ESTIMATING WHEAT YIELD VARIABILITY AND YIELD GAP BY USING QUADRATE METHOD IN DISTRICT KARNAL, HARYANA

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Abstract: *Crop yield estimation is very crucial as well as challenging and to deal with it numerous techniques are being used such as remote sensing, simulation modeling, farmyard studies etc. but these techniques are seems to be costly, highly skill oriented and required larger sample quantity. In the present study we used quadrate method primarily aimed to minimize the sample size, skill dependency along with its operational cost. Although this process is tedious and labour intensive. A composite sample of 15 sub-samples had been collected from the single field and overall 11 random samples were obtained from the district, Karnal (Haryana) with an average distance of 31.5 km (min.19 km and max. 59 km) from the central city area. The lab analysis results shows the variability ranging from 4.46 t ha^{-1} to 6.62 t ha^{-1} whereas farmer informed yield extended from 3.95 t ha^{-1} to 6.03 t ha^{-1}. Although the yield gap is exceeding to the actual (farmer informed) on an average by 10.95% (maximum 33.81 % and minimum 2.09 %) but results are quite satisfactory, economic.*

Keywords: *Agriculture, wheat yield, variability, quadrate, yield gap.*

Introduction

The world population has been projected to rise 35% by 2050 that means achallenge of feeding more than 9 thousand million people is standing ahead (*Fischer, R.A.et. al. 2009; UNFPA, 2010*). This problem is becoming more severe with limited land and its fertility i.e. availability of essential eighteen nutrients (*Dobermann, A., Cassman, K.G., 2002*; *Hillel, D. 2008*). So it is essential to have finest crop varieties along with the best crop and land management practices and that will certainly help in exploiting the potential and actual yields gap of crops (*Bruinsma, 2009; Rosegrant et al., 2009).* Although crop yield is also determined by a number of other factors such as thegenetic potential of crop cultivar, weather, and cultivation practices (date of sowing, theamount of irrigation and fertilizer) and biotic stresses (*Dadhwal, V.K. et al., 2003*).

Besides of these factors we also need some techniques that can help us in prediction and estimation of crop yield prior harvesting, so that better management can be adopted to minimize the yield gap. Now a day number of techniques are being available ranging from highly sophisticated, costly to simple and cheap. Such as yield potential estimation through **simulation modeling** that presume ideal management and lack of all yield-reducing factors. Although the validity of such models relies on validation under field environment that can never achieve perfect management. (*Lobell, D.B et al., 2009*). Some direct measures of **field experiments**for maximum farm yields that utilize crop management practices designed to eliminate all yield-reducing factors, such as nutrient deficiencies or toxicities, damage from insect pests and diseases, and competition from weeds (*Lobell D.B. et al., 2005; Sadras V. et al., 2002*). These are high labour and huge land oriented practices One more advanced technique is **remote sensing** which utilize satellite data, calibrated against observed field data and a fixed harvest index (*Bouman, B., A., M.1995; Doraiswamy, P., C. et al., 2003;Hatfield, J.,L. 1983*,) and

data from monitoring of a large number of farmers' fields over a number of seasons (*Godfray, J. et al. 2010; van Ittersum, M., K. et al, 2013*) have also been used to estimate Ya (actual yield). This is better and unbiased but economically challenging and high skill dependent.

The above all techniques are best in estimating yield potential and yield gap but simultaneously carrying some limitations too such as costly data, skill, large sample size etc. The present study has been conducted on actual field basis to know the magnitude of wheat yield and its variability. The overallexperiment has been designed to cover the maximum parts of the district Karnal, Haryana. There were following objectives behind this experiment.

1. To minimize the sample size for yield estimation and level of skill requirement
2. To study the yield gap between estimated and the actual yield.
3. To study the wheat yield magnitude variation using quadrate within the district.
4. To estimate the impact of biased and unbiased sampling.

