Estimation of variability in wheat production levels in middle Gujarat using simulation model

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ABSTRACT

An effort was made in the direction of estimating yield gap in wheat production in middle Gujarat agro climatic zone (Anand and Panchmahals districts) using InfoCrop simulation model. Historical weather data were used in order to estimate potential and attainable wheat production levels. The actual wheat production was plateau in both the districts while, the potential yield estimated by the model was about 2.4 times higher than actual yield giving the indication about the possibility of harnessing higher wheat yields in this zone.

Key words: Simulation models, InfoCrop, yield gap, middle Gujarat

Estimation of yield gap in any crop helps to have target-oriented approach in achieving regional food security. The yield targets serve as a reference for calculating the required agronomic inputs and for assessing their environmental effects. Hence, estimation of yield gap for the whole country was done in wheat as wheat yields were decreased by 7 M t during 2000 – 2001 season as compared with previous production of 75.5 M t (Ministry of Agriculture, 2001). Gujarat state yielded a productivity of only 2670 kg ha^{-1} during 2000 (Anon., 2000), despite being fifth in area under wheat. This is an attempt to estimate the potential productivity of wheat producing middle Gujarat agroclimatic zone and also assess the gap that exists between the potential and attainable / actual wheat production levels using a crop simulation model.

MATERIALS AND METHODS

Anand and Panchmahals representing middle Gujarat state were the two districts selected for the study, keeping in view availability of pertinent historical weather data required by simulation model, InfoCrop. InfoCrop developed by Aggarwal *et al.* (2004) was calibrated and evaluated with the genetic input data generated from the field experiments carried out for two consecutive years during *rabi* 2000 and 2001 at B A College of Agriculture, Anand, Gujarat. The production levels estimated by the model were categorised as 'potential' and 'attainable'; and were compared with the actual. The crop yield data reported by

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Table 1: Estimation of wheat yield gap by InfoCrop in middle Gujarat

Details	Yield (kg ha⁻¹)			Yield gap (kg ha⁻¹)		
	Actual	Potential	Attainable	Total	Management	Sowing
			Anand			
Mean	2321	5929	4823	3608	2502	1106
S D ±	318	464	449	284	402	326
C V (%)	14	8	9	8	16	29
Slope	13	32**	29*	56*	15	36
R^2	0.19	0.48	0.31	0.41	0.11	0.17
			Panchmahals			
Mean	2132	4929	3890	2797	1758	1039
S D ±	285	744	573	592	434	312
C V (%)	13	15	15	21	25	30
Slope	16	120*	98*	136**	144**	22
R^2	0.07	0.45	0.60	0.75	0.86	0.06

* * Significant at 1% probability   * Significant at 5% probability

The Directorate of Agriculture Gujarat state was considered as actual yield. The potential yield was simulated assuming no limitation of water and nutrients with optimum cultural management using soil and weather data of the respective districts. To assess the yield gap due to possible delay in sowing by twenty days, attainable yields were also simulated using the optimum sowing time as 15 ᵗʰ November as the base. Potential minus the actual yield was considered as 'total yield gap' while; 'management gap' was defined as that between attainable yield and the actual. 'Sowing yield gap' was defined as the difference between potential and attainable yields due to delay in sowing. The statistical analyses included regression analysis of the three – year moving averages in order to minimize the seasonal effect and to study yield trends. Wherever the trend was not significant averages were worked out to know the trend.

RESULTS AND DISCUSSION

Wheat production in Anand district

Actual yield

Actual wheat yields of Anand district as reported by Directorate of Agriculture ranged from 1664 kg ha⁻¹ (1987) to 3122 kg ha⁻¹ (1983) with an average of 2321 kg ha⁻¹ (Fig. 1) for the period, 1981 to 2000. The standard deviation of yield was 318 kg ha⁻¹ with CV of 14 per cent. The very severe drought of 1987 in India as well as

Table 2: Simulated wheat yield levels by InfoCrop in Panchmahals district

Year	Actual yield	Mov avg of actual yield	Potential yield	Mov avg of potential yield	Attainable yield	Mov avg of attainable yield
1992	2203	2178	4501	4512	3702	3710
1993	1969	2075	3449	4500	2986	3515
1994	2361	2307	5586	5315	4443	4040
1995	1895	2210	4465	5138	3116	3826
1996	2664	2361	5895	5513	4560	4283
1997	2070	2073	5055	5148	3801	4131
1998	2350	2009	5588	5137	4488	4135
1999	1800		4802		4105	
2000	1877		5022		3811	
Average	2132		4929		3890	
SD ±	285		744		573	
CV (%)	13		15		15	

in Gujarat was the reason for the dismally low yields of wheat during that particular year. The closeness of the moving averages of yields to the average yield indicated plateau in yield. Sinha et al., 1998 and Aggarwal et al., 2000 also observed that the growth in productivity of rice and wheat showed either a decline or stagnation in several intensive farming districts of Punjab and Haryana.

Potential and attainable yield

Potential yields as simulated by InfoCrop (Fig.1) ranged from 5017 kg ha^{-1} to 6664 kg ha^{-1} with an average of 5929 kg ha^{-1}(Table 1). The potential yields estimated by the model were about 2.6 times higher than actual yields. The attainable yield was lowest (3889 kg ha^{-1}) and highest (5390 kg ha^{-1}) in 1987 and 1999 respectively with an average of 4823 kg ha^{-1} (Table 1).

