Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; SP2: 247-253

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National Conference on Conservation Agriculture
(ITM University, Gwalior on 22-23 February, 2018)

Crop yield sustainability: A few measures

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Abstract
Guided by the food and food habits of the people, crops and cropping systems are developed in any particular ecogeographic region. At the same time ecogeographic and environmental factors also result in types of crops or cropping system could be developed in a particular area. Thus, a mutual dependence. Growing of similar or same crops year after year may result in depletion or imbalance of some specific nutrients in soil and in turn soil productivity. Consequently, sustenance of the specific crop or cropping system come under question. Though sustainability is a complex, contested and multifariously defined concept, by and large it means longevity or continuity or persistence of a system. In case of sustainable land management system, we are to provide due consideration to most of the pillars of sustainability viz. productivity, security, protection, viability and acceptability. As such the question of good indicators of sustainability and measurement of sustainability comes in to consideration. In literature one can find a good number of researches on good indicators (social, economical, biophysical) of sustainability (Landres, 1992; Meyer *et al*., 1992; Pomeroy, 1997; Walker 1997 etc). Yield data on particular crop or crop sequence emanated from long term experimental plots or from a particular area can effectively be used in measuring the sustainability of crop or crop sequence in particular area. Researches on measuring the yield sustainability, though quite few in number, but have been taken up by Narain *et al*., 1990, Singh *et al*., 1990; ICARDA,1994; Katyal *et al*., 1998, 2000; Gangwar *et al*., 2003; Sahu *et al*. 2005, Pal and Sahu, 2008. But most of these were aimed at measuring the yield sustainability of nutrient combinations in particular crop or crop sequence. In this paper an attempt has been made to summarize these measures along with some new measures with an objective to study the yield sustainability of particular crop over the growing regions and compare across the states/regions. Existing and developed measures of sustainability have been used on time series yield data of gram over the major growing states of India to compare the measures as well as the states w.r.t. their yield sustainability. The study revealed that productivity of gram in all the states under study has followed non linear nature. India as a whole is shows the highest sustainability in productivity of gram. Among the states, Madhya Pradesh and Rajasthan has higher capacity to produce continuously for long time. On the other hand Karnataka and Andhra Pradesh are the showing lowest sustainability for gram productivity. By and large results of existing measures and proposed measure are almost in conformity with each other. Though, unique results are not obtained but a clear idea about the states having sustainability in yield of gram can be identified and which in turn may help the policy makers to take appropriate steps boosting the crop yield of gram during the years to come.

Keywords: Productivity, sustainability, trend analysis

Introduction
Agriculture plays an important role in Indian economy, 58% of Indian population depend upon the agriculture and allied sector (Anonymous, 2015) [5]. About 17.80% (2013-14) Gross Domestic Product (GDP) of Indian economy is contributed by agriculture. In addition to cereals and oilseeds, pulses are one of the important contributor to Indian agriculture. Pulses are known as poor man's meat as these are comparatively cheaper sources of protein in balancing human diet. In a populous developing country like India, production of pulses play pivotal role in nutritional security of the country. The most important pulse crop in India is gram which occupied an area of about 8958.50 thousand hectares and contributes 44.33 percent of total pulse production during 2012. It constitutes nearly two-fifth share of the area of total pulses. It may be noticed that gram is extensively cultivated as a winter crop in India especially in the states of Madhya Pradesh (33.88%), Rajasthan (19.41%), Maharashtra (15.60%), Karnataka (10.44%), Andhra Pradesh (6.34%) and Uttar Pradesh (6.20%). These states together accounted for 91 percent of all India area under gram. These are also leading states in terms of production but Uttar Pradesh crossed Karnataka and Andhra Pradesh due to

highest productivity. The state of Uttar Pradesh was leading with a yield rate of 930 kg/ha followed by Andhra Pradesh with 920 kg/ha.

