

RESEARCH ARTICLE

DOI: 10.15740/HAS/IJFCI/9.2/53-59

Trends in growth and instability of major *Rabi* crops in Western Maharashtra

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ABSTRACT : The present investigation focuses on instability and growth trends in production of major *Rabi* crops viz., sorghum and wheat in Western Maharashtra. The area under *Rabi* sorghum in all the district were quite fluctuating in overall period. It was mainly due to the rainfall and competing crops like *Rabi* onion and wheat in irrigated region and gram in un-irrigated region for *Rabi* sorghum. The analysis revealed that there is a wide variation in the performance of *Rabi* sorghum crop in terms of changes in area, production and productivity among the districts and region as a whole over a period of time. In case of wheat for the entire period (1960-61 to 2012-13) in Western Maharashtra, area, production and productivity found to be positive and significant with 0.63, 3.31 and 2.66 per cent per annum, respectively. The production of wheat was increased mainly due to the productivity improvement for Nasik, Dhule, Jalgaon, Pune and Ahmednagar districts of Western Maharashtra region not due to area expansion.

KEY WORDS : Growth, Area, Production, Productivity, Instability, *Rabi* sorghum, Wheat

HOW TO CITE THIS ARTICLE : Kulkarni, A.R., Pokharkar, V.G and Sanap, D.J. (2018). Trends in growth and instability of major *Rabi* crops in Western Maharashtra. *Internat. J. Forestry & Crop Improv.*, 9 (2) : 53-59, DOI: 10.15740/HAS/IJFCI/9.2/53-59. Copyright@ 2018: Hind Agri-Horticultural Society.

ARTICLE CHRONICAL : Received : 27.10.2018; Revised : 19.11.2018; Accepted : 30.11.2018

INTRODUCTION

Sorghum is par excellence a rainfed crop of dry farming areas where irrigation is not used. *Rabi* sorghum is sown after a fallow period (*Kharif*) in certain medium

to deep soil areas where the rainfall frequency is high. Both excessive moisture and prolonged droughts are harmful for its proper growth. Sorghum (*Sorghum bicolor*), belongs to Gramineae family and originated from India and Africa. Sorghum served as a staple food, hurda, bhakri and cooked like rice and eaten as ghoogrya, pop-grain, starch, glucose, malt, kadbi as fodder, some varieties are specially grown for fodder which is fed to cattle at green stage.

Sorghum is known as 'great millet' because of larger size grains and having vast area under it. Staple food of very large population, withstand drought condition and

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extreme heat. Tolerate soil salinity and water-logging up to some extent. Hybrid varieties gives more yield as compared to other cereals. Grown on variety of soils and climate. Sorghum is the fourth most important world, cereal, following wheat, rice and maize. It is a staple food in the drier parts of tropical Africa, India and China. Provides raw material to starch and alcohol industry. In Maharashtra state it contributes 50 per cent of the total cereal production. Fodder fed to cattle at green stage.

Sorghum crop is grown during both *Kharif* (July-November) and *Rabi* (October-February) seasons, the *Rabi* crop constituting 36-38 per cent of the total area under this crop. The area under the *Rabi* sorghum is concentrated in the Deccan plateau more or less a contiguous belt. In the states of Maharashtra and Karnataka, the *Rabi* sorghum occupies about 55-60 per cent of the total sorghum area. In Andhra Pradesh, the distribution is 50-50 in *Kharif* and *Rabi* seasons. In the rest of the states the *Kharif* season sorghum is more important. Only a very small area of this crop, about 4-5 per cent, is grown under irrigation, usually during summer months (January-April).

Maharashtra far excels all other states and produces more than 54 per cent of the total sorghum production of India. As many as 22 districts of Maharashtra produce sorghum but Osmanabad, Nanded, Yavatmal, Buldhana, Parbhani, Kolhapur, Amravati, Ahmednagar and Solapur are important producing districts. In the Maharashtra plateau region, sorghum is the staple food of the people and two crops in a year are raised here. First is sown just before the onset of the monsoon and the second is sown after the retreat of the monsoon. In some districts to the south of Pune, as much as 80 per cent of the cultivated area is devoted to sorghum.

