ISSN (Online): 2455-3662
EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 11| Issue: 3| March 2025|| Journal DOI: 10.36713/epra2013 || SJIF Impact Factor 2025: 8.691 || ISI Value: 1.188

DEVELOPMENT OF YARDSTICK OF CV % FOR TOBACCO CROP EXPERIMENTS

G.N. Motaka, X. U. Shukla and A. N. Khokhar
Anand Agricultural University, Anand-388 110, India

Article DOI: https://doi.org/10.36713/epra20357
DOI No: 10.36713/epra20357

ABSTRACT

The data on C.V. % for tobacco crop yield along with other details of 548 field experiments conducted during 2003-04 to 2019-2020 at different research center of Anand Agricultural University 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 tobacco crop experiments for different research center of Anand Agricultural University which emerged as 15 %.

KEY WORDS: *CV%, Fiducial limit, Plot size, Non central t distribution, Experimental variability*

INTODUCTION

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 and the present paper deals with this aspect.

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 % 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 randomize complete block design 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.

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 548 experiments conducted on tobacco crop during 2003-04 to 2019-2020 at different

ISSN (Online): 2455-3662
EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 11| Issue: 3| March 2025|| Journal DOI: 10.36713/epra2013 || SJIF Impact Factor 2025: 8.691 || ISI Value: 1.188

research center of Anand Agricultural University. 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 error mean square (*S*) and mean ($\overline{X}$).

$$CV = \frac{S}{\overline{X}} = \frac{\sqrt{ErrorM.S.}}{Mean} \quad (1)$$

The distributions of $\overline{X}$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 σ, singly. But *t* distributioncannot be used for$CV = \frac{S}{\overline{X}}$. 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/f, with *f* degree of freedom. Then, if *t* is defined by the equation:

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

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

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

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

It appears from comparison with eq. (2) that $\frac{\sqrt{n}}{v}$is distributed as non-central *t* with $f = (n - 1)$ and $\frac{\sqrt{n}}{v}$. 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) $CV = \frac{\sqrt{Errormeansquare}}{Generalmean}$

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,

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

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.

ConsiderY', 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 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 548 tobacco 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.

ISSN (Online): 2455-3662
EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 11| Issue: 3| March 2025|| Journal DOI: 10.36713/epra2013 || SJIF Impact Factor 2025: 8.691 || ISI Value: 1.188

RESULTS AND DISCUSSION

Table 1: Upper fiducial limit of CV % for different disciplines of tobacco crop

Discipline	No.of expt.	CV %	U L		Range		CV % >14.76	
			(0.05)	(0.10)	(0.05)	(0.10)	No.of expt.	Proportion
Agronomy	104	11.64	14.38	13.71	2.74	2.07	26	25.0
Bio-chem	4	13.71	16.68	15.96	2.98	2.25	1	25.0
Pathology	21	18.71	24.94	23.28	6.23	4.57	13	61.9
Pl. breeding	393	11.40	14.51	13.72	3.11	2.32	56	14.2
Pl. Physio.	22	8.98	11.05	10.54	2.07	1.56	0	0.0
Soil Chem	4	12.53	15.17	14.53	2.56	2.01	1	25.0
Average	**548**	**11.65**	**14.76**	**13.98**				

The results presented in (Table 1) revealed that mean CV % and upper fiducial limits of average value of all the discipline except for Bio-chemistry, Plant Pathology and Soil Chemistry discipline, were below the mean CV (11.65) %.

Table 2: Upper fiducial limit of CV % for different design of tobacco crop for

Design	No.of expt.	CV %	U L		Range		CV % >14.76	
			(0.05)	(0.10)	(0.05)	(0.10)	No. of expt.	Proportion
FRBD2	28	12.26	15.19	14.47	2.93	2.21	8	28.5
FRBD3	13	14.33	17.22	16.53	2.89	2.20	5	38.5
RBD	428	11.46	14.70	13.88	3.24	2.42	65	15.2
Split Plot11	76	12.01	14.49	13.89	2.47	1.88	18	23.7
Split Plot111	2	12.80	15.72	14.99	2.92	2.19	0	0.0
Split Plot12	1	15.20	17.56	17.02	2.36	1.82	1	100.0
Average	**548**	**11.65**	**14.76**	**13.98**				

The design used in tobacco crop experiments (Table 2) indicated that the higher upper fiducial limits and proportion of experiments (>**14.76**%) were observed for FRBD2, FRBD3, Split plot111 and Split plot12 design was within average fiducial limit and average proportion.