Sustainability is a very complex, contested and multifariously defined concept, sometimes meaning longevity or continuity or stability of system. Despite its contested nature, there is an overall agreement that it is multifaceted and therefore, needs to be assessed across several dimensions. In its simplest form, it can be assessed from economic, social and biophysical aspects. Relative to a sustainable land-management system, the World Bank has identified five pillars, viz., productivity (maintain or enhance production services), security (reduces the level of production risk), protection (protect natural resources), viability (be economically viable) and acceptability (be socially acceptable). The questions now are: what should be good indicators of, and how should they be used to measure, sustainability; and how to quantify them. In 1989, FAO defined "sustainable agriculture is one that, over the long-term, enhances environment quality and the resource base on which agriculture depends; provides for basic human food and fiber needs; is economically viable and enhances the quality of life for farmers and society as a whole". Several other investigators, such as Landres (1992) [9], Meyer *et al* (1992) [11] have expressed their views on good indicators. Bryant (1992) [6] and Pomeroy (1997) [14] have pointed out the social issues must be investigated and incorporated into systems to understand and address constraints of sustainable agriculture. Walker's work (1999) [19] on health indicators, along with others, has adequately addressed the measurement/ quantification issue of indicators. In our present study, sustainability means persistence and the capacity of a state to produce crop continuously for a long time. Thus, under the present context, persistency in productivity of a crop across a long period of time implies sustainability.

Production of gram slipped down by 12 percent in 2014-15 and hence in 2015, the prices of gram have increased by 100 percent in market (Anonymous, 2015) [5]. Reduction in crop yield results in high demand- supply gap and ultimately results in sky rocketing prices in market which affects the common man pocket. Madhya Pradesh, Haryana and Bihar state showed high yield with high variability, while Uttar Pradesh having high yield and low variability. Rajasthan, Maharashtra, Karnataka, Andhra Pradesh and Gujarat has shown low yield with high variability in terms of pulse production (Maji and Sulaiman, 1995) [10]. So the measure of sustainability for specific purpose needs to be addressed properly. Hence sustainability analysis of gram in various states can give us idea about the present scenario and helps to design appropriate development strategies in various states. As such the study attempts to examine the productivity status of gram in major growing states and to measure the ability of states to produces the gram for longer term using sustainability measure in literature and using two proposed methods.

Material and Methods

Based on the relative contributions to Indian gram basket during 2011, five major states *viz.* Madhya Pradesh, Rajasthan, Maharashtra, Andhra Pradesh and Karnataka along with whole India are considered for the present study. Data related to gram yield in above five major states are obtained from Directorate of Economics and Statistics.

Time series data are often vulnerable to the presence of outlier. The study starts with examination for the existence of outlier. For our study, we employed Grubb's test. Grubb's test is the one of the most popular ways to define outlier, also called as the ESD method (extreme studentized deviate). Grubbs' test is defined for the following hypothesis:

H_0: There are no outliers in the data set.

H_A: There is at least one outlier in the data set

For a two-sided Grubb's test, the test statistic is defined as:

$$G = \frac{\max_{i=1,\ldots,n} \left| y_i - \bar{y} \right|}{s}$$

with $\bar{y}$ and s denoting the sample mean and standard deviation, respectively, calculated including the suspected outlier. The critical value of the Grubb's test is calculated as

$$C = \frac{(n-1)}{\sqrt{n}} \sqrt{\frac{t^2_{(\alpha/2, n-2)}}{n - 2 + t^2_{(\alpha/2, n-2)}}}$$

where $t_{(\alpha/2, n-2)}$ denotes the critical value of the t-distribution with (n-2) degrees of freedom and a significance level of $\alpha/2$. If $G > C$, then the suspected measurement is confirmed as an outlier.

