

Original Research Article

Evaluating the crop efficiency using productivity indices of different kharif crops grown in Chhattisgarh state

Abstract

The present study in this study is aimed to evaluate all the districts of Chhattisgarh ~~on the basis of~~ based on their relative yield and productivity. The regions were differentiated at the district level according to their crop production efficiency of ~~particular crops~~ crops. There ~~was-was a total~~ total 5 of 5 major kharif crops selected for the evaluation of efficiency zoning viz., rice, red gram, maize, groundnut and soybean. Area and production data collected from the Directorate of Agriculture for a period of twenty years (2000-01 to 2019-20) period. The analysis results showed that all over Chhattisgarh state includes all the ~~criteria~~ criteria of efficiency of kharif crops at ~~different levels~~ various levels. From the result, it can be suggested that no crop was recorded under the criteria of efficient and ~~high-highly~~ stable productivity. But for ~~crop-crops~~ like ~~red gram~~ red gram, the ~~Bastar~~ Bastar region recorded a zonation of potentially efficient ~~crop-crops~~ with high unstable productivity whereas districts like ~~Baloda~~ Baloda bazar, Dhamtari, Gariaband, Mahasamund and Raipur fell in the inefficient zone ~~with low~~ with low productivity. Another crop like rice result ~~showed~~ showed that only two districts namely Jashpur and ~~Kabirdham~~ Kabir Dham touched the criteria of inefficient and low productivity and districts like ~~Balod~~ Balor, Bijapur, Dhamtari, Kanker, Mungeli, Sukma and Janjgir Champa fall under potentially efficient districts with high unstable productivity. For other major kharif crops like maize, soybean and groundnut results recorded no area or district coming under the efficient zoning. For maize, it has been observed that districts like ~~Balrampur~~ Balarampur, Bastar, Bijapur, Dantewada, Dhamtari, Janjgir Champa, Kondagaon, Narayanpur, Sukma ~~coming come~~ under the criteria of a potentially efficient zone with ~~high-highly~~ unstable productivity whereas four districts Raipur, Mahasamund, Rajnandgaon and ~~Durg~~ Durg were reported to be ~~in-in~~ inefficient zone with low productivity. ~~Same-The same~~ result was also obtained for groundnut, very few districts like Rajnandgaon, Kondagaon, ~~Kabirdham~~ Kabir Dham recorded ~~with~~ potentially efficient with ~~high highly~~ unstable productivity while many districts are recorded to be ~~be-be~~ moderately efficient like Baloda Bazar, Bastar, Bilaspur, Janjgir Champa, Jashpur, Durg, Gariaband, Korba, Korea, Raigarh, Mahasamund, Mungeli, Sarguja, Surajpur. In the case of ~~Soybean~~ Soybean, the result obtained ~~are-is~~ that Baloda Bazar, Balarampur, Bastar, Bijapur, Dantewada, Gariaband, Janjgir-Champa, Kanker, Kondagaon, Mungeli, Narayanpur, Raipur, Sukma are the districts which fell under potentially efficient zone with high unstable productivity whereas four districts are noted with low productivity and inefficient zoning ~~i.e.i.e.~~ Balod, Bemetara, Kabir Dham, Korea. From the above analysis it can be concluded that the districts with potentially efficient and ~~high-highly~~ unstable productivity can be recommended with ~~the~~ ~~continuous~~ the continuous streamlining of technologies and promotion for that crop. The area

recorded with low productivity and inefficiency should be identified with ~~their~~ the proper reasoning behind it.

Keywords: Relative yield, Productivity, production efficiency, Kharif crops, Potential

INTRODUCTION

Kharif crops, also known as monsoon crops or autumn crops are domesticated plants that are cultivated and harvested in India, during the Indian subcontinent's monsoon season, which lasts from June to November depending on the area.

The Kharif season varies by crop and region, starting at the earliest in May and ending at the latest in January. In India, the season is popularly considered to start in June and end in October. Kharif crops are usually sown at the beginning of the first rains during the advent of the ~~south-west~~ southwest monsoon season and they are harvested at the end of the monsoon season (October–November).

