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Vol. 45
Number (2)
April, 2020

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Contents

Research Papers

Estimation of optimum size and shape of plot for field experiments on fenugreek *(Trigonella foenum* graecum)	R. I. PRAJAPATI G. K. CHAUDHARY AND J. M. LORIA	59
Variability study in safed musali crop field experiments and yardstick there of	G.N. MOTAKA AND D.J. PARMAR	62
Impact assessment and performance of Mahatma Gandhi national employment guarantee act (MGNREGA) in Jammu and Kashmir	M. H. WANI AND ARSHAD BHAT	69
Area response function of selected vegetables in West Bengal paving way to agricultural reforms in India	DATTATREYA MUKHOPADHYAY AND DEBASIS MUKHOPADHYAY	82
Study on variability in field experiments on Sugarcane crop and yard stick there of	G.N. MOTAKA AND D.J. PARMAR	93
Knowledge and adoption level of potato production technology among the farmers of Sabarkantha district	R. R. PRAJAPATI, B. K. PATEL AND ARNAB BISWAS	98
Pesticide buying behaviour of the potato growers in Banaskantha district	R. R. PRAJAPATI AND R. D. PARMAR	103

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Estimation of optimum size and shape of plot for field experiments on fenugreek (*Trigonella foenum graecum*)

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ABSTRACT

The optimum plot size for field experimentation on fenugreek crop was worked out using uniformity trial data. The popular methods *viz.,* maximum curvature was used for the purpose. One basic unit was fixed by taking 3 rows each of 1 meter length. A plot of 16 basic units size with shape of 12 rows each of 4 meters length (3.6 m × 4.0 m = 14.4 m^2) was found as optimum plot size for field experiments on fenugreek.

Key words: Optimum plot size, coefficient of variation, fenugreek

Agricultural research workers are mainly concerned with field experimentation. Efficient planning of precise field experiments largely depends on the nature of experiments, variability present in experimental materials and the cost of various operations as well as the materials involved in conducting the experiment. Each experimental site has an inherent variation i.e. soil variability which could be accessed through uniformity trial. The studies of such variation help in proper choice in size and shape of plots and blocks, experimental design and number of replications etc. Such studies based on uniformity trials in Indian conditions were undertaken with various annual crops like Bajra (Patel and Patel, 1967); Paddy (Agrawal and Deshpande, 1967), Tobacco (Prajapati and Patel, 1984), Wheat (Kumar and Singh,1986), Mungbean (Singh and Singh, 1989) and mustard (Prajapati *et al.*, 2013). However there is no information on optimum size and shape of plot for fenugreek which is an important cash crop of North Gujarat. Therefore, the uniformity trial on fenugreek crop was conducted.

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MATERIALS AND METHODS

The popular and high yielding variety GM 2 was sown at a spacing of 30 cm between two rows covering an area of about 0.40 hectare. The other crop cultivation practices in vogue were followed. A block of 20 m x 18 m was harvested and yield data were recorded separately for 400 basic units. The dimension of one basic unit was three rows of one meter length (0.9 m^2). Border areas were excluded from each side of experimental plot. The different sized plots of size 1, 2, 4, 5, 8, 10, 16,20, 25, 40, 50, 80 and 100 were formed by combining neighbouring units both length-wise as well as width-wise. The coefficient of variation (C.V.) for different combinations of above sized plots was calculated separately using seed yield data as under.

$$C.V.\% = \frac{\text{Standard Deviation}}{\text{General Mean}} \times 100$$

The optimum plot size was determined using maximum curvature method (Federer, 1955).

RESULTS AND DISCUSSION

The comparisons were made among different sizes and shapes of plots using C.V. % obtained for yield of fenugreek. The results are given in Table 1 and depicted by Fig. 1. The results revealed that the coefficient of variation (C.V. %) decreased with increase in plot size. The average C.V. per cent decreased from 15.79 per cent to to 1.51per cent with increase in plot size from 1 unit to 100 units. Initially the decrease in C.V. per cent was more rapid but after 10 units plot size the reduction was marginal. These results are in agreement with the results reported by Patel and Patel for Bajra (1967); Prajapati and Patel for bidi tobacco (1984); Kumar and Singh for wheat (1986); Naliyadara *et al.* for groundnut (2013); Prajapati *et al.* for mustard (2013) and Chaudhary *et al.* for mothbean (2017).

Table 1 C. V. per cent per unit size for seed yield of fenugreek

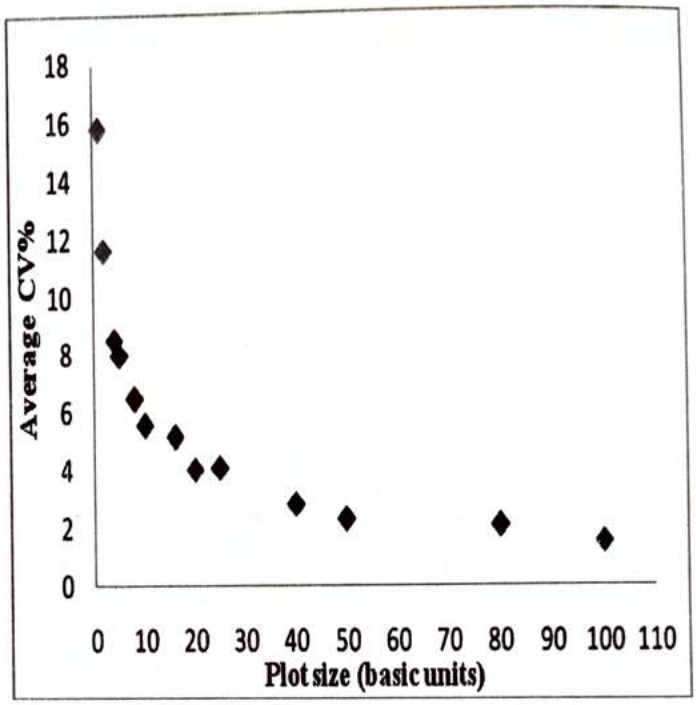
No. of basic unit	Combinations	C. V. %	Average C.V. % Per unit
1	1x1	15.79	15.79
2	2x1	11.68	11.63
	1x2	11.59	
4	4x1	8.32	8.53
	2x2	8.40	
	1x4	8.86	
5	5x1	8.00	8.01
	1x5	8.02	
8	4x2	6.30	6.50
	2x4	6.70	
10	10x1	5.50	5.58
	5x2	5.96	
	2x5	5.80	
	1x10	5.06	
16	4x4	5.15	5.15
20	20x1	3.99	4.04
	10x2	4.12	
	5x4	4.52	
	4x5	4.41	
	2x10	3.59	
	1x20	3.61	
25	5x5	4.10	4.10
40	20x2	3.34	2.85
	10x4	3.05	
	4x10	2.37	
	2x20	2.65	
50	10x5	2.48	2.28
	5x10	2.08	
80	20x4	2.31	2.06
	4x20	1.81	
100	20x5	1.81	1.51
	10x10	0.97	
	5x20	1.76	

The difference between C.V. per cent of the consecutive points (plot size) may help to estimate per unit decrease in C.V. per cent and thereby point of maximum curvature. The results are given in Table 2. The per unit decrease in C.V. per cent was observed from 4.16 per cent to 0.03 per cent with increase in plot size from 2 units to 100 units plot size. Further look into the data clearly indicated that the reduction in C.V. was more rapid in the beginning i.e. up to 10 basic units and then after it decreased marginally. Thus, reduction in C.V. was not proportional when plot size increased beyond 10 basic units. The same results graphically presented in Fig. 1 showed the curvature more clearly. Therefore, 10 basic units plot size could be taken as point of maximum curvature (Federer, 1955). The optimum plot size 16 basic units is that value of the size of the plot, which lies just beyond the point of maximum curvature and appeared to be optimum plot size for field experiments on fenugreek crop.

Table 2 Per unit decrease in C. V. % for seed yield of Fenugreek.

Plot size in basic unit	Average C.V. %	Difference in C.V. %	Per unit decrease In C.V. %
1	15.79		
2	11.63	4.16	4.16
4	8.53	3.10	1.55
5	8.01	0.52	0.5 2
8	6.50	1.51	0.50
10	5.58	0.92	0.46
16	5.15	0.43	0.07
20	4.04	1.11	0.28
25	4.10	-0.06	0.01
40	2.85	1.25	0.08
50	2.28	0.57	0.06
80	2.06	0.22	0.01
100	1.51	0.55	0.03

Fig 1 Coefficient of variation in per cent for different sized plots



CONCLUSION

A plot of 16 basic unit size having shape of 12 rows each of 4 meters length (3.6 m × 4 m=14.4 m^2) was found as optimum plot size for field experiments on fenugreek.

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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 $v = S/\bar{X}$ the sample coefficent of variation. Now, one my write

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

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).

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,

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

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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Impact assessment and performance of Mahatma Gandhi national employment guarantee act (MGNREGA) in Jammu and Kashmir

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ABSTRACT

Mahatma Gandhi National Employment Guarantee Act was launched on 2nd February 2006 as a historic initiative towards pro-poor growth in the country. The Act guarantees 100 days of assured man-days employment in a financial year to any rural household whose adult members are willing to do unskilled manual work. But due to administrative flaws, the performance of MGNREGA at national as well as at state level is very poor. The present study on evaluation of the MGNREGA scheme is intended to assess the performance & impact of this scheme on the overall quality of life of people by assessing different parameters associated with the scheme. The study was carried out in two community development blocks of district Pulwama, *viz.* block Shadimarg and block Newa. The tools employed on the data for obtaining logical results were descriptive statistics like averages, percentages, t-test, logit regression analysis and propensity score matching. The results of the study reveal less participation of weaker sections in sampled district. The percentage share of SCs, STs and Women stands 0.02 per cent, 4.34 per cent & 29.56 per cent respectively. The study further reveals that block wise financial and physical performance under MGNREGA depicts that the expenditure percentage has improved with the increase in wage rates. Due to better irrigation availability, 77.8 per cent of respondents in block Shadimarg and 80 per cent in block Newa recorded that MGNREGA has positive impact on the increase in agriculture production and productivity. To conclude, the scheme demands a re-orientation so that it can generate productive assets in the economy. It needs a strong planning and some additional features that can enable it to perform well as a scheme to contribute towards the shift of the economy towards full employment path. .

Key words: Poverty reduction, standard of living, improved irrigation, developed roads, employment man-days.