Once outlier is detected, one may choose to exclude/replace the value from the analysis or one can go for transformation of data or may choose to keep the outlier. In our study, if only one outlier was detected, it was replaced by the median, which is often referred to as robust (i.e. small variability) in the presence of a small number of outliers and of course it is the preferred measure of central tendency for skewed distributions. If more number of outlier was detected due to particular cause, we used suitable transformation of data before further analysis. Analysis has been carried out using Graphpad Software (http://graphpad.com).

Examination of behavior of the series under consideration starts with randomness test. Test of randomness is a technique to have an idea whether the values of series under examination have changed haphazardly or followed a definite pattern. The present test for randomness is a non-parametric test based on the number of turning points used when sample size is large. The process is to count peaks and troughs in the series. A "peak" is a value greater than the two neighbouring values and a "trough" is a value, which is lower than of its two neighbours. Both the peak and trough are treated as turning points of the series. Thus, to get a turning point, one needs at least three data points. The number of turning points is clearly one less than the number of runs up and down in the series. The interval between two turning points is called a "phase."Three consecutive observations are required to define a turning point, μ_1, μ_2, μ_3. If the series is random these three values could have occurred in any order of six possibilities. In only four of these ways would there be a turning point (when the greatest or least value is in the middle). Hence the probability of a turning point in a set of three value is 2/3.

Let us consider now a set of values $\mu_1, \mu_2, \ldots, \mu_n$, and let us define a "marker" variable X_i by

$$X_i = \begin{cases} 1, & \begin{cases} \mu_i < \mu_{i+1} > \mu_{i+2} \\ \mu_i > \mu_{i+1} < \mu_{i+2} \end{cases} ; i = 1, 2, \ldots, n-2 \\ 0, & otherwise \end{cases}$$

The number of turning points p is then simply

$$p = \sum_{i=1}^{n-2} X_t$$

on simplification one can work out

$$E(p) = \sum E(X_i) = \frac{2}{3}(n-2)$$

$$E(p^2) = E\left(\sum_{i=1}^{n-2} X_i\right)^2$$, on simplification

$$E(p^2) = \frac{40n^2 - 144n + 131}{90}$$ and

$$V(p) = \frac{16n - 29}{90}$$

It can easily be verified that as the number of observation increases (n), the distribution of 'p' tends to normal. Thus, for testing the null hypothesis, i.e., series is random

we have the test statistic, $$\tau = \frac{p - E(p)}{s_p} \sim N(0,1)$$

Where s_p is the standard deviation of 'p'.
Thus if the calculated value of τ is greater than 1.96, we reject H_0 that the series is random otherwise accept it.

Descriptive statistics
Descriptive statistics which includes numerical and graphical statistical measure like minimum, maximum, mean, standard error, skewness, kurtosis, simple growth rate are useful to describe the patterns and general behavior of data set were used in this study.

Trend Analysis
To trace the path of production process different parametric trend models as given in table below are used. Among the competitive trend models, the best models are selected based on maximum value of R^2 value, minimum value of RMSE and significance of the parameters.

Linear Model	$y_t = b_o + b_1 t$
Quadratic Model	$y_t = b_o + b_1 t + b_2 t^2$
Cubic Model	$y_t = b_o + b_1 t + b_2 t^2 + b_3 t^3$
Exponential Model	$y_t = b_o e^{(b_1 t)}$
Logarithmic Model	$y_t = b_o + b_1 \ln(t)$

Sustainability Index
1. Singh *et al* (1990) [16] proposed a sustainability index defined as:

$$SI = \frac{\bar{y} - s}{y_{max}}$$

Where $\bar{y}, s, y_{max}$ are the average, standard deviation and maximum yield respective of particular crop/ cropping sequence or treatment over a period of time.
This is a good measure of sustainability using both the measures of central tendency as well as measures of dispersion. According to measure, higher the value of the index, higher is the sustainability status. The problem with this index is that, the index doesn't have a definite range. Moreover, in some situations, the index may have negative value.
2. The technique of regression has been used in the method given by ICARDA (1994) [1] for the purpose of measuring sustainability. In this method, the overall mean yields ($\bar{y}_j$) of different time periods have been regressed on the individual yield values (y_{ij}) to frame a regression equation $y_{ij} = a + b_i \bar{y}_j$