Wheat:

Wheat is the staple food of north Indian people. Wheat grains are grounded into flour (atta) and consumed in the form of chapatees *i.e.* 80-85 per cent. Soft wheat is used for making chapatees, bread, cake, biscuits, pastry and other bakery products. Hard wheat is used for manufacturing rawa, suji and sewaya. In areas where rice is a staple food grain, wheat is eaten in the form of puri and uppumav. It is also used for making flakes and sweet meats like kheer, shira, etc. Wheat grain is used for preparing starch. Wheat straw is used as fodder, padding material and mulching material.

EXPERIMENTAL METHODS

The time series data are required to fulfill the objectives, such data was collected from secondary sources *i.e.*, different published records of the state government, co-operative institutions *viz.*, Season and crop reports, Departments of Agriculture, Government of Maharashtra, Pune, Statistical Abstract of Maharashtra State, Directorate of Economics and Statistics, Government of Maharashtra, Mumbai and Epitomes of Agriculture in Maharashtra.

Period of study:

To examine growth in the region, the period was considered from 1960-61 to 2012-13.

Analytical techniques:

Compound growth rates:

The compound growth rates were computed based on time series data on area, production and productivity of *Rabi* sorghum crop for each district as well as Western Maharashtra as a whole for 53 years of study period *viz.*, 1960-61 to 2012-13 using log-linear production function. Compound growth rates were estimated to study the percentage increase or decrease in the selected parameter. The following exponential growth function was used.

$$Y = ab^t e$$

where,

Y = Dependent variable for which growth was estimated (*i.e.* area, production and productivity etc.).

a = Intercept or constant

b = Regression/trend co-efficient

t = Periods in years (1, 2, 3...n)

e = Error terms with zero mean and constant variance.

Co-efficient of variation (CV):

To examine the stability, mean, standard deviation and CV were worked out. Standard deviation (σ) is positive square root of the arithmetic mean of the square of deviations of the given observation from their arithmetic mean. Standard deviation is an absolute measure of dispersion, given by formula.

$$(\sigma) = \sqrt{\frac{1}{n} \sum (x - \bar{x})^2}$$

where,

$$\bar{X} = \frac{1}{n} \sum x = \text{Mean sample observation}$$

n = Numbers of observation

CV is percentage variation in mean whereas, standard deviation considered as total variation in the mean.

$$\text{C.V.} = \frac{\sigma}{\bar{X}} \times 100$$

where,

σ = Standard deviation

\bar{X} = Mean

A distribution with smaller CV is said to be more homogenous or uniform or less variable than the other and series with greater CV is said to be heterogeneous or more variable than the other.

Cuddy and Della instability index (CV_i):

The co-efficient of variation is generally used as a measure of instability. But time series data often contain a trend component. In order to take care of this trend component and for meaningful measurement of instability, CV is modified as proposed by Cuddy and Della called as the Cuddy and Della instability index and given by formula:

$$CV_i = CV \sqrt{1 - R^2}$$

where,

CV = Co-efficient of variation

R² = Co-efficient of determination of trend

A linear trend was fitted to a time series data on area, production and productivity and wherever the trend was significant, the co-efficient of variation (CV) for unadjusted data were multiplied by the square root of unexplained portion of variation in the trend.

EXPERIMENTAL RESULTS AND ANALYSIS

The results obtained from the present investigation as well as relevant discussion have been summarized under the following heads :

Growth rates of the area, production and productivity of *Rabi* sorghum:

The districtwise and periodwise compound growth rates of area, production and productivity of *Rabi* sorghum during the period 1960-61 to 2012-13 have been estimated and presented in the Table 1.

