Society for Advancement of Wheat Research
ICAR-Indian Institute of Wheat & Barley Research
Karnal - 132 001, India

Journal of Wheat Research

8(1):45-50

Homepage: http://epubs.icar.org.in/ejournal/index.php/JWR

Research Articles

Analysis of yield gap in wheat

Priyanka Ashokrao Agam*, Sandip Shridhar Thakare, Deepak Hiroji Ulemale and Pritam Nagorao Chirade

Department of Agricultural Economics and Statistics, Shri Shivaji Agriculture College, Amravati, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola-444001, Maharastra, India

Article history

Received: 23 June, 2015
Revised : 08 October, 2015
Accepted: 06 May, 2016

Citation

Agam PA, SS Thakare, DH Ulemale and PN Chirade. 2016 Analysis of yield gap in wheat. *Journal of Wheat Research* 8(1):45-50

****Corresponding author***

Email : *priyanka.agam123@gmail.com*

Abstract

In this study, an attempt has been made to study the analysis of yield gap in wheat. The primary data on input used and there upon costs were collected from two tehsils viz. Amravati and Morshi, while the secondary data on area, production and productivity was pertained to the periods 1983-84 to 2012-13 was collected from various Government publications. The study reveals that the area under wheat in Amravati has increased by 17.29 percent per annum during period III while at overall level it shows significant growth. The yield gap analysis shows that at overall, yield Gap I (difference between potential yield and demonstration plot yield) worked out to be 879 kg/ha and yield Gap II (demonstration plot yield and farmers yield) was 579 kg/ha. The highest total yield gap was recorded in large farmers (830 kg/ha) while lowest in small farmers (508 kg/ha). Magnitude and direction of yield gap shows that the yield gap is increased at increasing rate. The path analysis measured the direct and indirect effect of input gaps on yield gaps explained that the total effect of human labour (0.613) was found to be highest in small farmers while bullock labour (0.371), machine labour (0.431) found to be highest in small groups farmers. At overall level total effect of seed and fertilizer (0.871) and (0.337) respectively. The manure and plant protection effect is (0.306) and (0.410). The total area effect highest in medium size group of farmers.

Keywords: Compound growth rates, coefficient of variation, path analysis, yield gap, wheat

1. Introduction

Wheat (*Triticum* spp.) is a cereal grain, originally from the South West Asia, is cultivated worldwide. It has been described as the “King of Cereal” India has second rank in world wheat production. In 2012-13, the world production of wheat was 654 (Million tons) In India was 29647 (000'ha) with production 92458 (000't) and productivity as 3119 (kg/ha). India's share out of world production is 13.15%. In Maharashtra in 2012-13, Area, Production and Productivity of wheat in Amravati district was 36100 ha, 71500 tonns and 1981 kg/ha, respectively. Wheat is the world’s most widely cultivated food crop. It is eaten in various forms by more than one thousand million human being in the world. In India, it is second important staple food crop, rice being the first. It is eaten in the form of ‘chapatis’, ‘puris’ or in the form of ‘upma’ (cooked from suji or rawa). In addition to this wheat is also consumed in various other preparations such as ‘dalia’, ‘halwa’, ‘sweet means’ etc. In most of the urban areas in the country the use of baked ‘leavened bread, flakes, cakes, biscuits etc., is increasing at a fast rate.

2. Materials and methods

2.1 Collection of data: The study was based on primary as well as secondary data collected from Amravati district. The secondary data on area, production and productivity of wheat was collected from various Government publications for last 30 years. The entire study was split up into three sub-periods like P1 (1983-84 to 1992-93), P2 (1993-94 to 2002-03) and P3 (2003-04 to 2012-13).

2.2 Primary data: The primary data on inputs used and yield obtained from wheat were collected from selected farmers by survey method. In all, 90 farmers were selected for the study. The data pertain to the year 2012-13. The selected farmers were stratified into three groups on the basis of size of holdings *viz.,* small farmers (i.e. 45) with the size of holding (0.01 ha. to 2.00 ha.), medium farmers (i.e. 26) with (2.01 to 4.00 ha.) and large farmers (i.e. 19) (4.01 ha. and above).

2.3 Analytical tools: One of the objective of the present study about the performance of wheat in Amravati district was examined by estimating.

i. Compound Growth rates of area, production and productivity.

ii. Degree of instability in area, production and productivity.