The state of Jammu and Kashmir like centre also adopted planning as an instrument for economic development and for this mission, launched various developmental programmes to alleviate poverty in the state. The Integral Rural Development Programme (1981-82) was launched in 75 community development blocks and latter, the programme was extended to all the 119 blocks to raise the income generating potential of various activities (Dandakar and Rath, 1970). Under this programme the small and marginal farmers, agriculture labourers, village artisans, schedule castes and schedule tribes were covered. The programme was equally

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funded by centre and state governments and under this programme in Jammu and Kashmir, Rs. 4412.05 lakhs (73.55%) were utilized against an availability of Rs. 5998 lakhs from 1981-82 to 1988-89 (Economic Survey, 2018).About 3,07,541 families (6.37%) have been raised above the poverty line from 1981-82 to 1986-89, out of 4,70,477, who were officially declared as below poverty line families (George, 1984).

As per the official records, the allocation and expenditure of various IRDP schemes for the state as a whole has increased from 7.36 per cent to 11.91 per cent and from 5.04 per cent to 14.30 per cent (percentage of total from 1981-82 to 1988-89 respectively) (Bhat, 1991).

MGNREGA was launched on 2nd February 2006 as a momentous initiative towards pro-poor growth. This Act, guarantees 100 days of employment in a financial year to any rural household whose adult members are willing to do unskilled manual work (Chakravarthy & Sukhamoy, 1977). By this work other number of rural issues will be addressed by generating productive assets and skills thereby boosting the rural economy, protecting the environment, empowering rural women, reducing rural urban migration and fostering social equity, among others. The Act offers an opportunity to strengthen our democratic processes by entrusting principle role to Panchayats at all levels in its implementation and promises transparency through involvement of community at planning and monitoring stages (CRRID, 2009).

The core objective of this programme is to make multi-pronged attack on the problems of rural development with particular emphasis on the removal of poverty (Rajasekhar *et al.*, 2007)and unemployment through the adoption of "family" as a unit of developmental process (Tripathi *et al.*, 1983). In India, there are profound regional variations in resource endowment, levels of development, incidence of poverty (Agro Economic Research centre, 2011).Every segments of the country possess certain location specific peculiar problems. Hence micro level studies not only provide greater insights on various aspects relating to the impact of the programme but also point out operational changes that are necessary in block level planning on the basis of results of such studies (Bandyopadhyay, 1985).

MATERIALS AND METHODS

For conducting the present study a multi-stage random sampling technique was utilized. There are 334 villages, 8 Tehsils (Pulwama, Awantipora, Tral, Pampore, Kakapora, Aripal, Rajpora & Litter), 11 community development blocks (Tral, Aripal, Dadsara, Awantipora, Pampore, Kakapora, Pulwama, Shadimarg, Achgoze, Lassipora and Newa) and 5 municipal counsels (Tral, Pampore, Khrew, Awantipora and Pulwama). All the community development blocks in the district were taken into consideration and were divided into high, medium and low performance blocks. From the 11 development blocks, Shadimarg and Newa community development blocks were randomly selected. The data was collected from 935 respondents of different villages working under MGNREGA scheme. The respondents were classified into two group's beneficiaries or non-beneficiaries. Among the respondents 303 were beneficiaries and 632 were non-beneficiaries. The data from the respondents was collected on following parameters;

- literacy level
- electrification
- road connectivity
- safe drinking water facility
- availability of health facility and
- percentage of population living below poverty line

The present study was undertaken with the following objective;

To appraise the impact of Mahatma Gandhi National Rural Employment Guarantee Act on income and employment of the beneficiaries.

Collection of Data

For the analytical purposes, the data was collected from both primary and secondary sources. The primary data collected from sampled respondentswas collected with the help of a pre-tested schedule. The secondary data for the studywas collected from Directorate of Rural Development, Kashmir, Rural Development Department of Jammu and Kashmir, Directorate of Economics and Statistics, Srinagar and other published and unpublished sources. In addition, the officials/Panchayat representatives and bankers were also interviewed for collecting the relevant and necessary data pertaining to MGNREGA.

Tools and Techniques

The study employed descriptive statistics, t-test, propensity score matching and logit regression for the analysis of data so that logical and reasonable results could be achieved.

The t-test utilised for the analysis of the data is of the form;

$$t = \frac{\bar{x} - \mu}{\frac{s}{\sqrt{n}}}$$

where $\bar{x}$ is the sample mean, s is the sample variance, n is the sample size, μ is the specified population mean and t is a Student t quantile with n-1 degrees of freedom.

Propensity Score for i^{th} respondent may be symbolically represented as:

$$e_i = \Pr(Z_i = 1 | X_i)$$

Where Z_i is indicator variable for application or non-application of treatment (0 or 1 respectively). Propensity Scores are generally estimated using a logistic regression model, which in this study, is Probit Regression (Rosenbaum *et al.*, 1983).

The Average Impact of the Treatment on Treated (ATT) can be estimated, which is defined as the average effect of treatment on those respondents who ultimately received the treatment. ATT could be represented as:

$$ATT = E(Y_1 - Y_0 | Z=1)$$

In this study, ATT was estimated using four different algorithms, namely Nearest Neighbor Matching (NNM), Kernel Matching Stratified Matching and Radius Matching.

RESULTS AND DISCUSSION

Table 1 shows the overall performance of MGNREGA scheme at National and J&K state during the reference period i.e. 2017-18. The overall scenario of the scheme is overwhelming and is showing progress with certain ill-elements as well. For the smooth and efficient results, there needs to be certain measures and steps that need correction and proper management and fair justice can do wonders through this scheme.

Table1 Performance of MGNREGA at national level and state level

S. No.	Activity	Physical progress	
		National level	J&K
1	Approved labour budget	2582134000	36000000
2	Person days generated so far	1033291000	3539289
3	Percentage of total labour budget	40.02	9.83
4	SC person days percentage as of total person days	19.42	4.56
5	ST person days percentage as of total person days	17.7	17.6
6	Women person days out of total (%)	57.21	28.82
7	Average days of employment provided per household	30.89	30.09
8	Average wage rate per day per person (Rs.)	176.07	188.63
9	Total no. of households completed 100 days of wage employment	248516	340
10	Total households worked	33455000	117606
11	Total individuals worked	46633000	164713

Source: Ministry of Rural Development, Government of India

The availability and expenditure performance under MGNREGA is given in Table 2 which shows that total central release for year 2017-18 was Rs. 31831860000/- and for J&K the release was Rs. 6742176000/- for the same period. Percentage utilization for overall India was 68.89 and for J&K it was 43.29. The liability of wages for J&K state was much higher than the National average i.e. Rs. 478263311/-.

Table 2 Financial performance of MGNREGA in Jammu and Kashmir (Rs in Lakhs) (2017-18)

S. No.	Activity	Financial progress	
		National level	J&K
1	Total central release	318318600000	6742176000
2	Total availability	328670600000	8902334000
3	Total expenditure	226420123000	3853605290
4	Percentage utilisation	68.89	43.29
5	Wages	193725194000	3184961870
6	Material and skilled wages	26678409000	517870195.52
7	Material (%)	12.1	13.99
8	Total admin expenditure	6016520000	150773222
9	Admin expenditure (%)	266	3.91
10	Liability (wages)	0	478263311.5
11	Average cost per day per person (in Rs)	211.69	387.11

Source: Ministry of Rural Development, Government of India

Table 3 shows the activity wise performance of the MGNREGA scheme in the national and state level. The table shows that during 2017-18, 132386000 job cards were issued to the willing persons in India and against this 1283270 of job cards were issued in J&K state. The total number of new workers taken up in the country were 12234000 and in J&K state were 75070. The total number of work completed during the reference period in both National and state level were 2122000 & 11463 respectively.

Table 3 Activity wise performance of the MGNREGA Scheme in India via-a-viz J&K

S. No.	Activity	Programme specification	
		National level	J&K
1	Total number of job cards issued	132386000	1283270
2	Total no. of active job cards	76065000	949177
3	Total number of workers	259673000	2204976
4	Total number of active workers	118068000	1492948
5	Total number of workers taken up (New + spill over)	12234000	75070
6	Number of ongoing work	10112000	63600
7	Number of completed work	2122000	11463
8	Number of GPS with Nil expenditure	29028	151
9	Percentage of NRM expenditure (public + individual)	73.5	40.73
10	Percentage of category works	63.92	19.11
11	Percentage on agriculture and allied works	75.47	31.21

Household size of the respondents

Majority of the respondents in the sampled areafall in the average family size of 5-7. In block Shadimarg 65.9 per cent respondents and in block Newa 64.1 per cent beneficiaries were having family size between 5-7 members. In case of non-beneficiaries, 82.0 per cent in Shadimarg block and 62.0 per cent in Newa block were having family size ranging between 5-7 members. Almost a very low percentage of respondents both in case of beneficiaries and non-beneficiaries fall in the family size of below 5 members.

Table 4 Household size of MGNREGA beneficiaries and non-beneficiaries

S. No.	Block	Beneficiaries (family members)			Non-beneficiaries (family members)		
		Below 5	5-7	7-10	Below 5	5-7	7-10
01.	Shadimarg	12 (3.8)	197 (65.9)	92 (30.3)	19 (3.0)	518 (82.0)	95 (15.0)
02.	Newa	19 (6.1)	194 (64.1)	90 (29.8)	38 (6.0)	392 (62.0)	203 (32.0)
03.	Total	15 (4.9)	194 (64.1)	91 (30.1)	26 (4.0)	476 (75.3)	132 (20.7)

Source: Field Survey Figures in the brackets are percentages

Educational level of respondents in the sampled blocks

Table 5 shows majority of the respondent in the sampled blocks, were having middle and primary level of education. 25.5 per cent were illiterate among beneficiaries in block Shadimarg and 26.4 per cent in block Newa. In block Shadimarg 41.9 per cent were having middle education compared to 31 per cent on block Newa. Among non-beneficiaries 39.0 per cent were having primary education in block Shadimarg and14 per cent in block Newa respectively. The beneficiaries in both the blocks were having less percentage of secondary education i.e. 1.0 per cent and 6.1 per cent in block Shadimarg and Newa respectively.

Table 5 Educational level of MGNREGA beneficiaries and non beneficiaries

S. No.	Block	Beneficiaries				Non-Beneficiaries			
		Illiterate	Primary	Middle	Secondary	Illiterate	Primary	Middle	Secondary
01	Shadimarg	77 (25.5)	96 (31.7)	127 (41.9)	4 (1.3)	228 (36.0)	247 (39.0)	158 (25.0)	-
02	Newa	80 (26.4)	104 (34.4)	94 (31.0)	19 (6.1)	190 (30.0)	89 (14.0)	89 (14.0)	13 (2.0)
03	Total	85 (28.4)	81 (26.7)	117 (38.5)	10 (3.4)	231 (37.3)	231 (37.7)	146 (23.3)	5 (0.7)

Source: Field Survey Note: Figures in the brackets are percentages

Impact of MNREGA on agriculture in the sampled area:

Agriculture the main and dominant occupation throughout the state, same is true of both the blocks in the districts. The impact of MGNREGA on agriculture is very important and it was asked from the beneficiary respondents. From the results it can be concluded that about 77.8 per cent in block Shadimarg and 80.0 per cent in block Newa were of the opinion that MGNREGA had positive impact on the agricultural production. Similarly,15.1per cent beneficiaries in block Shadimarg and 11.8 per cent in block Newa reported improvement in irrigation facilities due to MGNREGA as shown in Table 6.