The area, production and productivity of *Rabi*

Table 1: Compound growth rates of area, production and productivity of <i>Rabi</i> sorghum											
Particulars	Nashik	Dhule	Jalgaon	Pune	A.nagar	Solapur	Kolhapur	Satara	Sangli	Nandurbar	Western Maharashtra
Period-I	A -13.5***	-5.66***	-6.5**	-0.59***	-2.19***	-0.56**	-0.98	-3.01***	-2.37***	--	-1.82***
(1960-61 to	P -13.09**	-7.19***	-5.82	-2.96	-2.09	-2.3	4.55	-3.55	-6.19*	--	-3.1
1969-70)	Y 0.46	-1.63	0.72	-2.38	0.1	-1.75	5.59 **	-0.56	-3.91	--	-1.31
Period-II	A 8.34***	5.14 ***	9.82***	2.54**	-0.84	-10.9	9.79 *	-1.72	-3.55	--	-1.2
(1970-71 to	P 27.72***	15.3 ***	18.04***	17.86***	14.09**	-1.08	20.56 **	9.01*	10.01	--	12.44**
1979-80)	Y 17.8**	9.68 ***	7.47*	14.93***	15.06**	11.02*	9.79	10.91**	14.04	--	13.84**
Period III	A -1.52	-3.44 ***	2.76	1.59***	0.58	-0.62	3.95 **	-0.33	4.78***	--	0.42
(1980-81 to	P -1.25	-2.19	6.05	3.04	1.64	3.9	11.95***	3.06	10.29*	--	2.98
1989-90)	Y 0.26	1.29	3.21	1.42	1.05	4.55	7.7	3.41*	5.26	--	2.56
Period IV	A 1.59	0.12	2.78	-0.98	5.35	-0.63	7.63***	-0.64	1.25**	--	0.6
(1990-91 to	P 8.39	2.99	3.13	2.61	1.54	-0.71	6.6 **	1.65	7.42**	--	1.81
1999-00)	Y 6.7**	2.87	0.34	3.62	-3.61	-0.08	-0.96	2.3	6.09**	--	1.21
Period V	A -7.59***	7.58***	1.51	-5.38**	-0.88	-2.04**	2.6 ***	0.61	2.36**	-0.09	-1.57
(2000-01 to	P -5.31	15.16***	2.26	-0.37	2.2	1.62	3.57 ***	4.15	1.14	5.61**	1.64
2012-13)	Y 2.48**	7.05**	0.74	5.29**	3.11	3.72	0.94	3.52*	-1.2	5.71***	3.26
Overall	A -3.58***	-5.22***	1.03***	-0.16	-0.45***	-0.35	4.42 ***	0.26	1.23***	-0.09	-0.21*
(1960-61 to	P -1.64**	-3.6***	3.34***	1.23***	-0.16	0.16	8.47 ***	1.3***	3.04***	5.61**	0.71**
2012-13)	Y 2.02***	1.71***	2.29***	1.4***	0.29	0.52	3.88 ***	1.03***	1.8***	5.71***	0.92***

*, ** and *** indicate significance of values at P=0.01, 0.05 and 0.1, respectively

sorghum crop have fluctuated widely during the study period in all the ten districts and Western Maharashtra as a whole. The growth rates of production and productivity of sorghum for Western Maharashtra were observed to be positive and highly significant at 1 per cent level for the entire period of 53 years. The production and productivity of sorghum increased at the rate of 0.71 per cent and 0.92 per cent per annum, respectively, during the entire period. However, the area of sorghum has declined by 0.21 per cent per annum. It clearly indicates that the production of *Rabi* sorghum was increased by only productivity improvement for the entire period.

The production and productivity of *Rabi* sorghum increased at higher rates during the period II and V as compared to period I, III and IV. The performance of *Rabi* sorghum crop in respect of area, production and productivity was quite satisfactory in Jalgaon, Kolhapur, Satara and Sangli district for entire period. However, the area under *Rabi* sorghum is negligible in these district as compared to Pune, Ahmednagar and Solapur district. The productivity of *Rabi* sorghum in II and V period was significantly increased in Pune, Ahmednagar and Solapur district as compared to remaining periods. The area under *Rabi* sorghum crop in all the district were quite fluctuating in all the period. It was mainly due to the rainfall and competing crops like *Rabi* onion and wheat in irrigated region and gram in un-irrigated region for *Rabi* sorghum. Sorghum crop grown in those areas where there is no option for irrigation and shortage of irrigation availability.