2.4 Estimation of growth rates: The growth rates in area, production and productivity was studied by estimating compound growth rates at different periods.

The growth rate was estimated by using following model.

$$Y = a.b^t$$

Where,

Y = Area / Production / Productivity

a = Intercept

b = Regression coefficient

t = Time Variable

From the estimated function the compound growth rate was worked out by

CGR (r) = [Antilog (log b- 1)] X 100

Where

r = Compound Growth Rate

2.5 Degree of instability: The degree of instability in area, production and productivity of wheat of different period was measured by using coefficient of variation and coefficient of instability.

Coefficient of variation (CV) = $\frac{\sigma}{\bar{X}} \times 100$

Where,

σ = Standard Deviation = $\sqrt{\frac{\sum (X - \bar{X})^2}{n}}$

$\bar{X}$ = Arithmetic Means

Coefficient of instability was worked out by using Coppocks instability index

$$\bullet\ V = \log \frac{\sum (Log \frac{X_t + 1}{X_t} - - - - - - - m)2}{N}$$

The instability index = [Antilog ($\sqrt{V \log}$)-1] X 100

Where,

X_t = Area/ Production / Productivity of crop in year t

N = Number of year

m = Arithmetic mean of the differences between the log of X_t and

$X_t - 1,\ X_t - 2$ etc.

V log = Arithmetic Variance of series.

2.6 Yield gap analysis

2.6.1 Yield Gap I

It is the difference between potential yield and actual yield.

(i.e. Y_p - Y_a).

2.6.2 Yield gap II

It is the difference between potential farm yield and actual yield

(i.e. Y_d - Y_a)

The magnitude and direction of yield gap was studied by fitting Quadratic Function

$Y=a+bT=cT^2$

Where,

Y = Yield Gap

T = Time

So, about existing of acceleration or deceleration with a specified time period is based on the sign and statistical significance of the estimation of C in the quadratic trend function.

2.7 Factors responsible for yield gap: The factor contributing towards yield gap was studied using path analysis.

Path coefficient analysis technique was carried out to estimate direct and indirect contribution of input gap (X) is to yield gap (Y).

A path coefficient is the ratio of the standard deviation of the effect or it is a standardized partial regression coefficient (Deway and Lu, 1959). In the present investigation, the effect of difference actual utilization of key inputs and human labour (md), bullock labour (pd), seed (kgs), plant nutrients (Rs.) and plant protection (Rs.) between the farmers and field demonstration plant independent variable (Xi) were used. The path coefficients across different categories of farm will be studied by solving the following simultaneous equations.

$r_{y1}=P_{y1}+ r_{12}Py_2+r_{13}Py_3+r_{14}P_{y4}+r_{15}Py_5$ 1

$r_{y2}=r_{21}Py_1+ Py_2+r_{23}Py_3+r_{24}P_{y4}+r_{25}Py_5$ 2

$r_{y3}=r_{31}Py_1+ r_{32}Py_2+ Py_3+r_{34}P_{y4}+r_{35}Py_5$ 3

$r_{y4}=r_{41}Py_1+ r_{42}Py_2+r_{43}Py_4+r_{45}Py_5$ 4

$r_{y5}=r_{51}Py_1+r_{52}Py_2+r_{53}Py_3+r_{54}Py_4+Py_5$ ………….5

The generalized formula may be written as

$r_{yi}=r_{1i}Py_1+r_{2i}P_{y2}+r_{3i}P_{y3}+\ldots\ldots+r_{ni}P_{yn}$ …………6

Where,

i = (1 to 5) is the correlated cause and y is the effect.

$$P_{y1}=bi\,\frac{\partial i}{\partial y}$$ ………….(7)

The direct effects are given by the path coefficient (P_{yi}). The indirect effect is given by equal to

$$\sum_{\substack{i=1\\ i=j}}^{n} rij\, P_{yi}$$ ………….(8)

The unexplained variance (residual effect) not accounted for by the included variables can be obtained by

Where $P_{yj}=(1-R^2)^{1/2}$ ………….(9)

$$R^2=\sum^{n} P_{yj2}+\sum_{\substack{i=1\\ i=j}}\sum P_{yj}P_{yj}\,rij$$ ………….(10)

3. Results and discussion

3.1 Performance of wheat

3.1.1Growth in area, production and productivity: In this study, compound growth rates in area, production and productivity of wheat was estimated by using exponential function with time normalization on area, production and productivity. The growth performance of the wheat pertaining to three periods and overall is discussed and presented in Table 1, reveals that during period I, the compound growth rate of area and production of wheat was negative and significant. Only productivity of wheat in Amravati was increased by 4.56 percent per annum over the period of study it shows that during period III the compound growth rates of area, production and productivity of wheat in Amravati were 17.29, 23.79 and 5.78 percent per annum respectively which indicated that it is during period II and III the area, production and productivity of wheat in Amravati was rapidly increased.

