Optimum plot size for tomato by using S-PLUS and R-software’s in the soils of Kashmir
SAMEERA SHAFI, S.A.MIR, NAGEENA NAZIR AND ANJUM RASHID

ABSTRACT
Optimum plot shape and size of plot has been worked out from uniformity trial on S-II variety of tomato. Maximum curvature method, Fair-field Smith’s variance law was used for the purpose. A plot of 8 m² (4m x 2 m) was found to be optimum for S-II variety of tomato grown at RRS and FOA Wadura Campus, SKUAST-K. The trial indicated that coefficient of variation decreased with increase in plot size in either direction, but decrease was more in north-south direction than east-west direction. The shape of plot has been found to have very little influence on variability within the range of plot size considered.

Key words : Tomato, Trial, Variety

Investigations on optimum plot sizes and shapes of plots are important for the efficient planning of field experiments. This requires knowledge of variability presented with the experimental units and that with the crop. Uniformity trials with various crops have served a definite purpose in determining the most effective plot arrangement and experimental design for particular area involved, where growing conditions are subject to variations of similar magnitude. The idea of magnitude of variability can be obtained from data on uniformity trials conducted with the crop or from trials in which number of agronomic treatments on the crop are under study. Such studies have been made by Abraham and Vachhani (1964) for transplanted rice, Sreenath (1973) for sorghum, Upadhyay et al. (1994) for summer paddy, Shamasundaram and Singh (2004) for standard carnation.

MATERIALS AND METHODS
The trial was conducted in May, 2006 to October, 2006. The experiment was conducted at Regional Research Station and Faculty of Agriculture, SKUAST-K Wadura Campus. The S-II variety of tomato was sown in a field over an experimental plot of 40 m × 20m. The plant to plant and row to row distance was 60cm × 45cm. The basic unit of 1m × 1m was selected, and each basic unit (1m²) comprised of 2 to 3 plants. Therefore, 800 basic units were formed from an experimental plot of size 40m × 20m. Harvesting of tomato started from, last week of July to last week of October, 2006. All the recommended package and practices of SKUAST-K were adopted and then yield of all basic units was recorded. The data from basic units was used to obtain further different sizes and shapes of plots and coefficient of variation of every data set was obtained to estimate soil heterogeneity index in this uniformity trial on tomato. The coefficient of variation thus calculated for each arrangement was used to obtain optimum shape and size of plots and blocks.

RESULTS AND DISCUSSION
The Table 1 shows the coefficient of variation for different sizes and shapes of plots. Some of the combinations of the plot sizes like 1m x 3m, 3m x 1m, 6m x 1m, 3m x 3m, 7m x 1m etc. were not possible if all the 800 units would have been taken. It is obvious from the Table 1 that the coefficient of variation for individual units was 34% indicating high degree of soil heterogeneity. The coefficient of variation in general decreased with increase

<p>| Table 1 : Coefficient of variation of different plot sizes and shapes |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| No. of units   | Number of units | Number of units | Number of units | Number of units |</p>
<table>
<thead>
<tr>
<th>N-S</th>
<th>along E-W</th>
<th>along E-W</th>
<th>along E-W</th>
<th>along E-W</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>34.1</td>
<td>30.6</td>
<td>27.0</td>
<td>26.2</td>
</tr>
<tr>
<td>2</td>
<td>30.7</td>
<td>27.1</td>
<td>23.8</td>
<td>23.0</td>
</tr>
<tr>
<td>4</td>
<td>32.8</td>
<td>23.0</td>
<td>19.3</td>
<td>16.9</td>
</tr>
<tr>
<td>5</td>
<td>26.0</td>
<td>21.1</td>
<td>17.8</td>
<td>11.2</td>
</tr>
<tr>
<td>8</td>
<td>20.3</td>
<td>17.4</td>
<td>11.0</td>
<td>10.5</td>
</tr>
<tr>
<td>10</td>
<td>18.4</td>
<td>15.3</td>
<td>10.0</td>
<td>9.4</td>
</tr>
<tr>
<td>20</td>
<td>11.7</td>
<td>9.7</td>
<td>9.4</td>
<td>9.4</td>
</tr>
<tr>
<td>40</td>
<td>9.5</td>
<td>9.7</td>
<td>9.0</td>
<td>8.0</td>
</tr>
</tbody>
</table>
in plot size in either direction, but decrease was greater in north-south direction up to 7.7% rather than from east-west direction up to 19.8%. So, fertility gradient was along north-south direction.