Table 3: Upper fiducial limit of CV % for different treatments of tobacco crop

Treatments	No.of expt.	CV %	U L		Range		CV % >14.76	
			(0.05)	(0.10)	(0.05)	(0.10)	No. of expt.	Proportion
Up to 5	18	15.54	21.72	20.04	6.18	4.49	6	33.3
6-10	288	11.25	14.64	13.77	3.39	2.52	43	15.0
11-15	124	11.32	14.02	13.36	2.70	2.04	24	19.4
16-20	103	12.29	14.72	14.14	2.42	1.84	20	19.4
21-25	13	12.99	15.20	14.68	2.21	1.69	3	23.1
26-30	2	14.10	16.28	15.77	2.18	1.67	1	50.0
>30	0	0	0	0	0	0	0	0.0
Average	**548**	**11.65**	**14.76**	**13.98**				

The results presented in (Table 3) revealed that experiments conducted with the set of treatments were within average fiducial limit of CV % except treatments range between up to 6, 16-20, 21-25, 26-30.

ISSN (Online): 2455-3662
EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 11| Issue: 3| March 2025|| Journal DOI: 10.36713/epra2013 || SJIF Impact Factor 2025: 8.691 || ISI Value: 1.188

Table 4: Upper fiducial limit of CV % for different plot size of tobacco crop

Plot size (m^2)	No.of expt.	CV %	U L		Range		CV % >14.76	
			(0.05)	(0.10)	(0.05)	(0.10)	No. of expt.	Proportion
<3	0	0	0	0	0	0	0	0
3-6	0	0	0	0	0	0	0	0
6-9	99	13.47	17.17	16.23	3.70	2.76	32	33.3
9-12	114	11.11	14.11	13.35	2.99	2.24	25	22.0
12-15	220	10.94	13.80	13.08	2.86	2.14	16	7.3
15-18	15	18.33	24.87	23.11	6.54	4.77	6	40.0
18-21	6	10.97	13.87	13.15	2.90	2.18	1	16.7
21-24	10	9.12	11.38	10.82	2.26	1.70	1	10.0
>24	84	11.28	14.02	13.35	2.74	2.06	16	19.1
Average	**548**	**11.65**	**14.76**	**13.98**				

The results presented in (Table 4) revealed that mean CV % and upper fiducial limits were above of average value for 6-9 and 15-18 sq.m. plot size. The upper fiducial limit, mean CV % and proportion of experiments for plot size 9-12, 12-15, 18-21, 21-24 and > 24 sq.m. was less than average fiducial limit. Considering the proportion of experiments, plot size 9-12 sq.m.seems to be optimum plot size for tobacco crop experiments. However, it needs confirmation by plot technique study.

Table 5 : Upper fiducial limit of CV % for different replications of tobacco crop

Replication	No. of expt.	CV %	UL		Range		No. of expts.	Proportion
			(0.05)	(0.10)	(0.05)	(0.10)		
2	1	11.80	14.59	13.91	2.79	2.11	0	0.0
3	404	11.67	14.73	13.96	3.06	2.29	66	16.4
4	133	11.68	14.95	14.12	3.27	2.44	29	21.8
5	2	12.70	16.79	15.73	4.09	3.03	0	0
6	8	10.39	13.15	12.46	2.77	2.07	2	25.0
Average	**548**	**11.65**	**14.76**	**13.98**				

The results presented in (Table 5) revealed that all experiments conducted with different number of replications were near to above average fiducial limit except with number of replications 6.

Table 6 : Upper fiducial limit of CV % for different locations of tobacco crop

Location	No. of expt.	CV %	UL		Range		No. of expts.	Proportion
			(0.05)	(0.10)	(0.05)	(0.10)		
ANAND	424	12.17	15.40	14.59	3.23	2.42	78	18.4
DHARMAJ	102	10.88	13.84	13.10	2.97	2.22	18	17.7
LADOL	20	4.51	5.78	5.45	1.27	.95	0	0.0
SANAND	2	13.80	17.31	16.45	3.51	2.65	1	50.0
Average	**548**	**11.65**	**14.76**	**13.98**				

The results presented in (Table 6) revealed that all experiments conducted with different research stations like Anand and Sanand were above mean CV % and upper fiducial limits except Dharmaj and Ladol research stations.

Table 7: The average upper fiducial limit and yardstick for CV % for the experiments of tobacco crop

Name of Crop	No. of experiments	Mean CV %	Upper fiducial limit of CV %		Overall yardstick of CV%
			0.95	0.90	
Tobacco	548	11.65	14.76	13.98	15%

ISSN (Online): 2455-3662
EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 11| Issue: 3| March 2025|| Journal DOI: 10.36713/epra2013 || SJIF Impact Factor 2025: 8.691 || ISI Value: 1.188

The yardstick or average upper fiducial limit at 95% and 90% confidence and mean CV% for 548 experiments were worked out and presented in Table 7. The mean CV % and upper fiducial limits of average value at 95 and 90 per cent confidence and average CV % of all 548 experiments were 11.65 %, 14.76 % and 13.98 % respectively (Table 7). The average upper fiducial limit of CV % (14.76 %) covers the region related to average CV % of all the experiments.