Table 1. Growth Performance of Wheat

Sr. No.	Particulars	Period I	Period II	Period III	Overall
1	Area	-11.94***	-1.77	17.29***	-0.17
2	Production	-7.93**	-4.07	23.79***	2.20*
3	Productivity	4.56**	-2.13	5.78***	2.37***

(Note : ***, ** & * denotes significant at 1%, 5% & 10% level of significance)

At overall level, the Table 1 shows that during period 1983-84 to 2012-13, the area of wheat in Amravati district was declined (i.e. -0.17 percent per annum) and production (i.e. 2.20 percent per annum) and productivity (i.e. 2.37 percent per annum) of wheat shows positive and significant growth.

3.1.2 Coefficient of variation in area, production and productivity: One should not obvious of instability by taking the growth rates only. Because the growth rates will explain only the rate of growth over the period, whereas, instability will judge whether the growth performance is stable or unstable for the period for the pertinent variable.

In order to know the instability in area, production and yield of wheat fluctuation is measured with the help of coefficient of variation. The results are presented in Table 2 and discussed as under for the period with ten years breakage and overall also. Fluctuation in area, production and productivity due to the uncontrollable factors like climatic conditions can cause upward bias in coefficient of variation.

Table 2. Coefficient of variation in area, production and productivity of wheat in Amravati district.

Sr. No.	Particulars	Coefficient of variation (%)			Overall
		I	II	III	
1	Area	35.30	20.41	50.99	53.18
2	Production	33.63	32.29	60.10	71.55
3	Productivity	19.79	18.91	19.56	26.11

As seen from Table 2 the coefficient of variation in area for overall period was 53.18 percent during the period I, there was highest variation as compared to period I and period II (i.e. 35.30 percent and 20.41 percent) respectively.

During period III Amravati district recorded highest variation (i.e. 50.99 percent) as compared to I and II period.

It is cleared that this district exhibited less variation in second period and highest variation in area during third period of study. As revealed from Table 2 the district witnessed very high instability of production as indicated by high coefficient of variation of 71.55 percent for overall period.

Among periods under study, the period III has highest coefficient of variation in production. While during the second period it was 32.29 percent and first period it was 33.63 percent. Thus, it is cleared from the study that the production of wheat in Amravati district has increased during the period of study.

Table 3. Coppocks Instability Index of area, production and productivity of wheat in Amravati district.

Sr. No.	Particulars	Coefficient of variation (%)			Overall
		I	II	III	
1	Area	19.12	19.68	33.05	53.16
2	Production	26.12	29.85	35.98	68.35
3	Productivity	14.84	18.02	10.98	17.99

Table 3. of reveals that the productivity of wheat over the entire period shows low coefficient of variation of 26.11 percent. The first period witnessed coefficient of variation of 19.79 percent while in second period, the coefficient of variation in productivity of wheat decreased to 18.91 percent and third period the coefficient of variation in productivity of wheat is increased by 19.56 percent.

From above it is cleared that the instability in wheat was decreased during second period and productivity were decreased over period at time. At overall level Coefficient of variation was 26.91 percent per annum.

From Table 3 that the instability index of area under wheat for overall was 53.16 percent. During first period the instability in area was comparatively low which means that there was instability in area under wheat. This was increased during period III (33.05 percent)

Above table present instability index for production the instability index of production for the overall period was 68.35 percent. During first period the instability index was 26.12 percent while in second period the instability index witnessed 29.85 percent and third period instability index was 35.98 percent.

Revealed from table that the instability index during overall period 17.99 percent during first period instability index 14.84 percent while in second period instability index was 18.02 percent and third period instability index was 10.98 percent.

3.1.2 Yield gaps in wheat production

The study was undertaken with the overall objective of estimating the magnitude of yield gaps and factor contributing to yield gap in wheat production. The results obtained are presented in Table 4.