Table 6 Perceptions of respondent regarding MGNREGA impact on agriculture

S. No.		Shadimarg	Newa
1.	Improvement in Agricultural productivity due to MGNREGA	728 (77.8)	748 (80.0)
2.	Improved irrigation	142 (15.1)	111 (11.8)
3.	No impact	67 (7.1)	77 (8.2)

Source: Field Survey
Note: Other respondents did not respond due to low level of knowledge.
Figures in the brackets are percentages

MGNREGA and impact of rural connectivity

The prime aim of the MGNREGA scheme was to make the improvement in the connectivity of the villagers, and hence the perceptions of the respondents were recorded in this regard. The study records that 87.6 percent respondents in Shadimarg block and eighty percent in Newa block reported overall development due to construction of bridges/culverts/roads/paths etc. Few of the respondents in both the blocks i.e., 12.4 percent in block Shadimarg and 7.3 percent in block Newa reported no impact in this regard as given in Table 7.

Table 7 Perceptions of respondent regarding MGNREGA impact on agriculture

S. No.		Shadimarg	Newa
1.	Overall development due to construction of bridges/culverts/roads/paths	819 (87.6)	774 (82.7)
2.	No Impact	116 (12.4)	66 (7.3)

Source: Field Survey
Note: Other respondents did not respond due to low level of knowledge,
Figures in the brackets are percentages

Propensity Score Matching Method

The results of the logit model reveals that values of odds ratio of these variables were less than unity which implies that probability of participation is less than that of non-participation. Coefficients of variables of education and livestock are negative and statistically significant. The households having more education and livestock variables are participating less in MGNREGA. The inverse relationship is true because literates have better employment opportunities outside than that of illiterates in all pursuits of life. Similarly with increase in number of livestock, participation decreases significantly and they get less time for wage employment.

Table 8 Determinations of participation in MGNREGA work based on logit model

Independent variable	Coefficient	P-Value	Odd ratio
Constant	β_o 4.881	0.00	-
Family size X_1	β_1 0.081	0.034	0.993
Age X_2	β_2 -0.027	0.059	0.953
Livestock X_3	β_3 -0.181	0.000	1.204
Education Level X_4	β_4 -2.266	0.000	0.165
Occupation X_5	β_5 0.241	0.208	0.757
OBC Caste X_6	β_6 -0.266	0.317	0.481

Source: Computed form Field data
Number of observations = 685
LR $Chi^2(6)$= 51.99
Prob > Chi^2= 0.000
Pseudo R^2=0.0719
Log likelihood =-335.31578

Propensity score of beneficiaries and non-beneficiaries

The study was carried out in the district Pulwama with 574 beneficiaries and 536 non beneficiaries of MGNREGA. The propensity score of the beneficiaries in the distribution is given in table 9. The range of propensity and the number of beneficiaries and non-beneficiaries ranges from .25 to .6. The highest number of both beneficiaries and non-beneficiaries falls in the propensity range of .4 and lowest number falls in the .28125.

Table 9 Propensity score of beneficiaries and non-beneficiaries in the sampled area

Propensity score	Trt		Total
	0	1	
.25	3	2	5
.275	0	3	3
.278125	4	1	4
.28125	1	0	1
.2875	18	0	18
.3	44	36	80
.35	45	9	54
.375	39	71	110
.4	353	364	717
.6	41	50	91
Total	574	536	1083

From the analysis of table 10 after regression of income with the treatment and the beneficiaries, the average income of the farmers in the distribution turns out to be Rs. 14881.58 /- with a standard error of 801.6658 having a t-value 18.56 at 5% level of significance and the income of non-beneficiaries out to the tune of Rs. 81446.78/- with a standard error of 543.5337 and a t-value 149.85 at 5% level of significance.

Table 10 Regression co-efficient of the beneficiaries and non-beneficiaries in the sampled area

Y	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]
Beneficiaries	14881.58	801.6658	18.56	0.000	13308.7 16454.45
Non-beneficiaries	81446.78	543.5337	149.85	0.000	80380.37 82513.2

Table 11 shows the average treatment effect on treated with different matching methods. In the present study four different matching methods where employed on a group of 1083 observations. The four different matching methods employ different procedures for getting the proper match among the distribution, the nearest neighbour method or nn'match method shows that in the total observation number of beneficiaries where 536 and it could only find 248 non-beneficiaries whole propensity score has been matched with an ATT of 16088.200, standard error 1626.942and a t-value 9.889meaning thereby that there a significant impact at 5 per cent level of significance. The Kernel and radius matching methods, took 536 beneficiaries with 547 non-beneficiaries each for mating and there ATT, standard error and t-value comes out as 14825.096, 848.816 & 17.466, 14831.472, 817.762 & 18.137 respectively. Similarly, the stratification method took 533 beneficiaries and 550 non-beneficiaries with an ATT of 15281.839, standard error of 898.504 and t–value of 17.008 at 5% level of significance.

variables are participating less in MGNREGA. The inverse relationship is true because literates

have better employment opportunities outside than that of illiterates in all pursuits of life. Similarly with increase in number of livestock, participation decreases significantly and they get less time for wage employment.

Table 11 Matching methods and impact on the income of beneficiaries

Matching Method	n. treat.	n. contr.	ATT	Std. Err.	T
Nearest Neighbour Method	536	248	16088.200	1626.942	9.889
Kernal Method	536	547	14825.096	848.816	17.466
Radius Method	536	547	14831.472	817.762	18.137
Stratification Method	533	550	15281.839	898.504	17.008

Table 12 shows the average treatment effect on treated (ATT) calculated from different matching methods employed to the set of observations. The ATT estimated from nearest neighbour method by doing 200 replications to the data set comes out to be Rs. 16088.2/- with a bias of -194.2143 and standard error of 1861.997 at 5% level of significance. Similarly, the average treatment effect of treated (ATT) estimated through kernel matching method, radius matching method and stratification matching method by doing 100 replications each comes to the tune of Rs. 14825.1/-, Rs.14831.47/-, Rs. 5281.84/- with a bias of 64.24272, 72.16093 , 54.06642 and a standard error of 848.8162, 797.765, 898.5044 at 5% level of significance respectively meaning that beneficiaries have increased their income.

Table 12 Average treatment effect on MGNREGA beneficiaries

Variable	Reps	Observed	Bias	Std. Err.	[95% Conf.	Interval]
Nearst Neighbour Method	200	16088.2	-194.2143	1861.997	12416.42 (N)	19759.9
					12171.06	
					19800.38	(P)
					12724.48	
					20657.29	(BC)
Kernal Method	200	14825.1	64.24272	848.8162	13151.27	
					16498.92	(N)
					13350.75	
					16581.46	(P)
					13277.83	
					16540.69	(BC)
Radius Method	200	14831.47	72.16093	797.765	13258.31	
					16404.63	(N)
					13395.88	
					16502.14	(P)
					13343.93 (BC)	16343.5
Stratification Method	200	5281.84	54.06642	898.5044	13510.03	
					17053.65	(N)
					13643.41	
					17257.93	(P)
					13621.4	
					17010.36	(BC)

Note: N= normal, P=per centile, BC=bias-corrected

Kernel density

Estimating the density with a histogram is easy but it is not smooth enough to get a good enough of a picture of the distribution. In order to get a smoother picture kernel density method is employed. In kernel density the data are divided into non-overlapping intervals, and counts area made of the number of data points within each interval. To be specific in kernel density, the range is still divided into intervals, and estimates of the density at the centre of intervals are produced.

From the fig.1, it can be seen that the density ranges from 0 to 4 as is shown along the y-axis and the scale of propensity is shown along x-axis. The area under the brown line (non-beneficiaries) whose propensity ranges from 0.1 to 0.7 and the majority of the beneficiaries (green line) also fall in 0.3 to 0.7 range, that means almost 70 to 80 per cent of the beneficiaries are falling within the range and finds their common support in the data set and few of the observations are there which does not find their support in the data set.

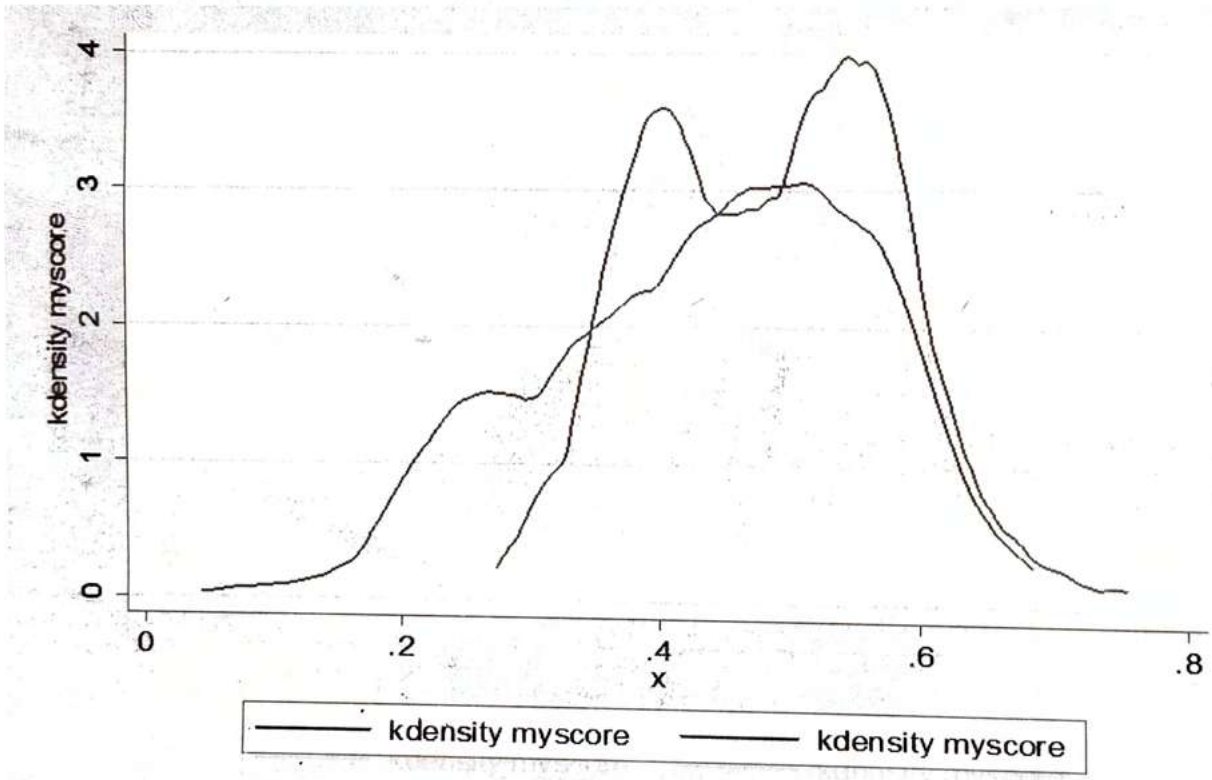

Fig 1 Kernel density map of MGNREGA beneficiaries and non-beneficiaries in the sampled area

Propensity score graph (ps-graph)

The propensity score matching graph is utilised to show the number of beneficiaries and non-beneficiaries who got support and who do not find their support in the distribution. Ps graph shows the beneficiaries in green on top and the non-beneficiaries in brown on bottom and the blue bars show the cases which are non-beneficiaries who do not found any match in the whole distribution. The fig.2 looks promising, because, almost all the beneficiaries and non-beneficiaries have propensity score ranging from 0.1 to 0.8 and there seems to be less cases having propensity score greater than 0.6 and, similarly, some of the case are there which does not find any support in the distribution and likewise some cases are there in the beneficiaries which not at all have any support in the non-beneficiaries group.

