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Variability study in safed musali crop field experiments and yardstick thereof

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ABSTRACT

The data on C.V. % for safed musali crop yield along with other details of 99 field experiments conducted during 1989-90 to 2011-12 at Main Research Station, Medicinal and Aromatic crop, Anand Agricultural University, Anand 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 safed musali crop experiments which emerged as 21%.

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

Statistics is used to interpret data and sometimes to determine whether the data are suspect or not? Most researchers are familiar with the use of 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 or the CV. This familiar measurement was created in the late 1800s as a measure of population variability. However, 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

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than in the uniformity trials. (Bajpai and Nigam, 1980) suggested a working rule for deciding the value of *W2* (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 % for varietal trials, 10 to 12 % for fertilizer trials and 13 to 15% for insecticidal and herbicidal trials on rice. No other information (except reviewed and reported here) is available in the literature on the yardstick of CV for field experiments on crops. (Patel *et al*. 2000), 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. (Snedecor and Cochran, 1967) They stated, "a knowledge of relative variation is valuable in evaluating experiments." They go on to say variation of the yield of hay is comparable to that of the yield of corn." 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) states that "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. Based on CV, Masood and Javed (2003) reported that 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 data on C.V.% safed musali crop yield of 99 field experiments conducted Main Research Station, Medicinal and Aromatic crop, Anand Agricultural University, Anand during 1989-90 to 2011-12 in plant breeding and agronomy disciplines on different safed msali crop were utilized for the variability study. 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 $\overline{(x)}$

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

The distributions of 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 μ or ?, singly. But t distribution cannot be used for $cv = \frac{S}{X}$ (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 X^2, with degrees of freedom of X^2, Then, if t is defined by the equation:

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

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

Let an estimate of *V* be $v = S/\overline{X}$ the sample coefficent of variation. Now, one my write

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

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).

The procedure is briefly explained below. Let,

(i) $CV = \frac{\sqrt{Error\ mean\ square}}{General\ mean}$

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,

$$CV_{UL} = \frac{\sqrt{n}}{\delta}(f, t_0\ \varepsilon)$$

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

(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 *y'*, if $\frac{t_0}{\sqrt{2f}}$ lies between - 0.75 and 0.75, otherwise consider *Y*.

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

(iv) Select desired probality level of confidence, i.e. and obtain $\lambda(f, t_0, \varepsilon)$ from the table in (Johnson and Welch, 1939) interpolating wth respect to the quantities obtaned 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 99 field experiments on safed musali crop 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 safed musali crop

Discipline	No. of expt.	CV %	U L		Range		CV % > 20.61	
			(0.05)	(0.10)	(0.05)	(0.10)	No. of expt.	Proportion
Agronomy	76	14.54	19.78	18.39	5.24	3.85	15	0.19
Pl. Breeding	23	17.72	23.36	21.85	5.64	4.13	11	0.47
Mean		15.28	20.61	19.19	-	-	-	-

The results presented in Table 1 revealed that mean C.V. % (15.28) and upper fiducial limit (20.61) of average value of all the discipline except for plant breeding discipline, were below the mean C.V. %. The experiments on plant breeding discipline showed large variation (average C.V. = 23.26 %) showed poor precision may be because of experimental requirements such as sample size, natural population of pests and diseases. Use of proper statistical tools may help to improve the precision of the results. More than 50% experiments of this disciplines had more than 20.61%.

Table 2 Upper fiducial limit of CV % for different design Safed musali crop

Design	No. of expt.	CV %	U L		Range		CV % > 20.61	
			(0.05)	(0.10)	(0.05)	(0.10)	No. of expt.	Proportion
FRBD	20	13.32	16.71	15.87	3.40	2.56	01	0.05
RBD	75	15.45	21.32	19.74	5.88	4.29	22	0.29
Other	4	21.96	26.81	25.63	4.85	3.67	03	0.75
Mean		15.28	20.61	19.19	-	-	-	-

The results presented in Table 2 indicated that most of the experiments were carried out in RBD and about 30 % of them had C.V. % higher than the fiducial limit worked out. Average value of FRBD, were below the mean C.V. % (15.28 %).