Table 4. Wheat yield levels realized and estimated yield gap under different field situation

Sr. No.	Particulars	Yield(Kg/ha)
1	Potential yield	4200
2	Potential farm yield	3900
3	Actual yield	
	Small farmers	3392
	Medium farmers	3380
	Large farmers	3070
	Overall	3321
4	Yield gap I	
	Small farmers	808
	Medium farmers	820
	Large farmers	1130
	Overall	879
5	Yield gap II	
	Small farmers	508
	Medium farmers	520
	Large farmers	830
	Overall	579

It could be observed from the Table 4. that there is a wide gap in the gram productivity between the research station, the potential farm (demonstration plots) and the sample farmers fields.

The magnitude of yield gap I worked out to be 879 kg/ha which observed relatively higher size of yield gap II 579 kg/ha. The higher magnitude of yield gap II may be attributed to the significant experimental difference and partly to the non-transferable component of technology like cultural practices between the demonstration plot and the research stations. Farm size group wise analysis observed that the highest in magnitude of yield gap was recorded on the large farm (1130 kg/ha) and medium farms (820 kg/ha) while the lowest magnitude was notice on small farms (808 kg/ha). And in yield gap II it has been noticed that highest magnitude notice on large farm (830 kg/ha), and the lowest in small farm (508 kg/ha).

Farm size group wise analysis showed that the medium and large farmers obtained relatively better yield levels than small farmers. This resulted comparatively higher yield levels and narrower yield gap on medium and large farmers than on their medium counterparts. Due to knowledge of new technology and proper cultural practices should manage their farms better resulted in higher yield levels on the other hand comparatively lower yield level realized on small farms. This was due to their economical condition and unawareness.

Table 5. Magnitude and direction of yield gap for wheat.

Sr. No.	Intercept	Coefficient		
		X	X^2	R^2
	578	-9.04 (11.03)	0.14** (0.11)	0.48**

(Figure in parenthesis indicate the standard error) (**significant at 5% level)

The analysis of yield gap II for gram shows that the quadratic function fitted for yield gap data for Amravati district had R^2 value is positive. This indicates that yield gaps for wheat is showing acceleration and increased i.e. yield gap is increased at increasing rate.

3.2 Factor contributing to the yield gap path analysis

The direct and indirect effects measured both in terms of correlation coefficient and percentage of input use gaps on yield gaps are presented in Table 6

Table 6. Direct and Indirect effects of input use gaps on yield gap in wheat

Sr. No.	Particulars	Field situation			
		Small	Medium	Large	Overall
A					
1	Direct effect of Human Labour	0.356 (58.16)	0.404 (63.97)	0.510 (124.22)	0.328 (56.11)
2	Indirect effect of Human Labour	0.256 (41.84)	-1.0417 (163.97)	-0.921 (224.22)	0.256 (43.88)
3	Total effect of Human Labour	0.613 (100)	-0.643 (100)	-0.411 (100)	0.585 (100)
B					
1	Direct effect of bullock Labour	0.235 (62.28)	-0.309 (22.22)	-1.212 (208)	0.039 (9.95)
2	Indirect effect of bullock Labour	0.142 (37.72)	-1.083 (77.78)	0.629 (108)	0.360 (90.04)
3	Total effect of bullock Labour	0.377 (100)	-1.392 (100)	-0.583 (100)	0.400 (100)
C					
1	Direct effect of machine Labour	-0.249 (57.95)	-1.380 (111.02)	0.646 (116.82)	0.001 (0.37)
2	Indirect effect of machine Labour	0.681 (157.95)	0.137 (11.02)	-0.553 (218.49)	0.463 (99.62)
3	Total effect of machine Labour	0.431 (100)	-1.24 (100)	-1.199 (100)	0.46 (100)
D					
1	Direct effect of seed	0.075 (15.72)	0.317 (127.15)	0.407 (118.49)	0.198 (22.81)
2	Indirect effect of seed	0.406 (84.28)	-0.567 (227.15)	-0.751 (218.49)	0.672(77.18)
3	Total effect of seed	0.482 (100)	-0.249 (100)	-0.343 (100)	0.871 (100)
E					
1	Direct effect of fertilizer	0.099 (20.31)	-0.057 (12.33)	-0.036 (12.28)	0.097 (29.03)
2	Indirect effect of fertilizer	0.389 (79.69)	-0.408 (87.67)	-0.261 (87.72)	0.239 (70.96)
3	Total effect of fertilizer	0.488 (100)	-0.466 (100)	-0.298 (100)	0.337 (100)
F					
1	Direct effect of manure	0.050 (22.40)	-0.006 (9.68)	-0.417 (217.67)	0.037 (12.15)
2	Indirect effect of manure	0.174 (77.60)	0.077 (109.68)	0.225 (117.67)	0.269 (87.84)
3	Total effect of manure	0.225 (100)	0.070 (100)	-0.417 (100)	0.306 (100)
G					
1	Direct effect of plant protection	0.138 (35.13)	-0.021 (6.06)	-0.417 (100)	0.306 (100)
2	Indirect effect of plant protection	0.256 (64.87)	-0.330 (109.68)	-0.303 (42.11)	0.285 (69.55)
3	Total effect of plant protection	0.395 (100)	-0.351 (100)	-0.720 (100)	0.410 (100)
H					
1	Direct effect of area	-0.242 (43.76)	-0.041 (5.63)	0.686 (113.02)	-0.013 (2.70)
2	Indirect effect of area	-0.311 (56.24)	0.782 (105.63)	-0.079 (13.02)	-0.491 (97.29)
3	Total effect of area	-0.553 (100)	0.740 (100)	0.686 (100)	-0.504 (100)