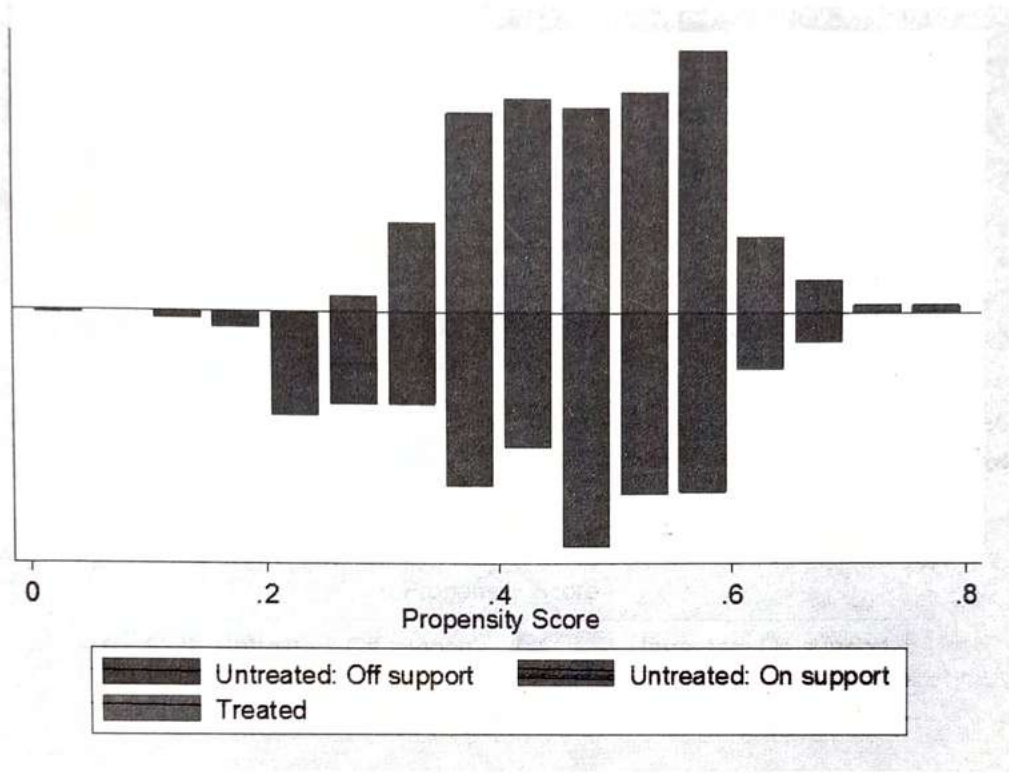

Fig 2 Ps-graph of the beneficiaries and non-beneficiaries' in the sampled area

CONCLUSION

To conclude the MGNREGA scheme has a positive impact on employment, income and living standard of the beneficiaries' in the sampled area. The scheme has made its impact on the agriculture through irrigation and restoration of irrigation canals. Through this scheme, the road connectivity to the villages has improved. Water has been supplied to the every nook and corner in the sampled blocks. The irrigation facility has improved the agricultural pursuits through higher production and productivity. The sachem has also provided a lot of employment avenues to the local people in the sampled area.Though a lot has been achieved on the development front, but, for much better results, the scheme demands a re-orientation so that it can generate productive assets in the economy. It needs a, strong planning, and some additional features that can enable it to perform well as a scheme to contribute towards the shift of the economy towards full employment path.

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Area response function of selected vegetables in West Bengal paving way to agricultural reforms in India

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ABSTRACT

Vegetables have emerged as an important sector with high potential in our economy. They are regarded as high value crops due to its high potentiality in terms of income augmentation and employment generation. The economic importance of the crops has been slowly increasing on account of increase in domestic as well as international demand. West Bengal is the leading vegetable producing state in the country, accounting over 10% of crop's area and 8% of output in the country. The growth of vegetables has been uneven across regions and over time in West Bengal. While the area under cultivation recorded a significant expansion in some regions, in other regions it either declined or was stagnant. The objective is to study the factors influencing the area response of vegetables in selected regions of West Bengal and to project the emerging scenario of how the substitute crops influence the area response decision of the vegetable growers in the state. An improvised version of Nerlove's adjustment lag model has been adopted to explain area allocation decisions of farmers and it is preferred over expectation model. It can be said that the experience regarding area response of vegetable is not similar, the technological factors, price factors vis-à-vis higher return have favored vegetable cultivation in area increasing regions. Technological factors like irrigation though insignificant, have worked to the detriment of vegetable cultivation in Rarh and Eastern Plateau region. It has been also observed that vegetable did not enjoy any distinct comparative advantage over its substitutes either in terms of yield or price in this region and hence possibly this accounts for the stagnation of the crop in the area.

Key words: area response, income augmentation, agricultural reforms

Vegetables have emerged as an important sector with high potential in our economy. They are regarded as high value crops due to its high potentiality in terms of income augmentation and employment generation. The economic importance of the crops has been slowly increasing on account of increase in domestic as well as international demand. West Bengal is the leading vegetable producing state in the country, accounting over 10% of crop's area and 8% of output in the country.

Under the above backdrop the objective is to study the factors influencing the area response of vegetables in selected regions of West Bengal and to project the emerging scenario of how the substitute crops influence the area response decision of the vegetable growers in the state

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FACTORS INFLUENCING AREA RESPONSE OF VEGETABLES

The growth of vegetables has been uneven across regions and over time in West Bengal. While the area under cultivation recorded a significant expansion in some regions, in other regions it either declined or was stagnant. The factors influencing the area response of vegetables in selected regions of West Bengal have been analyzed. An improvised version of Nerlove's adjustment lag model has been adopted to explain area allocation decisions of farmers. It is preferred over expectation model because of its advantages spelt out by Raj Krishna. The model is:

$$A_t^* = a_0 + a_1 P_{t-1} + a_2 Y_{t-1} + a_3 {}^{\sigma}P_t + a_4 {}^{\sigma}Y_t + a_5 I_t + a_6 W_t + U_t \quad \ldots\ldots\ldots\ldots\ldots (1)$$

$$A_t - A_{t-1} = \gamma (A_t^* - A_{t-1}) \quad \ldots\ldots\ldots\ldots (2)$$

Where,

A_t= Area under the crop in year't'

P_{t-1}= Price of crop deflated by price of substitute crop in year't-1'

Y_{t-1}= Yield of crop deflated by yield of substitute crop in year't-1'

${}^{\sigma}P_t$ = Standard deviation of preceding three years price of crop relative to that of substitute crop

${}^{\sigma}Y_t$= Standard deviation of proceeding three years yield rates of crop relative to that of substitute crop

W_t= Rainfall during a specified period (either in kharif or rabi season)

I_t= Gross irrigated area under all crops in the current year

A_t^*= Desired area under the crop in year 't'

A_{t-1}= Area under the crop in year 't-1'

γ = Adjustment coefficient

U_t= Error term

The first equation is a behavioural relationship stating that the desired area under the crop (A_t^*) depends on relative farm prices and yield (both lagged by one year), price and yield risk (in relative terms) and irrigation and weather (represented by rainfall). The second equation is a partial area adjustment equation. The γ is the Nerlovian coefficient of adjustment. The growers, it is postulated, are able to increase the area of the crop in any year only to the extent of a fraction γ of the difference between the area they would like to plant and the area actually planted in the preceding year. The above two equations (after some algebraic manipulations) may give the estimating equations as follows:

$$A_t = b_0 + b_1 P_{t-1} + b_2 Y_{t-1} + b_3 {}^{\sigma}P_t + b_4 {}^{\sigma}Y_t + b_5 I_t + b_6 W_t + b_7 A_{t-1} + V_t \quad \ldots\ldots\ldots\ldots (3)$$

Where,

$b_1 = a_1 \gamma$ $\quad$ $b_5 = a_5 \gamma$

$b_2 = a_2 \gamma$ $\quad$ $b_6 = a_6 \gamma$

$b_3 = a_3 \gamma$ $\quad$ $b_7 = (1 - \gamma)$

$b_4 = a_4 \gamma$ $\quad$ $V_t = \gamma U_t$

In order to relate profitability to the area allocation decisions of farmers an alternate model has been tried wherein lagged relative gross income variable has been used instead of separate price and yield variables. Other alternate models have also been tried by dropping some of the independent variables like irrigation and lagged area.

Output decisions of growers are approximated in terms of the planted area rather than yield. Further area is subject to endogenous factors, that is, within a farmer's control, whereas yield is influenced by several exogenous factors which are beyond the grower's control, such as weather.

It is, of course true that a grower can keep area constant and increase output by varying yield levels. Area should be taken as a proxy for output if secondary data be not available. In case of most vegetables area has been the main source of growth in output. Hence area response functions can more or less truly represent output supply response functions in the case of vegetables.

Instead of selecting several substitute crops it is preferred to select only two substitute crops per region, one food crop and another a cash crop. This means a vegetable grower has two alternatives i.e, either to grow a food crop or a cash crop. An inter-correlation matrix of the change in area under different vegetables and their substitute have to be fitted for different regions and these results are to be taken into account while selecting the substitute crop for the vegetables to be studied. Further, while selecting the substitutes the weightage of the substitutes in the states' crop economy should be taken into account. In other words, the selected substitute crop should be a major crop in the respective regions. Multiple linear regression models using ordinary least squares (OLS) techniques have to be fitted to estimate the coefficients in the area supply functions.