Chhattisgarh, the 26th state of the Indian Union came into existence on November 1, 2000. The geographical location of Chhattisgarh is 17°46' to 24°5' North Latitude and from 80°15' to 84°20' East Longitude, with an average rainfall of around 1207 mm. The total geographical area of the state is around 138 Lakh ha. With a net sown area of 46.51 Lakh ha, which is 34% of its total geographical area. About 57% area has medium to light soil. Chhattisgarh has one of the richest bio-diverse areas in the country with ~~around 63.4~~ around 63.4 Lakh ha. The area under forest cover, ~~which~~ is 46% ~~of its of its~~ total geographical area (Directorate ~~Agriculture, Chhattisgarh~~ Agriculture, Raipur, Chhattisgarh Raipur, Agriculture Development and Farmer Welfare and Bio-Technology Department). Paddy, soybean, urd & arhar are the major Kharif Crops while rabi season is mainly led by chickpea and ~~lathyrus~~ Lathyrus. Some districts of the state have good potential for sugarcane ~~crop crops with~~ 04 with 04 Co-operative Cooperative sugar factories running successfully in the state. Other crops of the state are maize, millets, moong, wheat, groundnut etc. Central plains of Chhattisgarh are known as the Rice Bowl of Central India.

Chhattisgarh has embarked on a concerted plan to increase ~~double-cropped~~ double-cropped areas, diversify the cropping pattern and improve income from agro-based small-scale enterprises. ~~In order to~~ To unlock the true potential of the agriculture sector in the state, the Government is paying special attention ~~towards to~~ better management of its water resources. To reduce the ~~farmers~~ farmer's dependency on rainfall, the Government is working towards increasing the irrigation potential of the state. At present around 14.76 lakh ha. The area is a net irrigated area of the state which is about 32% of the net sown area. Such an analysis also throws light on the misfits in cropping patterns and gaps in production performance and the potential to serve as a basis for developing resources and technologies and for evolving risk management ~~strategies,~~ fulfilling national requirements ~~and~~ achieving even production targets. The area sown under different crops expressed as a percentage of gross cropped area in each administrative unit ~~are~~ is usually ~~utilized~~ used to give a good description of inter-regional differences and to demarcate homogeneous crop regions.

Comment [mdo1]: ??????

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Another approach is to study the relative yield and relative spread of each crop on a district and regional basis to define the crop regions. The best index of the suitability of an area for a particular crop is its relative yield as well as its stability from year to year as judged ~~from~~ by the coefficient of variability (CV) regardless of the area under the crop (Singh et al., 1995). Such quantitative information on spatial and temporal variability in crop production can be assessed through crop production models and geographical information systems.

METHODOLOGY

Area and production data of major crops of Chhattisgarh state were collected from the Directorate of Agriculture for a period of twenty years (2000-01 to 2019-20) period. Crop yield was calculated for each year on a district basis. That was analyzed to work out the relative yield and coefficient of variation in the yield with methods:

$$\text{Relative Yield of Crop X} = \frac{\text{Average yield of crop x in a district}}{\text{Average yield of crop x in the state}} \times 100$$

$$\text{Coefficient of Variability of Crop X} = \frac{\text{Standard Deviation of Crop X Yield in a district}}{\text{Average yield of crop x in the state}} \times 100$$

The relative yield and CV for each crop in each shire was classified as follows:

Criteria	High	Medium	Low
Relative Yield	Above 120%	80-120%	Below 80%
CV	Threshold varied crop to crop on the basis of <u>based on</u> the range in values and frequency of their distribution		

Nine combinations of relative yield and CV are arranged in a 3x3 two-way table for each crop indicating the districts in each classification. These were grouped ~~in~~ into 5 categories.

S.No.	Category	Productivity level	Efficiency level
01	Districts with low yield and low/medium/high CV	Low productivity	Inefficient
02	Districts with medium yield and medium/ high CV	Medium unstable productivity	Less efficient
03	District with medium yield and low CV	Medium stable productivity	Moderately efficient
04	District with high yield and medium/ high CV	High unstable productivity	Potentially efficient
05	District with high yield and low CV	High <u>stable productivity</u>	Efficient

Based on these ~~criteria~~ criteria, the production efficiency of six major crops grown across Chhattisgarh state is presented in tables. The performance of a crop can be interpreted against

the ecological requirements of the crop for climatic, soil conditions and irrigation development. Climate is the major factor that regulates and determines the growth and development of crop plans. The excess or deficiency of climatic elements exerts a negative influence on plant production. In this study, ~~the~~ interpretation of crop efficiency is ~~attempted~~ only in terms of climatic conditions. To interpret the productivity in terms of climate, monthly rainfall data for 20 years corresponding to crop data ~~was-were~~ collected for the representative stations of each district. Monthly rainfall data from Directorate of Agriculture, Chhattisgarh were ~~analysed-analyzed~~ to work out the average crop season rainfall and its coefficient of variability. Temperature data were collected from the IMD gridded data website.