In conclusion, the analysis revealed that there is a wide variation in the performance of *Rabi* sorghum crop in terms of changes in area, production and productivity

among the districts and regions as a whole over a period of time. In general, the period-II was characterized by the increase in production and productivity. However, the period-V was characterized by decrease in area. The increase in the production was observed mainly due to productivity improvement of *Rabi* sorghum (Mukherjee and Kuroda, 2003; Nethravathi and Yeledhalli, 2016 and Tripathy, 1996).

Co-efficient of variation and instability in area, production and productivity in *Rabi* sorghum in Western Maharashtra overall (1960-61 to 2012-13):

Co-efficient of variation and instability in area, production and productivity in *Rabi* sorghum in Western Maharashtra for overall period (1960-61 to 2012-13) is presented in Table 2. It can be revealed from Table 2 that in overall period there is less variation in area *i.e.* 13.9 per cent and instability 13.47 in the sorghum crop of Western Maharashtra. Highest instability was found in the Satara district 123.35 per cent this may be because of crop diversification in Satara district. Lowest instability was found in Ahmednagar district 2.02 per cent.

At overall period in general there is high variation and instability was found in production of sorghum crop it was 32.59 per cent and 31.29 per cent, respectively in Western Maharashtra. Highest instability in the production of Satara district 91.23 per cent is due to high instability in area under sorghum crop.

In case of productivity of the sorghum crop in Western Maharashtra the co-efficient of variation was 36.87 per cent and instability was 21.91 per cent it clearly indicates that sorghum productivity in Western

Particulars	Area		Production		Productivity	
	CV	CDV	CV	CDV	CV	CDV
Nashik	56.40	38.14	58.16	54.73	38.33	29.82
Dhule	60.44	32.92	56.75	42.50	40.37	29.77
Jalgaon	39.23	35.89	58.86	40.70	37.11	20.36
Pune	18.04	17.93	38.79	35.48	31.79	26.04
A.nagar	7.09	2.02	21.12	20.22	18.60	18.60
Solapur	17.48	17.24	37.85	37.82	34.09	33.60
Kolhapur	61.80	30.90	95.82	36.37	57.71	28.42
Satara	124.1	123.35	100.90	91.23	27.03	23.54
Sangli	23.98	14.61	57.27	40.76	41.93	36.41
Nandurbar	13.18	13.17	29.29	22.64	26.00	17.71
Western Maharashtra	13.90	13.47	32.59	31.29	36.87	21.91