The analysis has been conducted at the region level and hence can throw light on the role of different factors in different regions which may not be possible, if the analysis was at the state level only.

The supply function has been fitted by attempting a cross section analysis at region level in order to assess the role of different factors in different regions. In order to adequately assess the role of different factors in different regions, regions have been classified on the basis of typology of growth. Since area is selected as the dependent variable in the supply function the growth trend in area has been used as the criterion for classifying regions. Three broad typologies have been identified (1) regions reporting positive and significant trends in area, for conveniences are referred to as "area increasing regions", (2) regions with negative and significant trends in area are referred to as "area declining regions" and (3) regions where the trends in area, positive or negative, are not statistically significant are referred to as "area stagnant regions". In case a region reported a particular trend in one period and a different one in the next period (say positive in one and negative in next) in such cases the trend of the latter period has been taken into account to group the region. Though there are apparent limitations in attempting a supply analysis of area stagnant regions still the analysis has been attempted in the hope of getting some clues about the factors influencing vegetable cultivation in these regions. At least one region from each group of regions has been selected in order to comprehend the role of different factors in different contexts in explaining the growth behaviour of the vegetables under study.

West Bengal is the leading vegetable producing state in the country, as mentioned earlier, accounting for over 10% of the crop's area and 8% of the output in the country. Area under vegetable cultivation in the state increased rapidly over 3lakh hectares during 1980-81 to 1985-86. However, after 1985-86 the vegetable area started declining and only after 1990-91 that this trend was reversed and the crop's cultivation started picking up again. Its area during 2001-02 to 2012-2013 was estimated over 5lakh hectares. The area under vegetable increased marginally to 9.23 lakh hectares in 2017-18 from 9.12 lakh hectares in 2007-08.

Though vegetables are cultivated in all regions of West Bengal, over 61% of the crop's output comes from the Alluvial and Coastal regions alone, particularly from the districts of 24-Parganas (South), 24-Parganas (North), Nadia, Hooghly, Burdwan, Murshidabad and Midnapore. The crops that compete with vegetables in West Bengal are mainly summer paddy in summer, Kharif paddy in rainy season and mustard as well as wheat in the winter season. These crops have

been selected as the substitute crops for the analysis of the vegetables area response. It will be helpful to know as to how vegetable growers in West Bengal respond given the alternative of growing food crops like paddy and wheat or a non-food cash crop like mustard. An analysis of the changes in the area under vegetables, paddy and wheat during 2010-11 to 2017-18 indicated a negative and statistically significant correlation between vegetables area and that of paddy and wheat area, the coefficients being -0.92 in case of paddy and -0.67 in case of wheat. Though the mustard area was positively correlated with the vegetables area the coefficient 0.14 was not statistically significant. The analysis of the growth behaviour and pattern of growth of vegetables indicated that Alluvial and Coastal regions recorded a significant expansion of the area under vegetables during the period under study. Barind and Terai regions recorded a significant decline, whereas Rarh and Eastern Plateau reported that the area was stagnant during this period. It has been mentioned earlier that Alluvial and Coastal regions are the leading vegetable producing regions accounting more than 61 % area in the state in 2017-18.

By observing the movements in the yield rates and prices of vegetables vis-à-vis those of its substitute crops in West Bengal during 2010-11 to 2017-18, it appears that vegetable yields have declined in relation to the yields of its substitute. What is commendable is that the ratio of vegetable yield to that of wheat and mustard yields was greater than unity during the period. In relation to paddy it was slightly less than unity during 2010-11 to 2017-18. Taking entire twenty years period, the ratio of vegetable yield to paddy has been greater than unity. Thus, though vegetable has been losing its yield advantage over some of its substitute, it still continues to hold an edge over them in this respect.

The price of vegetable relative to the prices of paddy, wheat and mustard has increased significantly, taking the period as a whole. The ratio of vegetable price to those of paddy, and wheat has exceeded one during 2010-11 to 2017-18 and less than unity in relation to mustard. But vegetable price relative to mustard has been improving over time. Trends fitted to the relative gross income (i.e. yield valued at farm harvest price) of vegetable to those of its substitute crops indicate that they have declined in relation to paddy and wheat whereas they have improved in relation to mustard, taking the period as a whole. Though the movements in relative gross income have been favorable to vegetable vis-à-vis mustard it is not so in relation to paddy and wheat. However, in terms of gross returns vegetable still enjoys a distinct advantage over paddy, wheat and mustard. The ratio of gross income from vegetable to paddy is around 3, and over 4 in relation to both wheat and mustard.

Table 1.1 presents the OLS estimate of vegetable area response for West Bengal during 2010-11 to 2017-18. It is interesting to observe that the relative yield variable is positively and significantly correlated with the vegetable area where paddy is the substitute crop. The relative yield risk variable is negative and significant in case of wheat substitution only. Irrigation is seen to have a positive and significant influence on the vegetable area when paddy is considered as a substitute crop. The coefficient is positive in some equations and negative in others, though none is significant. Does this imply that price is not at all a factor of consequence in influencing the vegetable area response? In fact the relative gross income variable is positively correlated and significant with the vegetable area when wheat and mustard are the substitute crops. This clearly shows that ultimately it is the expected returns which influence the supply response behavior of vegetable growers. Though ultimately it is the expected returns from vegetable, technology-related factors, seem to be more prominent in explaining the variations in vegetable area.

Hill region accounts for about 2% of the area and output in the state. The area under vegetable cultivation which was around 7.5 thousand hectares in 2010-11 declined steadily and the crop's area during 2017-18 was estimated at over 6.5 thousand hectares. As in other districts, in hill region also the substitute crops of vegetable are

mainly coarse cereals and ginger. For the analysis of vegetable area response in this region two substitute crops have been selected i.e. one maize a food crop and the other ginger a non food crop. The correlation coefficient between the vegetable area and the maize area was negative (- 0.33) and positive (0.24) in case of ginger area. But the coefficients in both cases are not statistically significant. The movement of the vegetable area and that of maize and ginger have not necessarily been in opposite directions.

The yield or price of vegetable relative to yields and prices of maize and ginger have not shown any significant rise in the state during the period under review. In fact, vegetable yield relative to ginger yield recorded a decline. In relation to maize yield it recorded a positive trend. But these trends are not statistically significant. Trends in the gross income from vegetable relative to maize and ginger did not record any significant rise. In fact, in relation to ginger, gross income of vegetable declined taking the trend for this period. Thus, movement of relative yields, prices and gross incomes has not been favorable to vegetable in hill region.

Table 1.1 Factors influencing vegetable area response in Alluvial and Coastal regions of W.B.

Equation No.	Constant term	Lagged area	Lagged Relative yield	Lagged Relative price	Lagged Relative Gross income	Relative Yield risk	Relative Price risk	Irrigation	Rainfall	.	h or DW Statistics
Subs	titute	Crop:	Paddy								
1. a	-138.61	0.84*	291.70*	-229.21	-	0.39	0.75	0.35***	0.17	0.83	-1.46
2. a	1814.58*	-	-	-	-56.58	-0.63	5.61	-	0.20	0.11	0.49
Subs	titute	Crop:	Wheat								
3. a	126.73	0.73*	163.85**	-71.21	-	-33.21***	-11.09	0.18	0.17	0.81	-1.69
4. a	1381.56*	-	-	-	121.71***	- 60.41***	11.98	0.20	-0.02	0.32	0.65
Subs	titute	Crop:	Mustard								
5. a	-384.20	0.74*	82.61*	671.56	-	-0.51	9.91	-0.02	0.28	0.82	-1.16
6. a	1018.41*	-	-	-	182.64***	1.12	41.23	0.14	0.20	0.28	0.53

Notes: 1. *, **, *** significant at 1%, 5% and 10% levels of significance.
2. In the equations where lagged area variable appears we have presented
the 'h'statistics, in other cases the DW statistics.

The OLS estimates of the vegetable area response in hill region are presented in Table – 1.2. The yield variable is positive and significant where ginger is substitute crop. The price risk variable is negative and significant. But what is most interesting to observe is that the irrigation variable is negatively correlated with the vegetable area. In other words the farmers in the hill region faced new production options and hence when irrigation is available the farmers preferred to grow other crops. In fact, there is a strong positive and significant correlation between the gross irrigated area and the maize, paddy and ginger area in the region, the correlation coefficients exceeding 0.9 with respect to these three crops. Availability of irrigation and access to high yielding new varieties and other modern inputs have thus worked out to be detriment of vegetable in the region.

Rarh and Eastern Plateau region is also major vegetable producing area accounting for around 12 to 13% of the crops total area and output in the state. The area under the crop in the region has been more or less stagnant varying between 50 to 53 thousand hectares during the period 2017-18. In spite of a significant increase in the gross irrigated area in the region over the years, it still covers only less than 20% of the state's gross sown area. This has affected vegetable also and as of today only about 40 to 50 % of the vegetable area is properly irrigated. The bulk of the crop is therefore raised under severe crisis of irrigation.

Paddy, wheat, sugarcane and mustard are the main competing crops of vegetable in this region. For the analysis of the vegetable area response paddy, wheat and mustard have been selected as the substitute crops. This will enable one to know as to how vegetable growers in this region will respond given the alternative of growing a food crop like paddy or wheat or an oilseed crop like mustard. The correlation coefficient between the vegetable area and the paddy area for the period 2010-11 to 2017-18 was negative (-0.21) though not statistically significant, and positive with respect to wheat area (0.29) and the mustard area (0.56). Unlike vegetable, the paddy and wheat have recorded a significant increase in the region during the period under review, increasing at over 11 and 0.7 % per annum respectively.

The yield of vegetable relative to those of paddy, wheat and mustard has registered a significant decline in this region during the period under study. The price of vegetable relative to those of its substitute appears to have increased during the same period. But these positive trends in the vegetable's relative price to paddy, wheat and mustard were significant only in case of wheat. Whatever advantage vegetable may have gained through an increase in its relative price has been offset by the steep decline in its relative yield. In fact, trends fitted to the relative gross income of vegetable to those of paddy, wheat and mustard indicate a decline in the relative gross income of vegetable during the period under study.

Table 1.2 Factors influencing vegetable area response in Barind and Terai regions of W.B.