RESULT AND DISCUSSIONS

The analysis was conducted at Department of Agrometeorology, College of Agriculture, Raipur (C.G.). In this ~~study,~~ ~~the~~ study, ~~the~~ objective was to evaluate all the districts of Chhattisgarh ~~on the basis of~~ based on their relative yield and productivity. The regions were differentiated at district level according to their crop production efficiency ~~of particular of~~ crops. There ~~was-were~~ total 5 major kharif crops selected for the evaluation of efficiency zoning viz., ~~Rice,~~ Rice, Red gram, Maize, groundnut, and soybean.

a. Arhar (Red gram)

The ~~long-term~~ long-term data of productivity recorded for arhar is analyzed and the output is described in Table 1 below ~~on the basis of~~ based on their efficiency. As the result ~~observed~~ saw it was found that only Bastar district was found to be highly unstable productivity which comes under potentially efficient zone. Districts like Bemetara, Kondagaon, Raigarh, Surajpur were noted to come under the moderately efficient zone and productivity is in medium stable classification. The data recorded for low productivity areas of arhar are Baloda bazar, Dhamtari, gariaband, Mahasamund, ~~Raipur which~~ Raipur which ~~was-were~~ found inefficient zone while 17 districts were found less inefficient showing medium unstable productivity zone having less efficiency level.

Table No. 1: Productivity and efficiency level of different districts producing Arhar.

S. No.	Category	Productivity	Efficiency level	District
1	Districts with Districts with low yield and low/medium/High/CV	Low productivity	Inefficient	Baloda bazar, Dhamtari, gariaband, Mahasamund, Raipur

2	Districts with medium yield and medium/High/CV	Medium unstable productivity	less efficient	Balod, Balrampur, Bijapur, bilaspur, Dantewada, Durg Dantewada, Durg, janjgir champa, Jashpur, Kabirdham, Kanker, Korba, Korea, Mungeli, Narayanpur, Surguja, Sukma, Rajnandgaon
3	Districts with medium yield and low/CV	medium stable productivity	Moderately efficient	Bemetara, Kondagaon, Raigarh, Surajpur
4	Districts with high yield and medium/High CV	high unstable productivity	Potentially efficient	Bastar
5	Districts with high yield and low CV	high stable productivity	Efficient	-

S. No.	Category	Productivity	Efficiency level	District
1	Relative yield	Above 120%	80-120%	below 80%
2	CV	above 40%	20-40%	below 20%

b. Rice

Rice is the most important food crop ~~of in~~India. Rice is grown under diverse ~~agro-ecological~~agroecological conditions in a variety of soils, in combination or ~~in~~sequence with a large number ~~of crops of crops~~. Rice ranks first in the use of land at > 43 million (M) ha, water resources (> 50% irrigation water), and inputs (38 to 40% of fertilizers and 17 to 18% of pesticides) among the crops cultivated in India (Rice Knowledge Management Portal, <http://www.rkmp.co.in>). Grown in an area of 43 million ha with ~~an average~~ productivity ~~of productivity 2.5 of 2.5~~ t/ha, rice contributes to nearly 41%~~to of~~ the total food-grain production. The demand for rice is projected to increase ~~in the near future~~shortly with the increase in population in India. Future gains in rice yield ~~is are~~expected to be largely driven by ~~knowledge-intensive~~knowledge-intensive crop and soil management as compared to the ~~germplasm-driven~~germplasm-driven yield gains since the start ~~of of the~~ green revolution.