where y_{ij} is the yield corresponding to i[th] treatment in the j[th] time period. The sustainability index, according to this method, is $\left| 1/b_i \right|$. Thus as the value of $|b_i|$ increases, the sustainability will decrease and vice-versa. According to this method, as b decreases, the sustainability index increases. This is one step forward because of the fact that it takes care of the average values at different time periods. However, this method is criticized because of two main limitations: 1) while computing $\bar{y}_j$'s, (i.e. the average value for the j[th] time period combining all the treatments) the value of the i[th] treatment has also been included, 2) like the measures of Singh (1990) [16], here also the sustainability index doesn't have any limit.
3. In an attempt to improve the above measure of ICARDA (1994) [1], Katyal *et al* (2000) [8] introduced a time coefficient in the above regression. Thus the regression takes the shape of $y_{ij} = a + b_i t + c_i \bar{y}_j$.

According to this method $\left| 1/c_i \right|$ is the sustainability index. Thus, depending upon the value of the regression coefficient c_i, sustainability index is worked out. Though, this is again one step forward of the measure given by ICARDA (1994) [1], the same two objections still remains.
4. To overcome the criticism of the measures two and three, Pal and Sahu (2008) proposed the following modifications in the above two measures:

$$y_{ij} = a + b_i' \bar{y}_j'$$

and $$y_{ij} = a + b_i t + c_i' \bar{y}_j'$$

where $\bar{y}'_j$ is the average yield for j[th] year excluding the yield for i[th] treatment in the particular year and as usual $\left| 1/b'_i \right|$ and $\left| 1/c'_i \right|$ are the sustainability indices for the two measures respectively. Though, these two measures incorporate improvement during the construction of sustainability indices, the demerits of not having limits for sustainability indices still remains. Another serious objection to all these four measures is that the assumption of linearity of the regression. If the linearity of the regression is not valid, then the above measures will be put under question.

5. Sahu *et al* (2005) [15] proposed sustainability index based on average performance and the highest ever performance during the period of investigation with the help of the following formula :

$$SI = \frac{Y_{max} - \bar{Y}}{\bar{Y}}.$$

In this measure sustainability has been visualized as the minimum deviation of the average performance over highest ever achieved value during the period of investigation. As such, lower the value of the index higher is the sustainability. Thus from sustainability point of view, a sustainability index value closer to zero is the most desirable value.

In an attempt Pal and Sahu (2008) [13] proposed the following measures of sustainability which do not require any assumption like the above measures 2-5 which are based on regression technique.

6. $$SI = \frac{s_i}{\bar{y}_i \times s_{max}}$$

where S_i is the standard deviation of i[th] treatment over the entire time period. S_{max} is the maximum value of the standard deviation of all the treatments.

7. $$SI = \frac{1}{n}\sum_j \left[\frac{\left| y_{ij} - y_{max} \right|}{\bar{y}_i} \right]$$

$\bar{y}_i$ is the average of i[th] treatment over the entire time period. Y_{max} is the maximum value of the i[th] treatment over the time period.

8. $$SI = \frac{1}{n}\sum_j \left[\frac{\left| y_{ij} - y_{med} \right|}{\bar{y}_i} \right]$$

where, $\bar{y}_i$ is the average of i[th] treatment over the entire time period. y_{med} is the median value of the i[th] treatment over the time period.

9. $$SI = \frac{1}{{}^{n}c_2}\sum_j \sum_{j<j'} \frac{\left| y_{ij} - y_{ij'} \right|}{y_{i\,max}}$$

where n is the number of time periods y_{ij} and y'_{ij} are the value of the i[th] treatment in j[th] and j`[th] year respectively. $y_{i\,max}$ is the maximum value of the i[th] treatment over the time period.