Table 6 presents the information on yield gap which were the result of gap in the quantity of input used and a composite variable that included all other factor affecting yield gap not included in the model. These could be differences in the climatic conditions, various cultural and crop management practices between the farmers and demonstration plots.

Results of correlation coefficient between the yield gap and input use gaps revealed that the total effect of Human labour was found to be highest (0.61) in small farmers. Machinery labour 0.43 in small farmers.

On small category of farmers seed was found to be the most important variable conditioning yield gap as indicated by its correlation coefficient (0.48) and it explained direct and indirect effect 15.72 percent and 84.28 percent of total effect.

The overall total effect of fertilizer is (0.33) and direct and indirect effect 29.03 percent and 70.96 percent.

In small category of farmers manure and plant protection was found to be the most important variable conditioning yield gap as indicated by its correlation coefficient (0.22) and (0.39) and it explained direct and indirect effect respectively. 22.40 percent, 77.60 percent and 35.15 percent, 64.87 percent area effect is the most responsible factor of yield gap in medium and large farmers.

The positive correlation between the input use gaps and the yield gap indicated a direct association between the input use differences and yield gap. The findings of the study clearly demonstrated the possibility of reducing the yield gap by reducing the input use gaps. In addition to this, the farmers ability to use higher level of input need to be considered and there is a need to educate farmers about the benefits of using the recommended level of inputs.

The results of the study conclude that the area under wheat was decreased over a period, however the production and productivity of wheat was increased and significant growth was observed. Variability in area and production of wheat during period III were the highest variation as compared to period I and period III. Instability in wheat was decreased during second period and productivity decreases over period of time. Due to variability and instability in production and productivity is necessary to evolve high yielding cum high stability varieties of wheat. The yield gap analysis concluded that large farmers. There is a possibility of reducing the yield gap by reducing the input use gaps. In addition to this, farmers ability to use the level of input need to be considered.

References

1. Ahmed S, SR Singh and SA Mir. 2007. Path analysis studies in wheat, *Annals of Agricultural Research* **28** (34) : 253-257.

2. Bera B K, A J Chakraborty, A K Nandi and A Sarkar. 2011. Growth and instability of food grain production of India and West Bengal. *Journal of Crop and Weed* **7** (1) : 94-100.

3. Chaudhari, D J and ND Pawar. 2010. Performance of major cereals in Marathwada region. *Agriculture Update* **5** (3/4) : 365-369

4. Deway, DR and KH Lu. 1959. A correlation and path coefficient analysis of compounds of crested wheat grass seed production. *Agronomy Journal.* **51** : 515-518.

5. Gavali AV, TD Deokate, RB Chaudhari and B H Kamble. 2011. Yield Gap Analysis of Jowar in Maharashtra. *Journal of Agriculture Economy* **7** (1) : 26.

6. Kemirembe D.2014. An analytical study into growth and variability in area, yield and production of wheat in Punjab. *Indian Journal of Economics and Developmen* **10** : 146-152.

7. Patel HR, V J Patel and V Pandey. 2007. Estimation of wheat yield gap in Anand and Meshsana districts using ceres - wheat model in Gujrat. *Asian Journal of Environmental Sciences* **2** (1/2) : 81-84.