During the analysis of rice ~~crop crops~~, ~~it was it was~~ observed that districts producing rice are evaluated and according to the data recorded it has been noticed that ~~a few districts comes come~~under the ~~criteria of criteria of~~high unstable productivity i.e. Balod, Bijapur, Dhamtari, Kanker, Mungeli, Sukma, Janjgir Champa which is potentially efficient zone.~~While few~~While ~~few~~ districts are recorded with medium unstable productivity which is ~~the~~ less efficient zone for example- ~~Balodabazar, Balrampur~~Balodabazar, Balrampur, Bastar, Bemetara, Bilaspur, Dantewada, Durg, Kondagaon, Korba, Korea, Mahasamund, Narayanpur, Raigarh, Raipur, Rajnandgaon, Surajpur, Gariaband. After the analysis it can be concluded

that only one district comes under medium stable ~~productivity viz. Sarguja,~~ ~~which Sarguja which~~ is moderately efficient whereas two districts Jashpur and Kabirdham are reported with low productivity and these districts fall under less efficient zone.

Table 2: Productivity and efficiency level of different districts producing Rice.

S. No.	Category	Productivity	Efficiency level	District
1	Districts with low yield and low/medium/High/CV	Low productivity	Inefficient	Jashpur, Kabirdham
2	Districts with medium yield and medium/High CV	Medium unstable productivity	less efficient	Balodabazar, Balrampur Balod, Balrampur, Bastar, Bemetara, Bilaspur, Bemetara, Bhatkal, Dantewada, Durg, Kondagaon, Korea, Mahasamund, Narayanpur, Raigarh, Raipur, Rajnandgaon, Surajpur, Gariaband
3	Districts with Districts with medium yield and low CV	Medium stable productivity	Moderately efficient	Surguja
4	Districts with high yield and medium/High CV	High unstable productivity	Potentially efficient	Balod, Bijapur, Dhamtari, Kanker, Mungeli, Sukma, and Janjgir and Janjgir Champa
5	Districts with high yield and low CV	High stable productivity	Efficient	-

S.No	Criteria	high	medium	Low
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1	Relative yield	Above 120%	80-120%	below 80%
2	CV	above 30%	15-30%	below 15%

c. Maize

According to the result ~~obtained in~~ obtained in Table. 3, it can be ~~observed~~ seen that the districts growing maize are highly differentiated according to the data recorded. The areas which are found to be potentially efficient are Balrampur, Bastar, Bijapur, Dantewada, Dhamtari, Janjgir -Champa, Kondagaon, Narayanpur, Sukma with ~~high~~ highly unstable productivity whereas less efficient zone includes Balod, Baloda Bazar, Surajpur, Bemetara, Bilaspur, Kabirdham, ~~Gariaband, Jashpur~~ Gariaband, Jashpur, Kanker, Korba, Korea, Mungeli, Raigarh, Sarguja with medium unstable productivity. It has been observed that a few districts for example Durg, Rajnandgaon, Mahasamund, and Raipur are found inefficient with low productivity criteria.

Table 3: Productivity and efficiency level of different districts producing Maize.

S. No	Category	Productivity	Efficiency level	District
1	Districts with low yield and low/medium/High/CV	Low productivity	Inefficient	Durg, Rajnandgaon, Mahasamund, Raipur
2	Districts with medium and medium/High/CV	Medium unstable productivity	less efficient	Balod, Baloda bazar, Surajpur, Bemetara, Bilaspur <u>Bemetara, Bilaspur</u> , Kabirdham, Gariaband, Jashpur <u>Gariaband, Jashpur</u> , kanker, korba, korea, Mungeli <u>Korea, Mungeli</u> , Raigarh, Sarguja
3	Districts with medium yield and low CV	Medium stable productivity	Moderately efficient	-
4	Districts with high yield and medium/High CV	High unstable productivity	Potentially efficient	Balrampur, Bastar, Bijapur, Dantewada, Dhamtari, Janjgir -

				Champa, Kondagaon, Narayanpur, Sukma
5	Districts with high yield and low CV	High stable productivity	Efficient	-