.**Table 8: Power of F-test as influence by CV%**

Classes CV%	No. of experiments	F-test		
		Significant	Non-Significant	Ratio
1-4	14	13	1	.080
4-7	53	51	2	.040
7-10	124	104	20	.190
10-13	128	145	37	.260
13-16	103	76	27	.360
16-19	44	22	22	1.000
19-22	12	5	7	1.400
22-25	9	8	1	.130
25-28	3	0	3	-
28-31	2	0	2	-
31-34	0	0	0	-
34-37	0	0	0	-
37-40	0	0	0	-
40-43	1	0	1	-
43-46	0	0	0	-
46-49	0	0	0	-
49-52	1	0	0	-
52-55	0	0	1	-
Total	**548**	**424**	**124**	**.290**

The ratio of number of experiments having non-significant to significant F-test was worked for each class of frequency distribution (Table 8). 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 0.29. The ratio for the class 10-13 % was almost equal to the average ratio. The class included 11.00 %, the mean CV % of all experiments. It can be seen from Table 8 that more than 22% of experiments having 15 % and more CV % failed to detect difference in treatments means. Results clearly showed that when the coefficient of variation in tobacco crop experiments conducted in RBD exceeds 15%, the experimental finding should not be considered for any purpose.

YARDSTICK OF C.V. % FOR TOBACCO CROP EXPERIMENTS

The C.V. % data of 548 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 percent confidence level of C.V. % was worked out to be 14.76 per cent. Thus, the results suggested that about 15 percent C.V. % should be considered as a yard stick for tobacco crop field experiments. These having C.V. % > 15 should be rejected for drawing scientific conclusion.

ACKNOWLEDGEMENT

Research Scientist, Bidi Tobacco Research Station (BTRS), Anand, Anand Agricultural University, Anand for providing the data.

REFERENCES

1. *Allen, F.L., Comstock, R.E. and Rasmusson,D.C. 1978.Optimal environments for yield testing. Crop Sci.**18**:747–751.*
2. *Bajpai, S. N. and Nigam, A.K. 1980. Statistical evaluation of Agricultural field experiments. J. Indian Soc. Agric. Stat., **32** (2): 41-45.*
3. *Cochran, W.G., and Cox, G.M. 1957. Experimental designs. John Wiley & Sons, New York.*
4. *Darji,V.B., Bhatt, B.K. and Dixit,S.K. 2010. Variability in forage crop field experiments and yardstick thereof. Agric. Sci. Digest., **30** (4): 266 – 269.*
5. *Gomez, K. A. and Gomez, A.A. 1984. Statistical procedure for Agricultural workers, John Wiley and Sons, New York, 2nd Ed.*
6. *Gotoh, J., and Osanai,S. 1959. Efficiency of selection for yield under different fertilizer levels in a wheat cross. Jpn. J. Breed.**9**:173–178.*
7. *Kendall, M., and Stuart,A. 1977. The advanced theory of statistics. Vol. 1.Distribution theory.4th ed. MacMillan, New York.*
8. *Khan, M.I. and Mead, R. 1998. Improving Precision of Agriculture Field Experiments in Pakistan. Gomal Univ. J. Res.,**18**: 33-48.*

ISSN (Online): 2455-3662
EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 11| Issue: 3| March 2025|| Journal DOI: 10.36713/epra2013 || SJIF Impact Factor 2025: 8.691 || ISI Value: 1.188

9. *Masood, M.A. and Javed,M.A. 2003. Variability in field experiments in maize crop in Pakistan. Pak. J. Agri. Sci., Vol.* ***40****(3-4).*
10. *McKay, A. T. 1932.Distribution of the coefficient of variation and the extended "t" distribution. Journal of the Royal Statistical Society,* ***95****: 695–698.*
11. *Patel, J.K., Patel, N.M. and Shiyani, R.L. 2001.Coefficient of variation in field experiments and yardstick thereof – Anempirical study, Current Science,* ***81****(9): 1162-1164.*
12. *Patel, N.M., Prajapati, M.R. and Prajapati, K.H. 1978. Paper presented at XVII Annual conference of Gujarat Statistical Association, Anand, November, 4-5.*
13. *Snedecor, G. W. and Cochran W.G. 1967.Statistical Methods.(Sixth Edition), Oxford and IBH Pub. Co., New Delhi.*
14. *Tyagi, B. N., Kathuria, O.P., Sahni, M. L. and Kulharni, G. 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.*