Table 3 Upper fiducial limit of CV % for different treatments of Safed musali crop

Treatments	No. of expt.	CV %	U L		Range		CV % > 20.61	
			(0.05)	(0.10)	(0.05)	(0.10)	No. of expt.	Proportion
Up to 5	62	15.02	21.21	19.52	6.20	4.50	16	0.25
11-15	20	13.32	16.71	15.87	3.40	2.56	1	0.05
16-20	17	18.55	23.02	21.92	4.47	3.37	9	0.52
Mean		15.28	20.61	19.19	-	-	-	-

Influence of number of treatments was also examined and results are given in (Table 3) according to different treatments group 16-20 treatments in an experiment showed higher C.V. % than the overall average (C.V. 15.28 %).

Generally increased number of treatments in the experiments increases blocks (replication) size which increases error variance, affecting the precision of the results. Therefore, it is advisable to use such experimental designs(when treatment exceeds 16) which can help in controlling within block variation. Other means such as optimum plot size, more number of replications, proper site of the experiment etc. need to be considered. About 25 to 30 per cent experiments showed higher C.V. % compared to the overall average C.V. % except the treatment group up to 5 and 11-15.

Table 4 Upper fiducial limit of CV % for different plot size of Safed musali crop

Plot size (m^2)	No. of experiment	CV %	U L		Range		CV % > 20.61	
			(0.05)	(0.10)	(0.05)	(0.10)	No. of expt.	Proportion
<3	00	--	--	--	--	--	-	-
3-6	68	15.06	19.92	18.65	4.87	3.60	17	0.20
6-9	00	--	--	--	--	--	-	-
9-12	31	15.77	22.13	20.38	6.36	4.61	09	0.29
Mean		15.28	20.61	19.19	-	-	-	-

The results presented in (Table 4) indicated that the average C.V.% for different plot size experiments were below the average C.V.% (15.28) in plot size 3 to 6 sq.mt. Beyond 9 sq.mt. plot size the proportion of C.V.% having higher C.V.% increased from 0.29 Therefore, plot size of 3 to 6 sq.mt. seems to be an optimum plot size for safed musali crop. Therefore, this needs to be confirmed by plot technique study for different locations.

Table 5 Upper fiducial limit of CV % for different replications of safed musali crop

Replication	No. of expt.	CV %	U L		Range		CV % > 20.61	
			(0.05)	(0.10)	(0.05)	(0.10)	No. of expt.	Proportion
2	07	15.91	20.38	19.25	4.46	3.33	02	0.28
3	36	15.62	20.25	19.03	4.62	3.41	10	0.27
4	14	15.48	24.44	21.83	8.96	6.35	03	0.21
8	15	14.93	19.97	18.68	5.04	3.75	02	0.13
13	27	14.75	19.54	18.31	4.79	3.56	09	0.33
Mean		15.28	20.61	19.19	-	-	-	-

As far as replications are concerned, the experiments conducted with 2, 3 and 4 replications showed large variation 28, 27 and 21 per cent experiments showed C.V% > 20.61 respectively (Table 5). Analysis showed that majority experiments were conducted with 3 and 4 replications in field experiments on safed musali in which about 26 percent were having C.V. % > 20.61.

YARDSTICK OF C.V. % FOR SAFED MUSALI CROP EXPERIMENTS

The C.V. % data of 99 field experiments were used to fit non central 't' distribution and to work out upper confidence limit of C.V. at 0.05 level of probability. According the upper fiducial limit of C.V. % at 95 percent confidence level of C.V. % was worked out to be 20.61 per cent. Thus the results suggested that about 21 percent C.V. % should be considered as a yard stick for safed musali crop field experiments. These having C.V. % > 21 should be rejected for drawing scientific conclusion.