Yield gaps

Total yield gap

The average total yield gap estimated by InfoCrop was 3608 kg ha^{-1} with a range from 2995 to 4024 kg ha^{-1} (Fig.2). Standard deviation and CV calculated were, respectively 284 kg ha^{-1} and 8 per cent (Table 1). The trend of moving averages accounted for 41 per cent of variation (R^2 = 0.41) in total yield gap estimates by InfoCrop. Cultivation of the same high yielding variety Lok-1 from early eighties till date and also variety GW-496 since mid nineties together with several other
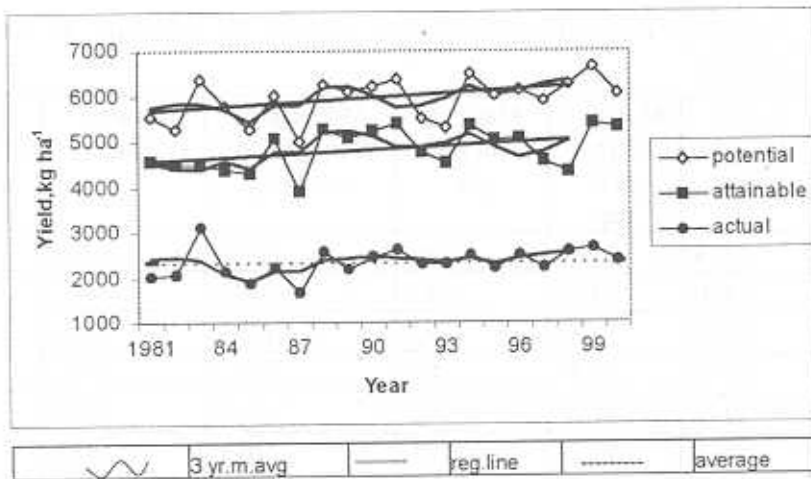
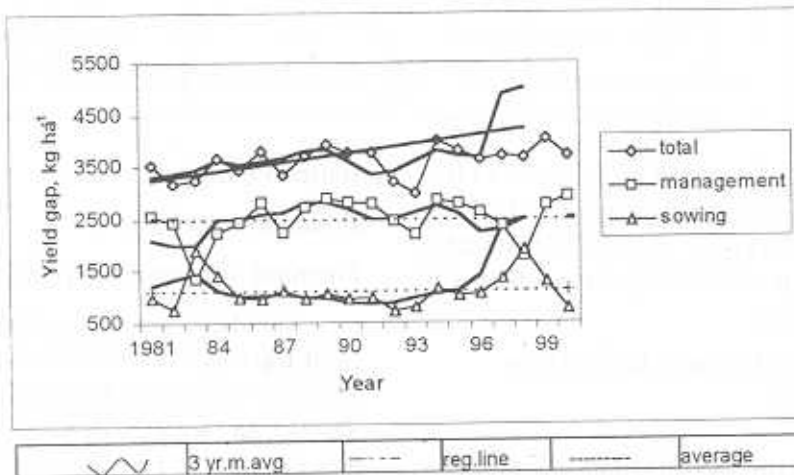Fig.1 : Simulated wheat yield levels by InfoCrop at Anand

Fig. 2 : Yield gap between wheat production levels at Anand as estimated
by InfoCrop

management factors including delayed
sowing were the reasons for large yield gap.
In steep contrast, Mall and Srivastava
(2002) have reported decline in total yield

gap in wheat at Varanasi, U.P, India.

Management and sowing gap

The average management gap

Table 3: Yield gap between wheat production levels in Panchmahals as estimated by InfoCrop

Year	Totoal yield gap	Mov avg of total yield gap	Manage-ment yield gap	Mov avg of Management yield gap	Sowing yield gap	Mov avg of sowing yield gap
1992	2298	2334	1499	1533	799	802
1993	1480	2425	1017	1440	463	985
1994	3225	3009	2082	1733	1143	1276
1995	2570	2929	1221	1616	1349	1313
1996	3231	3151	1896	1922	1335	1230
1997	2985	3075	1731	2058	1254	1017
1998	3238	3128	2138	2126	1100	1003
1999	3002		2305		697	
2000	3145		1934		1211	
Average	2797		1758		1039	
SD ±	592		434		312	
CV (%)	21		25		30	

estimated by the model was about 2.5 t ha^{-1} (Table 1). The sowing gap varied between 738 and 1336 kg ha^{-1} (Fig.2). The estimated average gap was 1106 kg ha^{-1} with the CV of 29 per cent.

Yield gap in Panchmahals district

Actual yield

Actual district yield data indicated that the maximum and minimum yields for the district were 1800 and 2664 kg ha^{-1}(Table 2), respectively with the average of 2132 kg ha^{-1} (Table 1). The yearwise actual yields failed to exhibit any discernible trend. Dave et al. (2000), Dunbury et al. (2000) have opined that, even with the best available cultivars and scientific management, cereal yields either have become stagnant or have started to decline.

Production levels

Potential and attainable yield

Simulated average potential yield by InfoCrop was 4929 ± 744 kg ha^{-1} (Table 1). Average simulated attainable yield was 3890 kg ha^{-1} with the deviation of ± 573 kg ha^{-1} (Table 1). The trend of the moving averages was significant and explained 60 per cent of variance.

Yield gaps

The break up of the estimated total yield gap (2797 kg ha^{-1}) into management and sowing gap was about 63 and 37 per cent, respectively. The trend emphasizes the necessity to bridge the gap, both in terms

of technology and input management (Table 2). Similarly, the management gap also expressed linear trend but not the sowing gap. Nevertheless the model quantified a sowing gap of 51 kg ha^{-1} per day due to delay in sowing.

Thus, about more than two-fold increase in potential wheat yield as compared to the actual indicated the scope of harvesting better yields in the middle Gujarat agroclimatic zone subject to biotic and abiotic stress free conditions.

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