**Effect of plot size on variability:**

The data frame of coefficient of variation of plots arranged according to different size and shape can be created in S-PLUS and R-software’s as

```r
> t4<-edit(data.frame())
```

The coefficient of variations of respective shape and size of plots were entered and the data frame generated by t4 are presented in Table 2. It is obvious that as the size of plot increases coefficient of variation goes on decreasing and fitted equation was obtained according to Fair field Smith’s law. The estimated Smith’s equation was obtained by using function nls() in S-PLUS and R-software’s. General command to nls() function is

```r
nls(formula,data,start)
```

```r
> fit1<-nls(cv~a/(size^b),data=t4,start=c(a=1,b=.35))
> summary(fit1)
```

Formula: cv ~ a/(size^b)

Parameters:

| Estimate Std. Error t value Pr(>|t|) |
|-------------------------------|-----------------|
| a 38.90494 1.31098 29.68 <2e-16 *** |
| b 0.30714 0.01451 21.16 <2e-16 *** |

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Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 2.121 on 38 degrees of freedom

Number of iterations to convergence: 8

Achieved convergence tolerance: 1.291e-06

From the results of summary (fit1), the value of a was obtained to be 38.9 and b as 0.307 and \( Y = 38.9 (x)^{-0.307} \). The graph between coefficient of variation and size was obtained Fig 1. By using curvature method the point just beyond maximum curvature was inspected to be 8, hence an optimum plot size is 8 m². Thus the optimum plot size obtained according to Fairfield Smith’s law and maximum curvature method is 8 m², which is further verified mathematically by using calculus method.

According to curvature method, curvature

![Graph](image-url)
Effect of plot shape on variability:

The coefficient of variation obtained for different sizes is inspected according to shape of plot. It shows that the shape of plot does not have any consistent effect on plot variability. However, compact plots in general show slightly more variability. Earlier, it was quoted the optimum plot size is 8 m$^2$ but shape of plot can either be 8 m x 1 m, 4 m x 2 m, 2 m x 4 m. Therefore, it appears that considerable variation in plot shape can be made to suit the agricultural operations involved.

As the plot shape was found to be of minor importance in affecting variability for the range of plot sizes under consideration, so we can easily take an average coefficient of variations (C.V.) used for given plot size for all shapes of plot which is given in Table 3. The estimated Smith’s equation was obtained as

\[
Y = 37.04(x)^{0.292}
\]

According to maximum curvature method, optimum plot size was found to be 8 m$^2$, which was further verified mathematically by using calculus method and $x = 5.58$, which implies that optimum plot size is 8 m$^2$.

So, the table between average C.V and graph between average C.V and size depicts that shape of plot do not have much effect on plot variability under consideration.

Previous findings indicate that the uniformity trial data satisfy the Fairfield Smith’s law for describing heterogeneity in the yields of agricultural crops. The present findings of uniformity trial on tomato have also substantiated Fairfield Smith’s law. Smith’s index of soil heterogeneity was used primarily to derive optimum plot size, which gives single value as a quantitative measure of soil heterogeneity in an area. The value of the index indicates the degree of correlation between adjacent experimental plots. Its value varies between 0 and 1. The larger the value of index, lower is the correlation between adjacent plots, indicating that fertile spots are distributed randomly or in patches. Smith’s index of soil heterogeneity is obtained from the empirical relationship between plot variance and plot size as $Y = ax^{-b}$.
The maximum coefficient of variation (34.106%) was observed in small sized plot 1 m x 1m and it decrease with increase in plot size up to 40 m x 10 m unit size (7.7%). The decrease in coefficient of variation is not proportional to increase in plot size beyond 5 m². Therefore 5m² plot size could be taken as a point of maximum curvature and 8m² plot size is just adjacent to 5m² unit size appeared to be optimum (net) size for field experiments on tomato crop. The shape of plot has been found to have very little influence on variability within the range of plot size considered. It appears that considerable variation in plot shape can be made to suit the agricultural operations involved. For 8m² plot size, 8m x 1m has minimum coefficient of variation per unit area, therefore it is concluded that a plot size of 8m x 1m is optimum. Keeping in view the practical difficulties for carrying out agricultural operations, the plot having dimensions of could be used instead of 8m x 1m. The 8m² plot size is optimum for tomato, while considering the yield criteria. Hence the optimum plot size have been found out to be and optimum plot shape 4 m x2m.

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REFERENCES