In all the last five measures, lower the value of the sustainability index higher is the sustainability of the treatment.

10. Mishra *et al.* in 2015 [12] modified the sustainability index given by Katyal *et al*. (2000) [8] by introducing the scope of non-linearity in the trend model against only the linearity assumption of Katyal *et al* (2000) [8]. According to this measure as the b_i decreases, the sustainability will increase and vice versa.

11. Proposed Method-1 (SI-1)

For any comparison across the treatments, it is essential to have a common estimate of error for sustainability. If individual estimates of treatments are derived for measuring sustainability, they do not provide a tool for comparison between treatments. To full the aspiration of achieving the maximum yield, it is always preferable to compare the yield of treatments with the maximum attained yield (Y_{jmax}) across the treatments for the j[th] years.

Hence an attempt has been made to compare the mean yield with the maximum yield for estimation of sustainability using robust error term. The developed sustainability index is a function of the estimate of error derived from a regression of yield through maximum yield among the treatments for j[th] time period.

In this method, the original values are transformed first using the mean of i[th] treatment and standard error of regression coefficient of the equation $y_{ij} = a + b_i y_{j\,max}$ where y_{jmax} is the overall maximum yield for the j[th] time period. Then the coefficient of variation of these transformed series is obtained.

According to this proposed measure $1/CV\left(y'_{ij}\right)$ is the sustainability index. Higher the value of index, higher is the sustainability.

$$SI = \frac{1}{CV\left(y'_{ij}\right)}$$

where, $y'_{ij} = \frac{y_{ij} - S.E\left(b_i\right)}{\bar{y}_i}$ and $y_{ij} = a + b_i y_{j\,max}$

Depending on the significance of the effect of maximum yield among the treatments for j[th] year on i[th] treatment yield, the error determined would represents estimate of the true deviation than the simple standard deviation. Hence use of de-trended error of maximum yield effect would provide a better estimate of sustainability index of a treatment than using simple standard deviation. Thus, it is one step advance measure than the index given by Sigh *et al.* (1990) [16] and ICARDA (1994) [1].

12. Proposed Method-2 (SI-2)

In this method we have combined the index given by ICARDA (1994) [1] and Pal and Sahu (2008) as follows:

According index given by ICARDA (1994) [1], $y_{ij} = a + b_i \bar{y}_j$, where $\bar{y}_j$ is the mean of all the treatments in the j[th] year and b_i is the regression coefficient for i[th] treatment, y_{ij} is the value of yield with respect to i[th] treatment and j[th] year and SI is $\left|1/b_i\right|$. Whereas in index of Pal and Sahu (2008) [13] as already discussed earlier i.e., $SI = \frac{s_i}{\overline{y}_i} \frac{1}{s_{i\max}}$.

We have used standard error of estimate from the regression equation $y_{ij} = a + b_i \overline{y}_j$ in the index given Pal and Sahu instead of using simple standard deviation. Advantage of using standard error in place of standard deviation is already been discussed. The proposed index is given below

$$S.I = \frac{SE\,(b_i)}{\overline{y}_i} . \frac{1}{SE\,(b_{i\max})}$$

where, $y_{ij} = a + b_i \overline{y}_j$

According to this proposed index, lower the value of the index, higher is the sustainability status of the treatment.