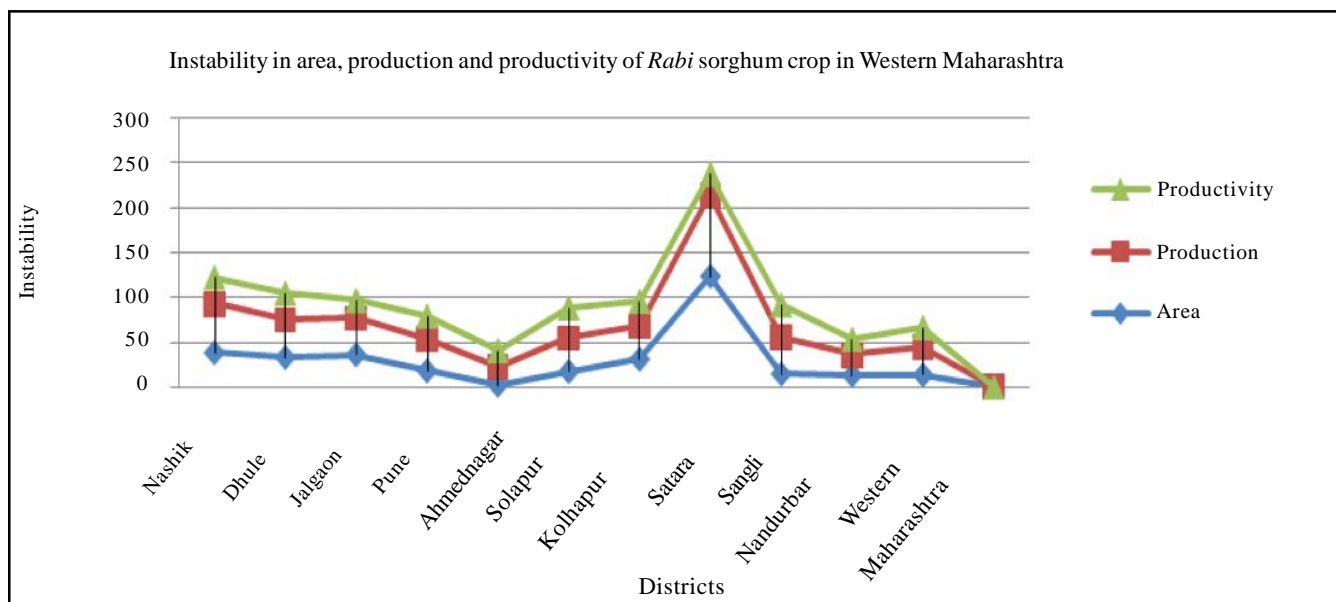


Fig. 1: Instability in area, production and productivity of wheat crop in Western Maharashtra

Maharashtra is instable for overall period. The productivity of Satara district shows high variation 27.03 per cent and instability 23.54 per cent this indicates that productivity of sorghum in Satara is stable. The high instability in production of Satara district was due to instable area under sorghum crop (Kumar and Jain, 2004 and Kumarvardan *et al.*, 2009).

Growth rates of area, production and productivity of wheat in Western Maharashtra:

The district wise and period wise compound growth rates of the area, production and productivity of wheat have been examined for the period 1960-61 to 2012-13 and presented in Table 3. It is revealed from the Table 3 that, the growth rates of area, production and productivity

Table 3 : Growth rates of area, production and productivity of wheat in Western Maharashtra

Particulars	Nashik	Dhule	Jalgaon	Pune	Ahmednagar	Solapur	Kolhapur	Satara	Sangli	Western Maharashtra
Period-I										
(1960-61 to	A -1.15**	3.96***	2.5**	-0.5	-0.46	2.25**	0.68	0.38	-1.02	0.53
1969-70)	P 4.56**	4.51**	4.02*	2.79	2.91	0.31	-0.32	-1.13	-0.19	3.06**
	Y 5.79**	0.53	1.49	3.3**	3.4	-1.9	-1	-1.5	0.86	2.52**
Period-II										
(1970-71 to	A 6.04**	1.76	2.82	8.22***	5.22**	7.59**	27.4***	5.81***	15.17***	6***
1979-80)	P 12.44*	5.02	2.04	14.32***	14.69***	10.47**	34.5***	12.81***	20.72***	10.5**
	Y 6.04	3.2	-0.76	5.64*	9***	2.67	5.57	6.63**	4.83**	4.24*
Period III										
(1980-81 to	A -3.28**	-4.88**	-4.28**	1.32	-1.35	-2.31	-1.87	-0.32	-8.24***	-2.54**
1989-90)	P -0.39	-6.82	-2.98	4.01**	-1.28	0.96	2.42	1.12	-2.74	-0.56
	Y 3	-2.06	1.36	2.65**	0.08	3.34	4.38*	1.45	6*	2.03
Period IV										
(1990-91 to	A 1.36	-4.39**	2.59*	2.75**	4.95**	7.35***	0.24	3.14***	2.69	3.23**
1999-00)	P 5.01*	-1.52	4.61	5.43**	6.75**	8.16**	-2.46	6.64***	5.94**	5.33**
	Y 3.6	7**	1.98	2.62*	1.72	0.74	-2.71	3.4**	3.16**	2.04
Period V										
(2000-01 to	A 3.14	11.29***	1.3	0.35	-2.38	-0.26	0.23	1.79	0.87	-0.15
2012-13)	P 6.15	17.82***	3.32	3.39	-1.56	0.87	2.81**	2.6	1.76	2.34
	Y 2.91**	5.83***	2	2.49	0.85	1.13	2.58***	0.8	0.88	2.5**
Overall										
(1960-2012)	A -1.12***	-1.63***	0.05	2.58***	1.66***	1.57***	3.33***	2.37***	1.19***	0.63***
	P 2.19***	0.51	2.54***	5.26***	4.55***	3.17***	6.24***	4.76***	4.07***	3.31***
	Y 3.34***	2.25***	2.5***	2.53***	2.85***	1.58***	2.81***	2.33***	2.85***	2.66***

Note : (1) **, **and *** indicate significance of values at P=0.01, 0.05 and 0.1, respectively

(2) Nandurbar district was not taken under consideration during analysis due to non-availability of data

of wheat for Western Maharashtra as a whole were observed to be positive and highly significant for the entire period of 53 years. The area, production and productivity of wheat have increased at the rate of 0.63 per cent, 3.31 per cent and 2.66 per cent per annum, respectively, during the entire period.