Equation No.	Constant term	Lagged area	Lagged Relative yield	Lagged Relative price	Lagged Relative Gross income	Relative Yield risk	Relative Price risk	Irrigation	Rain-fall		h or DW Statistics
Subs	Titute	Crop:	Maize								
1. a	13.23	0.97*	1.97	6.65	-	0.48	-3.61	-0.01	0.001	0.91	2.06
2. a	-36.10	-	-	-	0.07	13.44***	0.39	0.01***	0.11	0.35	0.56
Subs	Titute	Crop:	Paddy								
3. a	229.97	0.50**	5.05	3.09	-	-31.21	-11.41**	-0.02	0.03	0.55	-0.34
4. a	521.06*	-	-	-	-39.67	51.38	-14.90*	-1.01	-0.002	0.41	1.35
Subs	Titute	Crop:	Ginger								
5. a	-64.20	0.91*	16.61*	31.56	-	-0.07	8.51	-0.002	0.02	0.92	0.54
6. a	42.65	-	-	-	26.94	0.43	37.76***	0.01**	0.04	0.37	0.69

Notes: 1. *, **, *** significant at 1%, 5% and 10% levels of significance.
2. In the equations where lagged area variable appears we have presented the 'h' statistics, in other cases the DW statistics.

The OLS estimates of vegetable area response for Rarh and Eastern Plateau region are presented in Table - 1.3. The table shows that the relative yield variable has a positive and significant influence on the vegetable area, excepting mustard as substitute crop. The relative price risk variable has a negative sign and it is significant too only in case of wheat. The relative gross income variable is positively correlated with the vegetable area. But it is statistically significant only where mustard is the substitute crop. Interestingly, in this situation the irrigation variable is negative and significant which seems to suggest that the spread of irrigation has been working to the detriment of vegetable. No other clues could be obtained from the regression results as to why the vegetable area has been more or less stagnant in Rarh and Eastern Plateau region. However, as already observed, movement in relative yields and relative gross income of vegetable have not been favorable in this region. It is this factor which explains the stagnancy of vegetable in Rarh and Eastern Plateau region.

Table 1.3 Factors influencing vegetable area response in Rarh and Eastern Plateau regions of W.B.

Equation No.	Constant term	Lagged area	Lagged Relative yield	Lagged Relative price	Lagged Relative Gross income	Relative Yield risk	Relative Price risk	Irrigation	Rain-fall	R^2	h or DW Statistics
Subs 1. a	titute 939.69**	Crop: -0.06	Paddy 27.81**	-32.10	-	-0.15	2.86	-0.02	0.11	0.11	0.33
2. a	827.81*	-	-	-	14.81	1.43	-5.21	-	0.08	0.04	1.75
Subs 3. a	titute 790.17*	Crop: 0.13	Wheat 28.71**	23.10	-	11.61	- 23.11*	-0.01	0.01	0.43	0.23
4. a	817.79*	-	-	-	9.51	12.81	- 22.08*	-0.002	0.002	0.38	1.67
Subs 5. a	titute 711.88**	Crop: 0.11	Mustard 2.72	144.51	-	2.25***	-25.61	-0.09	0.21	0.36	- 0.34
6. a	876.43	-	-	-	3.21***	2.04***	-14.51	- 0.08***	0.21	0.34	1.88

Notes: 1. *, **, *** significant at 1%, 5% and 10% levels of significance.
2. In the equations where lagged area variable appears we have presented the 'h' statistics, in other cases the DW statistics.

To sum up it can be said that the experience regarding area response of vegetable is not similar. It has been observed that the technological factors, price factors vis-à-vis higher return have favored vegetable cultivation in area increasing regions. Technological factors like irrigation though insignificant, have worked to the detriment of vegetable cultivation in Rarh and Eastern Plateau region. It has been also observed that vegetable did not enjoy any distinct comparative advantage over its substitutes either in terms of yield or price in this region and hence possibly this accounts for the stagnation of the crop in this area.

CONCLUSION

Major vegetables grown in the state of West Bengal show significant overall increase in their production as well as productivity levels even in the face of considerable variation in acreage under these crops. It has been found that output instability has been observed to be much higher than area and yield instabilities across major vegetables in West Bengal.

It is fact that the growth of vegetables too has been uneven across regions and over time in West Bengal. While the area under cultivation of these crops recorded a significant expansion in some regions, in other regions it either declined or was stagnant. Thus the factors influencing the area response of vegetables in selected regions in West Bengal during 2010-11 to 2017-18 have been analyzed. It has been found that in Alluvial and Coastal region, lagged area as well as lagged yield ratios has positive and significant effect on area when paddy is taken as substitute crop. Lagged relative gross income favours area under vegetables when wheat and mustard are taken as substitute for vegetables. In case of wheat as substitute, relative yield risk has adverse effect on area allocation. In Barind and Terai regions of West Bengal, lagged area has positive and significant effect on area under vegetables in all the three crops substitution situations. In case of ginger as substitute crop, lagged yield ratios is in favour of area under vegetables. Relative price ratio has adverse effect on vegetable area when paddy is a substitute crop. In Rarh and Eastern Plateau region, lagged yield ratio has positive and significant effect except mustard, on vegetable area. Relative price risk has negative but significant effect on vegetable area only in case of wheat as substitute crop. The study clearly highlights that none of the factors considered have common effect on area response under vegetables in the three area allocation situations (regions) and crop substitution situations

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Study on variability in field experiments on Sugarcane crop and yard stick there of

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ABSTRACT

The data on C.V. % for sugarcane crop yield along with other details of 389field experiments conducted during 1997-98 to 2014-2015at Navsari center 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 sugarcane crop experiments which emerged as 11 %.

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 and the present paper deals with this aspect.Johnson and Welch, 1939 reported that 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

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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 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 389 experiments conducted on Sugarcane crop at Navsari center during 1997-98 to 2014-2015. 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 ($\bar{x}$)

$$cv = \frac{s}{x} \qquad (1)$$

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* distributionconnot 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 x^2/f, with *f* degree of freedomThen, if *t* is defined by the equation:

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

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

Let an estimate of v be v = s/$\bar{x}$ the sample coeffcient 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 distribution can be as non-central *t* with *f*= (n - 1) and $\frac{\sqrt{n}}{v}$ This diistrbution 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,

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

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

(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 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 probability level of confidence, i.e. e and obtain 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 Sugarcane crop

Discipline	No.of expt.	CV %	U L		CV % >10.16	
			(0.05)	(0.10)	No.of expt.	Proportion
Agronomy	103	8.01	11.15	10.27	25	0.24
Pl.Breeding	286	7.89	9.81	9.33	27	0.09
Mean		7.92	10.16	9.58	-	-

The results presented in (Table 1) revealed that mean CV % and upper fiducial limits of average value of all the discipline except for Agronomy discipline, were below the mean CV (10.16) %.

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

Design	No.of expt.	CV %	U L		CV % >10.16	
			(0.05)	(0.10)	No. of expt.	Proportion
FRBD	7	8.86	10.65	10.22	1	0.14
RBD	363	7.98	10.25	9.66	70	19.28
Split Plot	19	6.40	8.32	7.82	1	5.26
Mean	389	7.92	10.16	9.58	-	-

The design used in Sugarcane crop experiments (Table 2) indicated that the higher upper fiducial limits and proportion of experiments (>19.28%) were observed for RBD. Split plot was within average fiducial limit and average proportion.

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

Treatments	No.of expt.	CV %	U L		CV % >10.16	
			(0.05)	(0.10)	No. of expt.	Proportion
Up to 6	49	6.53	10.31	9.19	2	4.08
6-10	114	7.85	10.28	9.66	22	19.29
11-15	143	8.42	10.44	9.94	31	21.67
16-20	42	7.44	8.92	8.56	6	14.28
21-25	18	8.26	9.94	9.53	5	27.77
26-30	8	8.61	9.93	9.62	3	37.5
>30	15	8.88	10.01	9.75	3	20.00
Mean	389	7.92	10.16	9.58	-	-

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 16-20, 21-25, 26-30 and >30.

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

Plot size (m^2)	No.of experiment	CV %	U L		CV % >10.16	
			(0.05)	(0.10)	No.of expt.	Proportion
<3	-	-	-	-	-	-
3-6	23	7.65	9.27	8.88	3	13.04
6-9	-	-	-	-	-	-
9-12	25	8.58	10.84	10.23	6	24.00
12-15	6	8.39	10.42	9.92	1	16.66
15-18	41	7.55	10.45	9.65	6	14.63
18-21	126	7.98	9.87	9.41	20	15.87
21-24	10	10.55	13.96	13.04	3	30.00
>24	158	7.73	10.09	9.48	33	20.88
Mean	389	7.92	10.16	9.58	-	-

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 9-12, 12-15, 15-18 and 21-24sq.m. plot size. The upper fiducial limit, mean CV % and proportion of experiments for plot size 3-6, 18-21 and >24sq.m. was less than average fiducial limit. Considering the proportionexperiments, plot size 18-21sq.m. seems to be optimum plot size for sugarcane crop experiments. However, it needs confirmation by plot technique study.

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

Replication	No. of expt.	CV %	UL		No.of expt.	Proportion
			(0.05)	(0.10)		
2	28	8.51	10.18	9.78	6	21.42
3	321	7.96	10.27	9.67	62	19.31
4	40	7.25	9.34	8.81	4	10.00
Mean	389	7.92	10.16	9.58	-	-

The results presented in (Table 5) revealed that all experiments conducted with different number of replications were within average fiducial limit except with number of replications 2 and 3.

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

Name of Crop	No.of experiments	Mean CV %	Upper fiducial limit of CV %		Overall yardstick of CV%
			0.95	0.90	
Sugarcane	389	7.92	10.16	9.58	11 %

The average upper fiducial limit of CV % at 95 and 90 per cent confidence and average CV % of all 389 experiments were 10.16 %, 9.56 % and 7.92 % respectively (Table 6). The average upper fiducial limit of CV % (10.16 %) covers the region related to average CV % of all the experiments.

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

Classes CV%	No.of experiments	F-test		
		Significant	Non-Significant	Ratio
1-3	1	1	0	0.00
3-5	42	41	1	0.02
5-7	119	113	6	0.05
7-9	103	97	6	0.06
9-11	72	58	14	0.24
11-13	32	24	8	0.33
13-15	2	9	0	0.00
15-17	10	2	8	4.00
17-19	1	1	0	0.00
Total	389	346	43	0.12

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 0.12. The ratio for the class 9-11 % was almost equal to the average ratio. The class included 10.16 %, the mean CV % of all experiments. It can be seen from Table 7 that more than 20% of experiments having 11 % and more CV % failed to detect difference in treatments means. Results clearly showed that when the coefficient of variation in Sugarcane crop experiments conducted in RBD exceeds 11 %, the experimental finding should not be considered for any purpose.

YARDSTICK OF C.V. % FOR SUGARCANE CROP EXPERIMENTS

The C.V. % data of 389 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 10.16 per cent. Thus, the results suggested that about 11 percent C.V. % should be considered as a yard stick for sugarcane crop field experiments. These having C.V. % >11should be rejected for drawing scientific conclusion.