Results and Discussion

Gram productivity of India is varied from 453.00 kg ha^{-1} to 915.00 kg ha^{-1} with an annual simple and compound growth rate of 1.44 percent and 0.80 percent respectively. On average gram productivity remained 685.84 kg ha^{-1} during the study period. Madhya Pradesh has recorded the average highest productivity (684.87 kg ha^{-1}) and lowest of Karnataka (411.24 kg ha $^{-1}$). Productivity in case of Andhra Pradesh has increased by six and half times over the minimal value their by registering the highest annual simple and compound growth rate of 2.92 percent and 2.70 percent respectively among the major contributing states under study. Average gram productivity of all the major contributing states is below than the national average of 685.84 kg ha^{-1} thereby indicating the productiveness of other states which contributes comparatively less to Indian gram baskets. Positive skewness and kurtosis nature of Andhra Pradesh and Maharashtra, where the growth rate is comparatively higher than other states under study indicates that a maximum improvement in productivity has taken place during early period under study and remained almost same in later half. Gram productivity of Madhya Pradesh, Karnataka and India are positively skewed and platy kurtic in nature which reveals that steady changes in productivity has taken place during early half of period under study and remained almost same thereafter.

From the test of randomness one can see that productivity of gram in all the states under study including whole India has changed randomly (Table 2). The main reasons behind randomness nature of gram yield may be due to very less area under assured irrigation (only 29.57%, average of 2001-2011, computed from data available at indiastat.com) and high level of fluctuation in prices (in absence of an effective government price support mechanism, Anonymous, 2014) [4] farmers are not very keen on taking up gram cultivation in a flow. Poor spread of improved varieties, high breeds and technology, abrupt climatic changes, vulnerability to pest and diseases may have resulted in randomness nature of productivity in all major states and in whole India. It has been reported that the coverage of high yielding varieties of gram was of the order 3449.11 thousand hectare or 46.29 percent of total area under gram (average of 1996-97, 1997-98 and 1998-99, Anonymous, 2002) [2]; seed replacement rate estimated for the year 2006-07 was only 9.48% for gram (Anonymous, 2009) [3]. By and large there is absence of clear cut policies in major contributing states towards gram production or it has fails to execute in proper manner. By keeping food and nutritional security of ultimate mate consumer in mind, for the benefit of farmers and country as a whole, clear cut policies should be made.

From the table 3, it is clearly understood that, most of the data series exhibit non-linear nature. Expect the productivity of Madhya Pradesh and India, all other states exhibit polynomial nature there by indicating the more than one point of inflections in most of the cases. Productivity behavior of gram incase of Rajasthan exhibit quadratic trend indicating the two point of inflection, the quadratic time factor is negative in nature thereby indicating the tendency of the series to decline in recent past. Tuteja in 2006 reported that, during 1981-2002 in Rajasthan irrigation facilities have increased results in shifting of area under gram towards wheat, which yielded relatively higher profit per unit of land in irrigated regions while in rainfed, mustard replaced gram. As the Rajasthan is the major supplier of gram to the Indian basket this is a major concern towards food and nutritional security of the Indian people, one must think for resisting this tendencies so as to keep gram production at steady state.

Sustainability in yield of gram in different states along with whole India has been measured with the help of sustainability indices which are already in literature and proposed two methods i.e., SI-1 and SI-2 as described in the materials and methods section. From table 4., it is clearly visible that whole India shows the highest sustainability in productivity of gram as per maximum indices in literature and also according to proposed methods. Among the states, Madhya Pradesh is showing the high sustainability in productivity according to Singh *et al.*, Sahu *et al* (2005) [15]., Sahu and Pal (4&5)., Mishra *et al* (2014) [18] and proposed SI-2 and Rajasthan has higher capacity to produce continuously for long time as per indices of ICARDA, Katyal *et al.*, Pal and Sahu (1&2) and proposed SI-1. On the other hand, according to index of Sahu *et al.* and Sahu and Pal (2&3) Karnataka is showing low sustainability while maximum indices including proposed two methods reveals Andhra Pradesh as low sustainable state. In proposed new measure SI-1, higher value of sustainability index implies higher sustainability while in case of SI-2 lower the value higher the sustainability. So from the table it is clear that, by and large results of existing measures and proposed measure are almost in conformity with each other.

Table 1: *Per se* performance of gram productivity in major states of India during 1950-2012.