S.No.	Criteria	high	medium	low
1	relative yield	Above 120%	80-120%	below 80%
2	CV	above 30%	15-30%	below 15%

d. Groundnut

The result observed saw for ~~groundnut-producing~~ ~~groundnut-producing~~ districts all over Chhattisgarh state is interpreted in Table. 4. According to the data recorded it can be seen that areas of high unstable productivity with potentially efficient zones are Rajnandgaon, Kondagaon, ~~and~~ Kabirdham while areas with medium stable productivity with moderately efficient zones are Baloda ~~Bazar, Bastar~~ ~~Bazar, Bastar~~, Bilaspur, Janjgir champa, Jashpur, Durg, Gariaband, Korba, Korea, Raigarh, Mahasamund, Mungeli, Sarguja, Surajpur etc. The districts falling ~~in less in the less~~ efficient zone with medium unstable productivity are Bemetara, Balrampur, ~~Bijapur, Dantewada~~ ~~Bijapur, Dantewada, Dhamtari, Dhamtari~~, Raipur, Sukma and Kanker while only two districts of Chhattisgarh are reported to have inefficient zoning with low productivity criteria are Balod and Narayanpur.

Table .4: Productivity and efficiency level of different districts producing ~~Groundnut~~ ~~Groundnut~~.

S. No	Category	Productivity	Efficiency level	District
1	Districts with low yield and low/medium/HighCV	Low productivity	Inefficient	Balod, Narayanpur
2	Districts with medium yield and medium/HighCV	Medium unstable productivity	less efficient	Bemetara, Balrampur, Bijapur, Dantewada Bijapur, Dantewada, Dhamtari, Raipur Dhamtari, Raipur , sukma, kanker
3	Districts with medium yield and low/CV	Medium stable productivity	Moderately efficient	Baloda Bazar, bastar Bazar, bastar , Bilaspur, Janjgir champa, Jashpur, Durg, gariaband, korba,

				Korea, Raigarh Korea, Raigarh , Mahasamund, Mungeli, Sarguja Mungeli, Sarguja , Surajpur
4	Districts with high yield and medium/High CV	High unstable productivity	Potentially efficient	Rajnandgaon, Kondagaon, Kabirdham
5	Districts with high yield and low CV	High stable productivity	Efficient	-

S.No	Criteria	high	medium	low
1	Relative yield	Above 120%	80-120%	below 80%
2	CV	above 50%	25-50%	below 25%

e. Soybean

The result obtained in Table 5 concluded that production of soybean in different districts of Chhattisgarh is divided ~~in into~~ different ~~criteria of~~ [criteria of](#) efficiency levels. The result ~~observed saw~~ for the region of high unstable productivity are Baloda Bazar, Balrampur, Bastar, Bijapur, Dantewada, Gariyaband, Champa, Kanker, Kondagaon, Mungeli, ~~Narayanpur, Raipur~~ [Narayanpur, Raipur](#) and Sukma are potentially efficient. The districts recorded with less efficient zoning ~~are Bilaspur~~ [are Bilaspur](#), Dhamtari, ~~Durg, Jashpur~~ [Durg, Jashpur](#), ~~Korba~~ [Jashpur, Korba](#), Mahasamund, Raigarh, Rajnandgaon, Surajpur, Surguja for medium stable productivity. The districts with less efficient criteria and medium unstable for soybean production ~~are Bilaspur~~ [are Bilaspur](#), Dhamtari, Durg, Jashpur, Korba, Mahasamund, Raigarh, Rajnandgaon, Surajpur, Sauguja etc. The districts namely Balod, Bemetara, Kabirdham, ~~Korea~~ [are Korea](#) ~~noted are for~~ [noted for](#) low productivity and their efficiency level is also inefficient.

Table 5: Productivity and efficiency level of different districts producing [Maize](#)Maize.

S. No.	Category	Productivity	Efficiency level	District
1	Districts with low yield and low/medium/High CV	Low productivity	Inefficient	Balod, Bemetara, Kabirdham, Korea
2	Districts with medium yield and medium/High CV	Medium unstable productivity	less efficient	Bilaspur, Dhamtari, Durg Jashpur, Korba Jashpur, Korba , Mahasamund, Raigarh,

				Rajnandgaon, Surajpur, Surguja
3	Districts with medium yield and low CV	Medium stable productivity	Moderately efficient	-
4	Districts with high yield and medium/High CV	High unstable productivity	Potentially efficient	Baloda Bazar, Balrampur, Bastar, Bijapur, Dantewada, Gariyaband, Janjgir-Champa, Kanker, Kondagaon, Mungeli, Narayanpur, Raipur, Sukma
5	Districts with high yield and low CV	High stable productivity	Efficient	-