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Knowledge and adoption level of potato production technology among the farmers of Sabarkantha district

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ABSTRACT

The study was purposively conducted in the Dhansura and Bayad taluka of Banaskantha district of the Gujarat state. For selection of 6 villages and 120 respondents, multistage sampling technique was employed. A majority (61.67%) of the potato growers had medium level of knowledge regarding recommended practices of potato. Sowing time and method, irrigation management, land preparation, earthing up, recommended variety, harvesting, spacing, seed rate and basal application of chemical fertilizers were the practices in which potato growers had higher knowledge. While in case of adoption, majority (70.83 per cent) of the potato growers had medium extent of adoption of recommended production technology of potato. The important practices having higher adoption were: irrigation management (86.57 mean score), earthing up (85.23 mean score), spacing (81.19 mean score), sowing time and method (80.17 mean score), recommended variety (76.15 mean score), harvesting (75 51 mean score), seed rate (75.17 mean score), basal fertilizers (73.15 mean score) and seed treatment (72.27mean score). The independent variables viz., age, education, annual income, extension participation, method of irrigation, innovative proneness, risk orientation and level of knowledge were found having positive and significant association with adoption of recommended potato production technology by potato growers.

Key words: adoption, potato, technology, farmers

India is an important potato producing country in the world. It ranks fourth in area after China, Russia and Ukraine and ranks third in production after China and Russia. India has highest potato productivity than three largest potato producers *viz*. China, Russia and Ukraine. FAO identified potato as Food of Future as it has great potential of fighting hunger and poverty in large part of the world. In this context, year 2008-09 was celebrated as "International Potato Year" throughout the world.

Potato is an important vegetable crop of the Sabarkantha district of the Gujarat state occupying about 18.46% of total potato cropped area of the state. It ranks second in area and production of potato after Banaskantha district. Therefore, there is a wide gap between the highest productivity in the state and productivity of Sabarkantha. The low productivity of potato in Sabarkantha district could be attributed to the fact that the farmers have not still adopted the recommended production technology of the crop up to the extent. The knowledge about the new production technology plays vital role in their adoption by farmers. Taking all this in view, the present study was under taken with following specific objectives.

1. To study the personal, socio-economic, situational and psychological characteristics of the potato growers

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2. To find out knowledge level of the potato growers about potato production technology
3. To find out the extent of adoption of potato production technology by the potato growers
4. To ascertain the association between the extent of adoption of recommended potato production technology by the potato growers and their selected characteristics

MATERIALS AND METHODOS

The present study was undertaken in Sabarkantha district of Gujarat state. Using purposive random sampling, two talukas *viz.*, Dhansura and Bayad were selected as these talukas are having high area under potato sampling technique. From each selected village, twenty respondents were selected randomly for making a sample of 120 respondents.

The present study was confined to ex-post facto research design, the independent variables were measured by using suitable scale and procedure adopted by various researchers in past with due modification. Practice wise adoption index was worked out and then ranks were given to each practice on the basis of its adoption index.

The data were collected with the help of structured pre-tested interview schedule. The data collected were analyzed, tabulated and interpreted in the light of objectives for arriving at meaningful interpretation.

RESULTS AND DISCUSSION

Personal characteristics

The results regarding personal characteristics of the potato growers are presented in Table 1.

Table 1 Distribution of the respondents according to their personal characteristics

No	Characteristics	Group		Frequency	%
1	Age	1	Young (up to 35 years)	29	24.17
		2	Middle (36 to 50 years)	68	56.67
		3	Old (above 50 years)	23	19.17
2	Education	1	Illiterate	05	4.17
		2	Primary (up to VII std)	27	22.50
		3	Secondary (VIII to X std)	29	24.17
		4	Higher secondary (XI & XII std/diploma)	43	35.83
		5	Graduation	16	13.33
		6	Post-graduation	00	0.00
3	Size of family		Small	34	28.33
			Medium	65	54.17
			Large	21	17.50
4	Social participation	1	No membership	20	16.67
		2	Membership in one organisation	73	60.83
		3	Membership in more than one organisation	19	15.83
		4	Holding position	08	6.67
5	Land holding	1	Marginal (up to 1.00 ha)	19	15.83
		2	Small (1.01 to 2.00 ha)	35	29.17
		3	Semi-medium (2.01 to 4.00 ha)	51	42.50
		4	Medium (4.01 to 10.00 ha)	15	12.50
		5	Big (above 10.00 ha)	00	0.00
6	Annual income	1	Low (upto Rs. 42509/-)	24	20.00
		2	Medium (Rs.42510/- to 104224/-)	81	67.50
		3	High (above Rs. 104224/-)	15	12.50
7	Extension participation	1	Low (upto 7.64 score)	16	13.33
		2	Medium (7.64 to 15.00 score)	86	71.67
		3	High (above 15.00 score)	18	15.00
8	Method of irrigation	1	Furrow irrigation (Traditional method)	25	20.83
		2	Sprinkler irrigation	21	17.50
		3	Drip irrigation	74	61.67
9	Cropping pattern	1	— - —	76	63.33
		2	Groundnut - Potato-Cluster bean	65	54.17
		3	Cluster bean - Potato - Pearl millet	52	43.33
		4	Pulses-Potato-Fallow	47	39.17
		5	Groundnut – Potato - Watermelon	32	26.67
10	Innovative proneness	1	Low (upto 20.95 score)	12	10.00
		2	Medium (20.96 to 29.46 score)	91	75.83
		3	High (above 29.46 score)	17	14.17
11	Risk orientation	1	Low (upto 15.48 score)	24	20.00
		2	Medium (15.49 to 28.17 score)	72	60.00
		3	High (above 28.17 score)	24	20.00

A perusal of the data in Table 1 reveal that majority of the potato growers were middle aged (56.67 %), had secondary and above education (73.33 %) and small to semi-medium landholding (71.67 %). More than half (54.17%) of the potato growers were belonged to medium family. Majority of the potato growers had medium annual income (67.50 %), membership in one organization (60.83%) and medium extension participation (71.67%).

Majority of the potato growers had adopted drip system (61.67%) as a method of irrigation and followed Groundnut-Potato-Fodder sorghum cropping pattern (63.33%). More than three-fourths (75.83%) of the potato growers had medium innovative proneness. Nearly three-fifths (60.00%) of the potato growers had medium risk orientation.

Knowledge level

The information regarding knowledge level of the potato growers about potato production technology is depicted in Table 2.

Table 2 Distribution of the respondents according to their level of knowledge about potato production technology

Sr. No.	Level of knowledge	Frequency	Percent
1.	Low	19	15.83
2.	Medium	74	61.67
3.	High	27	22.50
	Total	120	100.00

Mean= 79.10 S D =6.05

Data presented in Table 2 portray that majority (61.67%) of the potato growers had medium level of knowledge about potato production technology, while 22.50 per cent and 15.83 per cent of the potato growers had high and low level of knowledge, respectively.

Thus, it can be concluded that majority of the respondents had medium level of knowledge regarding potato production technology. The probable reason might be that majority of the potato growers had medium level of social participation and extension participation.

This finding is in the line with the findings of Kadu and Saiyad (2009) and Rathod (2009).

Table 3 reveals that among the different recommended potato production technologies, 'sowing time and method' and 'irrigation management' were the practices of potato cultivation in which potato growers had highest knowledge (93.33 mean score each) and ranked first. The other practices in which potato growers had higher knowledge (mean score greater than overall knowledge mean score) were: land preparation (91.43 mean score), earthing up (87.17 mean score), recommended variety (86.67 mean score), harvesting (85.00 mean score), spacing (82.50 mean score), seed rate (81.67 mean score), basal application of chemical fertilizers (80.00 mean score) and were ranked second, third, fourth, fifth, sixth, seventh and eighth, respectively.

Table 3 Practice-wise knowledge of potato growers about improved potato production technology (n=120)

Sr. No	Potato production technology	Mean score	Rank
1.	Recommended variety	86.67	IV
2.	Land preparation	91.43	II
3.	Seed rate	81.67	VII
4.	Seed treatment	75.00	X
5.	Sowing time and method	93.33	I
6.	Spacing	82.50	VI
7.	FYM	76.67	IX
8.	Basal application of chemical fertilizers	80.00	VIII
9.	Top dressing of chemical fertilizers	74.00	XI
10.	Earthing up	87.17	III
11.	Weed control	68.33	XIII
12.	Irrigation management	93.33	I
13.	Insect -pest control	72.50	XII
14.	Disease control	66.00	XIV
15.	Crop rotation	60.00	XV
16.	Harvesting	85.00	V
	Overall Knowledge Mean Score	79.10	

The remaining potato cultivation practices which received knowledge mean score below the overall knowledge score (79.10 mean score) were: FYM (76.67 mean score), seed treatment (75.00 mean score), top dressing of chemical fertilizers (74.00 mean score), insect-pest control (72.50 mean score), weed control (68.33 mean score), disease control (66.00 mean score) and crop rotation (60.00 mean score) and ranked

ninth, tenth, eleventh, twelfth, thirteenth, fourteenth, fifteenth, respectively.

From the above discussion, it can be concluded that sowing time and method, irrigation management, land preparation, earthing up, recommended variety, harvesting, spacing, seed rate and basal application of chemical fertilizers were the practices in which potato growers had higher knowledge.

Adoption level

The details regarding extent of adoption of recommended potato production technology is presented in Table- 4.

It is clear from Table 4 that majority (70.83 %) of the potato growers had medium extent of overall adoption of recommended potato production technology followed by 15.83 per cent and 13.44 per cent of the potato growers who had low and high extent of overall adoption, respectively

Table 4 Distribution of the potato growers according to their extent of adoption regarding recommended potato production technology

Sr. No.	Extent of adoption	Frequency	Percent
1.	Low	19	15.83
2.	Medium	85	70.83
3.	High	16	13.44
	Total	120	100.00

Mean= 70.97 SD = 5.99

From the above table, it is clear that majority of the potato growers had medium extent of adoption regarding recommended potato production technology. The possible reason for medium adoption by the majority of potato growers might be their medium knowledge. Further, majority of the potato growers had small to semi-medium landholding hence they might have faced constraints in adopting recommended potato cultivation technology.

This finding is in the line with the findings reported by Parakash *et al.* (2003).