Table 6 The average upper fiducial limit and yardstick for CV % for the experiments of safed musali crop

Name of Crops	No.of experiments	Mean CV %	Upper fiducial limit of CV %		Overall yardstick of CV%
			0.95	0.90	
Safed musali	99	15.28	20.61	19.19	21 %

Table 7 Power of F-test as influence by CV%

Classes CV%	No.of experiments	F-test		
		Significant	Non-Significant	Ratio
3.35-8.35	18	6	12	2.00
8.35-13.35	23	12	11	0.92
13.35-18.35	28	17	11	0.65
18.35-23.35	15	9	6	0.67
23.35-28.35	11	7	4	0.57
28.35-33.35	3	3	0	00
33.35-38.35	1	1	0	00
Total	99	55	44	0.80

The ratio of number of experiments having non-significant to significant F-test was worked for each class of frequency distribution (Table 7). The results revealed that the ratio consistently 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 0.80. The ratio for the class 13.35-18.35 % was almost equal to the average ratio. The class included 15.28 %, the mean CV of all experiments. It can be seen from Table 7 that about 50% of experiments having 21 % and more CV failed to detect difference in treatments means. Results clearly showed that when the coefficient of variation in Safed musali crop experiments conducted in RBD exceeds 21 %, hence the experimental finding should not be considered for any purpose.

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REFERENCES

Aflakpui, G.K.S. 1995. Some uses/abuses of statistics in crop experimentation. *Trop. Sci.*, **35**: 347–353.

Allen, F. L., Comstock, R. E. and D.C. Rasmusson. 1978. Optimal environments for yield testing. *Crop Sci.*, **18**:747–751.

Bajpai, S. N. and A. K. Nigam. 1980. Statistical evaluation of Agricultural field experiments. *J. Indian Soc. Agric. Stat.*, **32** (2): 41-45.

Cochran, W. G., and G. M. Cox. 1957. Experimental designs. John Wiley & Sons, New York.

Darji, V. B., Bhatt, B. K. and S.K. Dixit, 2010. Variability in forage crop field experiments and yardstick thereof. *Agric. Sci. Digest.*, **30** (4): 266 – 269.

Gomez, K. A. and A.A. Gomez. 1984. Statistical procedure for Agricultural workers, John Wiley and Sons, New York, 2nd ed.

Gotoh, J., and S. Osanai. 1959. Efficiency of selection for yield under different fertilizer levels in a wheat cross. *Jpn. J. Breed.*, **9**:173–178.

Johnson, N. L. and B. L. Welch. 1939. Application of non central t-distribution. *Biometrika*, **31**: 362-389.

Kendall, M., and A. Stuart. 1977. The advanced theory of statistics. Vol. 1. Distribution theory. 4th ed. MacMillan, New York.

Khan, M. I. and R. Mead. 1998. Improving Precision of Agriculture Field Experiments in Pakistan. *Gomal Univ. J. Res.*, **18**: 33-48.

Masood, M. A. and M. A. Javed. 2003. Variability in field experiments in maize crop in Pakistan. *Pak. J. Agri. Sci.*, **40** (3-4).

McKay, A. T. 1932. Distribution of the coefficient of variation and the extended "t" distribution. Journal of the Royal Statistical Society, ***95****: 695–698.*

Patel, J.K., Patel, N.M. and R.L. Shiyani. 2001. Coefficient of variation in field experiments and yardstick there of- An empirical study, *Current Science*, **81** (9): 1162-1164.

Patel, N. M., Prajapati, M. R. and K. H. Prajapati. 1978. Paper presented at XVII Annual conference of Gujarat Statistical Association, Anand, November, 4-5.

Snedecor, G. W. and W. G. Cochran. 1967. Statistical Methods. (*Sixth Edition*), Oxford and IBH Pub. Co., New Delhi.

Tyagi, B. N., Kathuria, O. P., Sahni, M. L. and G., Kulharni. 1973. A study of coefficient of variation associated with plots and blocks of different sizes for some important field crops. *J. Indian Soc. Agric. Stat.*, XXV (II), 37-47.