During period I (1960-61 to 1969-70), highest increase in area was found in Jalgaon district *i.e.* 2.5 per cent while production and productivity observed to be highest in Nashik district 4.56 per cent and 5.79 per cent per annum, respectively. During period II (1970-71 to 1979-80), Kolhapur was the leading district in area and production 27.4 and 34.5 per cent per annum, respectively and productivity noted to be was highest in Ahmednagar

district 9.00 per cent per annum.

While in period III (1980-81 to 1989-90) area showed negative growth in all district except Pune. It may be due to introduction of technology mission on oilseeds, pulses and maize crop, which results in shifting of wheat crop area towards oilseeds and pulse crops were took place. Pune was leading district in production with 4.01 per cent growth per annum and Sangli district in productivity by 6 per cent per annum. In period IV (1990-91 to 1999-00) Solapur was leading district in area and production with 7.35 per cent and 8.16 per cent growth per annum, respectively. While Dhule district found to be highest in productivity with 7 per cent per annum. During period V (2000-01 to 2012-13) in case of area,

Table 4 : Co-efficient of variation and instability in area, production and productivity in wheat in Western Maharashtra overall (1960-61 to 2012-13)

Particulars	Area		Production		Productivity	
	CV	CDV	CV	CDV	CV	CDV
Nashik	25.26	20.79	43.97	33.18	48.12	17.90
Dhule	35.39	28.11	46.85	46.26	44.19	27.49
Jalgaon	26.35	26.34	54.63	37.43	42.00	19.01
Pune	37.88	17.55	64.24	27.25	38.20	19.80
A.nagar	42.29	33.24	74.28	44.34	41.35	21.53
Solapur	37.30	29.09	61.91	42.70	31.56	22.21
Kolhapur	71.32	55.58	63.54	37.21	46.47	28.11
Satara	35.94	12.99	65.13	22.59	37.09	17.67
Sangli	36.09	31.75	59.6	30.36	44.94	17.74
Nandurbar	48.32	19.76	64.76	24.43	29.99	16.96
Western Maharashtra	24.27	22.46	55.92	31.41	39.75	13.84