Table 5 The practice-wise adoption of recommended potato production technology by potato growers

(n=120)

Sr. No.	Recommended practices	Mean Score	Rank
1	Recommended variety	76.15	V
2	Land preparation	69.27	X
3	Seed rate	75.17	VII
4	Seed treatment	72.27	IX
5	Sowing time and method	80.17	IV
6	Spacing	81.19	III
7	FYM	66.24	XI
8	Basal application of chemical fertilizers	73.15	VIII
9.	Top dressing of chemical fertilizers	64.23	XII
10.	Earthing up	85.23	II
11.	Weed management	60.10	XIV
12.	Irrigation management	86.57	I
13.	Insect-pest control	61.19	XIII
14.	Disease control	56.80	XV
15.	Crop rotation	52.19	XVI
16.	Harvesting	75.51	VI
	Overall mean score	70.97	

Table 5 shows that among the different recommended potato production technologies, irrigation management technology had the highest adoption (86.57mean score) among the potato growers and ranked first. The other potato production practices in which potato growers had higher adoption (mean score greater than overall mean score) were: earthing up (85.23 mean score), spacing (81.19 mean score), sowing time and method (80.17 mean score), recommended variety (76.15 mean score), harvesting (75 51 mean score), seed rate (75.17 mean score), basal fertilizers (73.15 mean score) and seed treatment (72.27 mean score) and were ranked second, third, fourth, fifth, sixth, seventh, eighth, and ninth, respectively.

While, low extent of adoption of technology was observed in remaining practices having score below overall mean score (70.97 mean score). These practices in descending order were: land preparation (69.27 mean score), FYM (66.24 mean score), top dressing of fertilizers (64.23 mean score), insect-pest control (61.19 mean score), weed management (60.19 mean score), disease control (56.80 mean score) and crop rotation (52.19 mean score)

Relational Analysis

The correlation analysis was carried out to find out whether the selected characteristics of potato growers had any association with their

extents of adoption of recommended production technology.

Table 6 Association between the extents of adoption of recommended Production technology by the potato growers and their selected characteristics

(n=120)

Sr. No.	Independent Variable	Correlation Coefficient ('r' value)
1	Age	0.2149*
2	Education	0.2091*
3	Size of family	0.1498
4	Social participation	0.1433
5	Land holding	0.1004
6	Annual income	0.2166*
7	Extension participation	0.2435**
8	Method of irrigation	0.1868*
9	Cropping pattern	0.1009
10	Innovative proneness	0.2483**
11	Risk orientation	0.2041*
12	Level of knowledge	0.8476**

It is apparent from the Table 6 that the independent variables *viz.*, age, education, annual income, extension participation, method of irrigation, innovative proneness, risk orientation and level of knowledge had positive and significant correlation with adoption of recommended crop production technology by potato growers. While, the variables like size of family, social participation, land holding and cropping pattern positive and not-significant relationship with adoption of recommended crop production technology by the farmers.

CONCLUSION

From the aforesaid discussion, it can be concluded that majority (61.67%) of the potato growers had medium level of knowledge regarding recommended practices of potato. With regards to practice-wise knowledge, sowing time and method, irrigation management, land preparation, earthing up, recommended variety, harvesting, spacing, seed rate and basal application of chemical fertilizers were the practices in which potato growers had higher knowledge. While in case of adoption, majority (70.83 per cent) of the potato growers had medium extent of adoption of recommended production technology of potato. The important practices having higher adoption were: irrigation management (86.57 mean score), earthing up (85.23 mean score), spacing (81.19 mean score), sowing time and method (80.17 mean score), recommended variety (76.15 mean score), harvesting (75 51 mean score), seed rate (75.17 mean score), basal fertilizers (73.15 mean score) and seed treatment (72.27 mean score). The variables *viz.*, age, education, annual income, extension participation, method of irrigation, innovative proneness, risk orientation and level of knowledge were having positive and significant association with adoption of recommended crop production technology by potato growers.

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Pesticide buying behaviour of the potato growers in Banaskantha district

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ABSTRACT

The study was conducted in Banaskantha district of Gujarat state to understand the pesticide buying behaviour of the potato growers by selecting a representative sample of 150 potato growers using multistage random sampling technique. The data regarding pesticide buying behaviour of the potato growers revealed that nearly three-fifths of the potato growers purchased pesticides well in advance at the time of potato planting. The most important sources for making pesticide purchase decision were; farmers' own experience, relatives and friends, pesticide dealers and progressive farmers. Important factors considered by potato growers while purchasing pesticide in descending order were: quality (better control) of pesticide product, attractive packing of pesticide and popularity of pesticide in farming community.

Key words: Pesticide buying, potato, farmers

Potato (*Solanum tuberosum* L.) is one of the important cash crops in Banaskantha district of Gujarat state. Pest and disease infestations are common occurrences in potato cultivation. Potato crop is infested by a variety of fungal, bacterial and viral diseases. As regards pests, some pests attack the foliage while some attacks the tubers. Many of the diseases in potato are soil/seed borne and so once infected is very difficult to control them. Similarly viruses affect the seed quality and so has a chain of implications. Therefore, proper control of pests and diseases is of utmost importance for profitability.

Pesticides utility has increased rapidly in recent years. Day by day the use of pesticides is increasing in potato cultivation to increase the production. The pesticide market in India is becoming highly competitive. The number of pesticide options available to a potato grower for controlling a pest. Potato grower's decision making on pesticide purchase, therefore becomes of considerable interest. Research on the buying behaviour of pesticides has been very limited in the study area. This study attempts to develop an understanding of the pesticide buying behaviour of the potato growers in Banaskantha district.

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MATERIALS AND METHODS

The study was undertaken in Banaskantha district of Gujarat state. Three talukas *viz.*, Deesa, Dantiwada, and Vadgam were purposively selected considering the largest area under potato cultivation. Fifteen potato growing villages *i.e.* five from each taluka were randomly selected. Ten potato growers from each selected village were taken by random sampling technique for making a sample size of 150 respondents. Pesticide buying behaviour of the potato growers was assessed against three sub-heads *viz.*, time of purchasing pesticides, contacts made for getting advice to purchase

pesticides and factors considered by the potato growers for making pesticide purchasing decision. The data were collected with the help of structured pre-tested interview schedule. The present study was confined to ex-post-facto research design.

RESULTS AND DISCUSSION

Pesticide buying behaviour of the potato growers in Banaskantha district was assessed against three major areas *viz.*, (i) Time of purchasing pesticides (ii) Contacts made for getting advice to purchase pesticides and (iii) Factors considered for making pesticide purchasing decision.

Time of purchasing pesticides

Time of purchase of pesticides is a crucial aspect of pesticide buying behaviour of the potato growers as the potato is the most chemically dependent crop. Table 1 represents the time of purchasing pesticides by the potato growers in the study area.

Table 1 Distribution of the potato growers according to their time of purchasing pesticides

Sr. No.	Time of purchasing pesticides	Frequency	Per cent
1.	Advance purchasing	92	61.33
2.	At the time of pest attack	39	26.00
3.	After some loss due to pest	19	12.67
	Total	150	100.0

The data in the table 1 reveals that nearly three-fifths (61.33 per-cent) of the potato growers purchased their pesticides well in advance before the time of potato planting followed by 26.00 per cent of the potato growers purchased pesticides at the time of pest attack on potato crop and 12.67 per cent of the potato growers purchased pesticides after some loss of crop due to pest attack.

Occurrence of blight disease in the potato crop is very common in the study area. Therefore protective spraying of pesticides is recommended to prevent the diseases to occur. Hence, majority of the potato growers had adopted the protective spraying of pesticides in potato crop. This might be the probable reason for advance purchasing of pesticides by the potato growers in study area.

Contacts made for getting advice to purchase pesticides

For making decision to purchase pesticides, potato growers contact numbers of sources. The information sources contacted for making pesticide purchase decisions were studied and results pertaining to this are presented in Table 2.

Table 2 Distribution of the potato growers according to their contacts made for getting advice to purchase pesticide

Sr.No.	Contact for getting advice to purchase pesticide	Frequency	Per cent	Rank
1.	Own experience	139	92.67	I
2.	Relative / Friend	129	86.00	II
3.	Pesticide dealers	126	84.00	III
4.	Progressive farmer	83	55.33	IV
5.	Mass media	48	32.00	V
6.	Agriculture officer	46	30.67	VI
7.	KVK scientists	44	29.33	VII
8.	Agriculture scientists	22	14.67	VIII
9.	Gram Sevak	12	8.00	IX
10.	ATMA personnel	6	4.00	X

It is evidence from the Table 2 that all the sources enlisted were contacted by the potato growers for getting advice for purchase of pesticides. However, those sources which were contacted by more than 50.00 per cent of the potato growers were considered to be most important. These most important contacts made by the potato growers in descending order of ranks were; own experience (92.67 per cent), relatives and friends (86.00 per cent), pesticide dealers (84.00 per cent) and progressive farmers (55.33 per cent).

The probable reason might be the easy accessibility of these contacts to the potato growers for getting advice for pesticide purchase.

These findings are supported by the observations of Pawar (2013) and Tank (2014).

Factors considered for making pesticide purchasing decision Decision making is

influenced by various factors. Farmers while making decision regarding purchasing pesticides also consider some factors which contribute their decision making. Data regarding factors considered by the potato growers while purchasing pesticides are presented in Table 3.

Table 3 Distribution of the potato growers according to factors considered for making pesticide purchasing decision

(n=150)

Sr. No.	Factors considered	Frequency	Per cent	Rank
1.	Mode of payment (cash/credit) to seller	150	100.00	I
2.	Quality (better control) of pesticide	141	94.00	II
3.	Attractive packaging	139	92.67	III
4.	Popularity of pesticide in farming community	138	92.00	IV
5.	Guidance of dealers for purchasing pesticide	136	90.67	V
6.	Availability in local market	117	78.00	VI
7.	Availability of pesticide in small package	87	58.00	VII
8.	Reasonable price	52	34.67	VIII

A perusal of data presented in Table 3 indicates that mode of payment (cash /credit) to seller was the important factor considered by all the potato growers while purchasing pesticide and it ranked first. Other important factors considered by potato growers in descending order were: quality (better control) of pesticide (94.00 per cent), attractive packaging (92.67 per cent) and popularity of pesticide in farming community (92.00 per cent) and were ranked second, third, fourth and fifth, respectively. Whereas, guidance of dealers for purchasing pesticide (90.67 per cent), availability in local market (78.00 per cent), availability of pesticide in small package (58.00 per cent) and reasonable price (34.67 per cent) were also reported important factors towards purchasing decision of pesticide and were ranked sixth, seventh and eighth, respectively.

CONCLUSION

It is concluded that nearly three-fifths (61.33 per cent) of the potato growers purchased pesticides well in advance at the time of potato planting. The most important sources for making pesticide purchase decision were; own experience (92.67 per cent), relatives and friends (86.00 per cent), pesticide dealers (84.00 per cent), progressive farmers (55.33 per cent), important factors considered by potato growers while purchasing pesticide in descending order were: quality (better control) of pesticide product (94.00 per cent), attractive packing of pesticide (92.67 per cent) and popularity of pesticide in farming community (92.00 per cent).

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