S. No.	Criteria	high	medium	low
1	Relative yield	Above 120%	80-120%	below 80%
2	CV	above 50%	25-50%	below 25%

SUMMARY AND CONCLUSIONS

The analysis was conducted at Department of Agrometeorology, College of Agriculture, Raipur (C. G.). The analysis results showed that all over Chhattisgarh state includes all the ~~criteria~~ criteria of efficiency of kharif crops at different levels. From the result it can be suggested that no crop was recorded under the criteria of efficient and ~~high~~ highly stable productivity. But for ~~crop~~ crops like arhar, ~~Bastar district~~ Bastar district recorded a zonation of ~~potentially~~ of ~~potentially~~ efficient ~~crop~~ crops with high unstable productivity whereas districts like Baloda bazar, Dhamtari, Gariaband, Mahasamund and ~~Raipur were~~ Raipur were falling under inefficient zone with low productivity. As we know, rice is a staple crop all over India and Chhattisgarh state is known as ~~the~~ bowl of rice. ~~Therefore, according~~ Therefore, according to the result it has been noticed that only two districts namely Jashpur and ~~Kabirdham fell~~ Kabirdham fell ~~in the~~ in the criteria of inefficient and low productivity zone and districts like Balod, Bijapur, Dhamatari, Kanker, Mungeli, Sukma and Janjgir Champa ~~achieved~~ ~~potentially~~ achieved ~~potentially~~ efficient with high unstable productivity zone. Other major kharif crops like maize, soybean and groundnut ~~results also~~ results also recorded no area or district coming under the efficient zoning. For maize it has been observed that districts like Balrampur, Bastar, Bijapur, Dantewada, Dhamtari, Janjgir Champa, Kondagaon, Narayanpur, Sukma achieved the criteria of ~~the~~ potentially efficient zone with high unstable productivity whereas four districts Raipur, Mahasamund, Rajnandgaon and Durg are recorded to be ~~in~~ inefficient ~~in~~ inefficient zone with low productivity. ~~Same~~ The same result was also obtained for groundnut, very few districts like Rajnandgaon, Kondagaon, Kabirdham achieved potentially efficient with ~~high~~ highly unstable ~~productivity zone~~ productivity zone while ~~many~~

many districts are recorded to be moderately efficient zone like Baloda Bazar, Bastar, Bilaspur, Janjgir Champa, Jashpur, Durg, Gariaband, Korba, Korea, Raigarh, Mahasamund, Mungeli, Sarguja, Surajpur. In the case of Soybean many districts viz., Baloda, Baloda Bazar, Balrampur, Bastar, Bijapur, Dantewada, Gariyaband, Janjgir-Champa, Kanker, Kondagaon, Mungeli, Narayanpur, Raipur, Sukma are the districts achieved a potentially efficient zone with high unstable productivity whereas four districts are noted with low productivity and inefficient zoning i.e. Balod, Bemetara, Kabirdham, Korea. From the above analysis it can be concluded that the area with potentially efficient with high highly unstable productivity can be recommended with the proper and continuous streamlining of technologies. The area recorded with low productivity and inefficiency should be identified with the proper reason behind it and recommended for the proper management system or diversification.

References

Anonymous, Dept. of Agricultural and Farmers Welfare, Ministry of Agriculture and Farmers Welfare Govt. of India, Directorate of Economics and Statistics.

Bureau of Meteorology. 1988. Climatic Averages Australia, Melbourne, 532 pp.

David Willker de Sousa Santos, Weder Ferreira dos Santos, Clóvis Maurilio de Souza, et al. (2022). Trail Analysis with and without Inoculation of *Azospirillum brasilense* in the Corn Crop in GURUPI-TO. International Journal of Advanced Engineering Research and Science, 9, 9.

M.K. Mandal, S. Dutta, K. Majumdar, T. Satyanarayana, M. Pampolino, V. Govil, A.M. Johnston, and G.C. Shrotriya 2015. Enhancing Rice Yield, Profitability, and Phosphorus Use Efficiency in West Bengal using the Nutrient Expert® Fertilizer Decision Support Tool. Better Crops.

Queensland Department of Primary Industries. 2000. Australian Rain man 3.3

Singh, Mukhtiar; Dhingra, K.K. and Dhillon, M. S. 1995. Efficient crop zones of India based on productivity Indices. (*Personal Communication*).