*CV: Co-efficient of variation, **CDV: Cuddy della vella

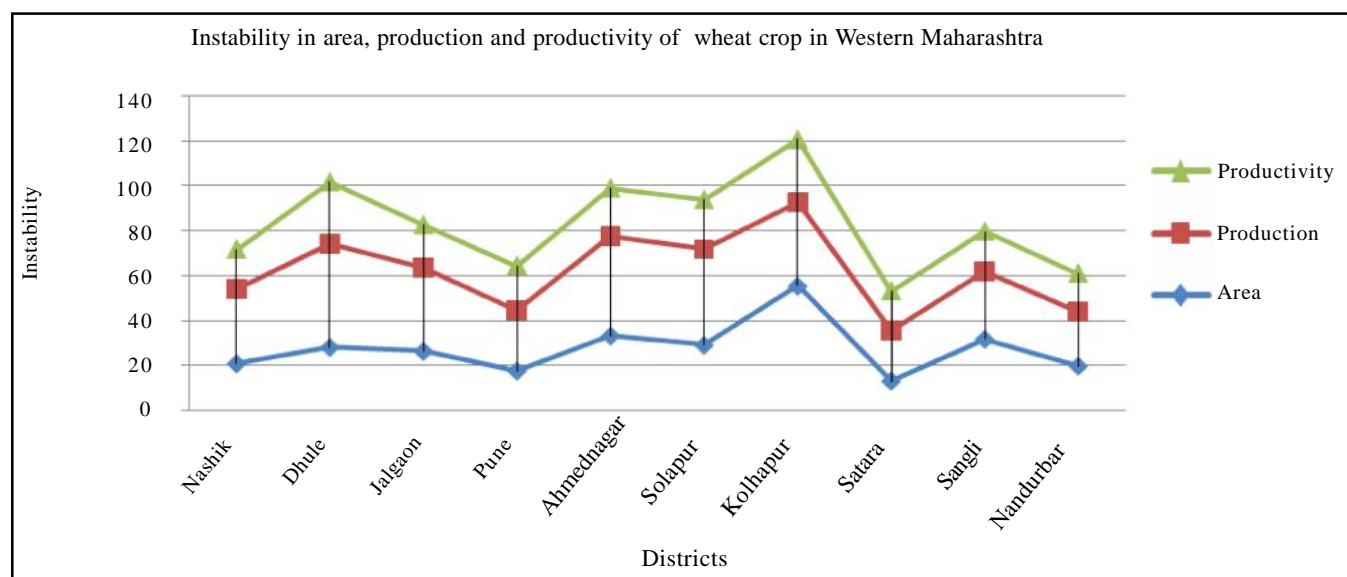


Fig. 2: Instability in area, production and productivity of wheat crop in Western Maharashtra

production and productivity of wheat Dhule district observed to be highest with 11.29, 17.82 and 5.83 per cent per annum, respectively. For the entire period (1960-61 to 2012-13) in Western Maharashtra, area, production and productivity of wheat found to be positive and significant with 0.63, 3.31 and 2.66 per cent per annum, respectively. In conclusion, the production of wheat was increased mainly due to the productivity improvement for Nasik, Dhule, Jalgaon, Pune and Ahmednagar districts of Western Maharashtra region.

Co-efficient of variation and instability in area, production and productivity in wheat in Western Maharashtra overall (1960-61 to 2012-13):

It can be revealed from Table 4 that in overall period there is more variation in area *i.e.* 24.27 per cent and instability 22.46 per cent in the wheat crop of Western Maharashtra. Highest instability was found in the Kolhapur district *i.e.* 55.58 per cent. This may be due to crop diversification and Kolhapur being prominent sugarcane producing district. Whereas lowest instability was found in Satara district 12.99 per cent.

The status of wheat at overall period depicts that there is high variation and instability was found in production of wheat crop with 55.92 per cent and 31.41 per cent, respectively in Western Maharashtra. Highest instability in the production was observed in Ahmednagar district *i.e.*, 44.34 per cent, it may be due to availability of irrigation facilities in *Rabi* season.

In case of productivity of the wheat crop in Western Maharashtra the co-efficient of variation was 39.75 per cent indicating more variation in productivity of wheat. While instability was 13.84 per cent it clearly indicates that wheat production in Western Maharashtra is more stable for overall period. The productivity of Nashik district shows high variation 48.12 per cent and highest instability with 28.11 per cent found in Kolhapur district, this indicates that productivity of wheat in Kolhapur is less stable. The high instability in production of Kolhapur district was due to in stable area under wheat crop (Chand and Raju, 2009; Kumar and Mittal, 2006).

Conclusion:

In case of sorghum crop in Western Maharashtra at overall period the compound annual growth rates in

production of sorghum was 0.71 per cent. Despite decrease in area by -0.21 per cent the increase in production is because of increasing in productivity by 0.92 per cent. This indicates that in Western Maharashtra the increased productivity plays major role in increasing the production of sorghum crop.

In Western Maharashtra co-efficient of variation and instability in area, production and productivity was stable for overall period for sorghum crop hence, it is one of the prominent crop in Western Maharashtra.

The growth rates of area, production and productivity of wheat for Western Maharashtra as a whole were 0.63 per cent, 3.31 per cent and 2.66 per cent per annum, respectively for overall period. The productivity of Nandurbar district was found positive and significant throughout the study period it was 6.66 per cent per annum.

In Western Maharashtra co-efficient of variation and instability in area, production and productivity of wheat crop for overall period was more. It indicates that wheat crop is more instable in *Rabi* season.

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