducial limit of CV using non-central t-distribution was estimated following the procedure given by (Johnson and Welch, 1939).

$$\text{(i) } CV = \frac{\sqrt{Error\ mean\ square}}{naem\ lareneG}$$

n = number of treatments × number of replications in a given experiment, $f = n - 1$ degrees of freedom.

Now, the upper fiducial limit of CV is,

$$CV_{LU} = \frac{\sqrt{n}}{\delta}(f, to\ \delta)$$

Where, $t_0 = \frac{\sqrt{n}}{CV}$

(ii) Find

$$Y = \left[1 + \frac{t_0^2}{2f}\right]^{1-/2}$$

Or

$$Y' = \frac{t_0}{\sqrt{2f}}\left[1 + \frac{t_0^2}{2f}\right]^{1-/2}$$

According to whether $\frac{t_0}{\sqrt{2f}}$ is greater than or less than 0.75. Consider $\frac{t_0}{\sqrt{2f}}$ lies between – 0.75 and 0.75, otherwise consider *Y*.

(iii) If $f > 9$, calculate $\frac{12}{\sqrt{f}}$

(iv) Select desired probability level of confidence, i.e. *e* and obtain $\lambda(f, t_0, \varepsilon)$ from the table in (Johnson and Welch, 1939) interpolating with respect to the quantities obtained in (ii) and (iii).

(v) Calculate

$$\delta(f, t_0, \varepsilon) = t_0 - \lambda\left[1 + \frac{t_0^2}{2f}\right]^{-1/2}$$

In the present investigation, the yardstick of CV for field experiments was worked out using two concepts: (i) average upper fiducial limit of CV for each of the 87 sorghum crop field experiments was worked out separately and then average of these upper fiducial limits was computed, and (ii) upper fiducial limit of CV based on average size of experiments, i. e. degree of freedom. The upper fiducial limit of 95 % and 90 % worked out using the theory of truncated t distribution as described by Johnson and Welch, 1939.

RESULTS AND DISCUSSION

Table 1 Upper fiducial limit of CV % for different disciplines of sorghum (Bhal and Coastal zone) crop

Discipline	No. of expt.	CV %	U L		Range		CV % > 16.18	
			(0.05)	(0.10)	(0.05)	(0.10)	No.of expt.	Proportion
Agronomy	30	14.10	16.95	16.25	2.84	2.15	7	8.00
Pl.Breeding	57	12.24	15.77	14.88	3.53	2.64	10	11.49
Average	87	12.88	16.18	15.35				

The results presented in Table 1 revealed that mean CV % and upper fiducial limits of average value of all the discipline except for Agronomy and soil science disciplines, were below the mean CV% (12.88).

Table 2 Upper fiducial limit of CV % for different design sorghum (Bhal and Coastal zone) crop

Design	No. of expt.	CV %	U L		Range		CV % > 16.18	
			(0.05)	(0.10)	(0.05)	(0.10)	No. of expt.	Proportion
FRBD	11	18.02	21.98	21.02	3.96	3.00	5	5.74
RBD	61	12.15	15.70	14.80	3.55	2.65	10	11.49
Split plot	15	12.07	13.85	13.44	1.78	1.37	7	8.00
Average	87	12.88	16.18	15.35				

The design used in Dhandhuka center (bhal and coastal zone) crop experiments (Table 2) indicated that the higher upper fiducial limits (>16.18%) were observed for FRBD design. RBD and split plot design were within average fiducial limit.

Table 3 Upper fiducial limit of CV % for different treatments of sorghum (Bhal and Coastal zone) crop

Treatments	No. of expt.	CV %	U L		Range		CV % > 16.18	
			(0.05)	(0.10)	(0.05)	(0.10)	No. of expt.	Proportion
< 6	3	11.25	15.55	14.40	4.30	3.15	0	00.00
6-10	46	10.62	13.89	13.05	3.27	2.43	4	4.59
11-15	28	16.21	19.66	18.82	3.45	2.61	9	10.34
16-20	9	14.76	17.56	16.89	2.80	2.13	4	4.59
21-25	1	11.70	13.33	12.95	1.63	1.25	0	00.00
Average	87	12.88	16.18	15.35				

The results presented in Table 3 revealed that experiments conducted with the set of treatments were within average fiducial limit of CV % except treatments 11-15 and 16-20.

Table 4 Upper fiducial limit of CV % for different plot size of sorghum (Bhal and Coastal zone) crop

Plot size (m^2)	No. of expt.	CV %	U L		Range		CV % > 16.18	
			(0.05)	(0.10)	(0.05)	(0.10)	No. of expt.	Proportion
<3	0	-	-	-	-	-	-	
3-6	1	18.54	22.03	21.21	3.49	2.67	1	1.14
6-9	20	17.20	20.94	20.03	3.74	2.82	8	9.19
9-12	58	11.32	14.56	13.74	3.24	2.42	6	6.89
12-15	7	13.45	16.21	15.55	2.76	2.10	2	2.29
15-18	1	7.20	8.30	8.06	1.10	0.86	0	0.00
Average	87	12.88	16.18	15.15				

The results presented in Table 4 revealed that mean CV % and upper fiducial limits were within limit of average value for all plot size except for 3-6, 6-9 and 12-15 sq.m. plot size. The upper fiducial limit, mean CV % and proportion of experiments for plot size 9-12 sq.m. was less than average fiducial limit. Under the circumstances plot size 9-12 sq.m. seems to be optimum plot size on Dhandhuka center (Bhal and coastal zone) for sorghum crop experiments. However, it needs confirmation by plot technique study for different location.

YARDSTICK OF C.V. % FOR SORGHUM CROP EXPERIMENTS

The C.V. % data of 87 field experiments were used to fit non central 't' distribution and to work out upper fudicial limit of C.V. at 0.05 level of probability. According the upper fiducial limit of C.V. % at 95 per cent confidence level of C.V. % was worked out to be 16.18 per cent. Thus, the results suggested that about 17 percent C.V. % should be considered as a yard stick for sorghum crop field experiments. These having C.V. % > 17 should be rejected for drawing scientific conclusion.

Table 5 The average upper fiducial limit and yardstick for CV % for the experiments of sorghum crop

Name of Crops	No. of experiments	Mean CV %	Upper fiducial limit of CV %		Overall yardstick of CV%
			0.95	0.90	
Sorghum	87	12.88	16.18	15.15	17 %

Table 6 Power of F-test as influence by CV%

Classes CV%	No.of experiments	F-test		
		Significant	Non-Significant	Ratio
1.0-11.0	41	38	3	0.08
11.0-21.0	37	30	7	0.23
21.0-31.0	6	6	0	0.00
31.0-41.0	3	0	3	0.00
>41	0	0	0	0.00
Total	87	74	13	0.18

The ratio of number of experiments having non-significant to significant F-test was worked for each class of frequency distribution (Table 6). The results revealed that the ratio increased with the increase in CV of the experiments. It also indicated that the efficiency (of detecting difference in treatment means) of F-test decreased with the increase in CV of experiments. The average ratio was observed to be 0.18. The ratio for the class 11.0-21.0 % was almost equal to the average ratio. The class included 16.18 %, the mean CV of all experiments. It can be seen from Table 6 that more than 50% of experiments having 17 % and more CV failed to detect difference in treatments means. Results clearly showed that when the coefficient of variation in Sorghum (Bhal and Coastal zone) crop experiments conducted in RBD exceeds 17 %, hence the experimental finding should not be considered for any purpose.

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