	Madhya Pradesh	**Rajasthan**	**Maharashtra**	**Andhra Pradesh**	**Karnataka**	**India**
Minimum	377.00	347.00	168.00	241.00	148.00	453.00
Maximum	1081.00	909.00	904.00	1591.00	670.00	915.00
Mean	684.87	634.77	445.27	555.79	411.24	685.84
SE	22.67	18.04	21.63	46.52	14.36	14.86
CV (%)	13.54	22.47	17.39	22.61	25.07	6.02
Kurtosis	-0.66	-0.59	0.05	0.53	-0.24	-0.63
Skewness	0.46	-0.14	0.94	1.30	0.36	0.04
SGR%	2.22	1.60	2.10	2.92	0.85	1.44
CGR%	1.20	0.60	1.60	2.70	1.10	0.80

Table 2: Test of outliers and randomness for productivity of gram in India

	Madhya Pradesh	Rajasthan	Maharashtra	Andhra Pradesh	Karnataka	India
No. of Obs.	62	62	62	62	62	62
P	45	41	38	38	44	44
E (P)	40.00	40.00	40.00	40.00	40.00	40.00
V(P)	10.70	10.70	10.70	10.70	10.70	10.70
τ_{cal}	1.53	0.31	0.61	0.61	1.22	1.22
Inference	Random	Random	Random	Random	Random	Random
Outlier	No	No	No	No	No	No

Note: p is the number of turning points

Table 3: Trends productivity of gram in major states of India

	Model	R^2	RMSE	Constant	b_1	b_2	b_3
Madhya Pradesh	Exponential	0.843	57.457	458.751	0.012		
Rajasthan	Quadratic	0.495	66.089	467.064	9.851	-0.106	
Maharashtra	Quadratic	0.905	47.369	347.555	-5.972	0.224	
Andhra Pradesh	Quadratic	0.946	80.741	412.034	-19.743	0.603	
Karnataka	Cubic	0.735	48.495	261.853	9.423	-0.269	0.003
India	Exponential	0.840	36.401	542.061	0.007		

Table 4: Sustainability index of gram productivity in major states of India

	Madhya Pradesh	Rajasthan	Maharashtra	Andhra Pradesh	Karnataka	India	Conclusion
Singh *et al* (1990) [16]	0.31916	0.31042	0.17366	0.12096	0.18800	0.35813	Maximum is Best
ICARDA (1994) [1]	0.95057	2.01207	0.99010	0.45455	1.73611	1.44092	Maximum is Best
Katyal *et al* (2000) [8]	1.23457	2.72480	0.96525	0.40568	1.80505	1.35501	Maximum is Best
Pal and Sahu (2008)-1 [13]	0.99746	3.21559	1.04025	0.40593	2.03413	1.57569	Maximum is Best
Pal and Sahu (2008)-2 [13]	1.96195	5.00504	1.30956	0.85646	3.38903	1.69795	Maximum is Best
Sahu *et al* (2005) [15]	1.32307	1.50640	2.57308	1.86259	2.86877	1.31979	Minimum is Best
Pal and Sahu (2008)-3 [13]	0.00071	0.00061	0.00104	0.00180	0.00075	0.00047	Minimum is Best
Pal and Sahu (2008)-4 [13]	0.16627	0.25831	0.79382	0.43713	0.94227	0.16462	Minimum is Best
Pal and Sahu (2008)-5 [13]	0.18094	0.19397	0.27218	0.31687	0.37118	0.17913	Minimum is Best
Pal and Sahu (2008)-6 [13]	0.00257	0.00542	0.00259	0.00247	0.00371	0.00279	Minimum is Best
Mishra *et al* (2014) [18]	83.33330	0.10151	0.16744	0.05065	0.10612	142.857	Maximum is Best
SI-1	0.03243	0.03576	0.02004	0.01124	0.02932	0.05368	Maximum is Best
SI-2	0.00079	0.00137	0.00112	0.00180	0.00122	0.00050	Minimum is Best

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