Material & Methodology

A total number of 11 samples have been collected from 11 differently located villages (table no. 1) to cover the whole district, a north-east region of the Haryana State and is located at North latitudes 29°25'05" and 29°59'20" and East longitudes 76°27'40" and 77°13'08" with an elevation of 257 m MSL (*Das, P. and Gupta, S. 2007, Agriculture Contingency Plan: Karnal*). A GPS 70 H (Garmin made) has been used with an average accuracy of 3.425 m (Max. 4.846 m and mini. 2.987 m). A wooden quadrate of 30 cm x 30 cm had been chosen for collecting a sample from 15 different points in a broadcast field with predetermined number of steps. The quadrate has been placed in consideration with border effects over tillers heads without visual assessment and concern of orientation of the sample, which was then pushed at ground level directly perpendicular to the direction of the area to be sampled (*Bell, M.A. and Fischer, R.A. 1994*). The 10 % of total plants falling in the quadrate area were collected on the basis of occupying a given predetermined position (7, 14, 21, 28 etc.). Tillers uprooted by an Iron metal scrapper. A mosaic sample of 15 sub-samples (1 sub-sample=10% tillers from each quadrate point) from the field has been collected.

The estimation of wheat yield requires three essential yields components i.e. tillers population m^{-2} (*Sylvester-Bradley, R. et al 2008*), number of seeds per spike and weight of 100 seeds (*Wheat yield estimation, Victoria*). In the present study after collecting the wheat sample from the different fields, hasbeen dried at 70°C for 24 hours in a pre-calibrated oven (*Bell, M.A. and Fischer, R.A. 1994*). After taking dry weight, the tillers were threshed manually and the total numbers of seeds per spike were counted which were then subjected for weight measurement using sophisticated digital electronic balance having accuracy from 210 gm up to 0.1 mg (A & D, Japan Made). The wheat yieldand yield gap% has been estimated by using the below formulae i.e.

$$\text{Tillers } (m^{-2}) = \frac{\text{Averageno. of tillers}}{\text{Area of the Quadrate}} \times 10000$$

$$\text{Yield } (tha^{-1}) = \frac{\text{Tillers } m^{-2} \text{ x grains per spike}}{10000} \times \text{wt. of 100 seeds(g)}$$

$$\text{Yield Gap (\%)} = \frac{\text{(Actual Yield - Estimated Yield)}}{\text{Actual Yield}} \times 100$$

Results & Discussion

Withthe aim of wheat yield estimation in the Karnal district of Haryana, wheat crop samples have been collected from the all 6 blocks of Karnal district i.e. Nissang, Assandh, Gharaunda, Indri, Nilokheri, and Karnal while opting multistage random sampling. The yield comparison has been done in between the estimated wheat yield (after lab analysis) and actual yield has been obtained by the farmer. The results found are quite impressive. Although the estimated yield has been found overestimated (Table 1) in all the 11 sampling sites in the study district but it is observed that this technique can minimize the sample size up to very few tillers/acre. Yield components have been chosen (table1 and 2) to

estimate the final yield of wheat i.e. tillers per Quadrate size (30 cm x 30 cm), Seeds per average spike, theweight of 100 seeds etc. The total 558 total tillers (theaverage count is 51 tillers per sample) were studied. The average tillers found in per quadrate area i.e. 30 cm x 30 cm of the field from all of 11 sample sites is 34 (375 tillers m^{-2}) whereas the average number of seeds is 40 (seeds m^{-2}14918, Table 1). The highest average number of tillers was found in Pingli village i.e. 46 (511m^{-2}) in the given size of quadrate whereas least is in Indri village 26 (i.e. 289 m^{-2}).The number of seeds/average spike has been found largest in Chaura Khlasa i.e. 46 seeds/Average spike and smallest in Pingli village i.e. 32 seeds/Average spike (Table 2). The weight of 100 seeds was found highest in Kalsaura village i.e. 4.5534 gm and lowest in Mardan Khera i.e. 2.9318 gm. Village Chaura Khalsa stands 1st in estimated and actual yield whereas village Chauchra stand last in the estimated as well as actual yield (Fig. 1).

During the sampling, the two samples have been taken from Barsat village and Arinpura village with biased intention just to check the impact of biased and unbiased sampling and results states that biasedness deviate the normal measurement up to 1.5 – 2 times (Table 1). The average sampling yield gap of all 11 samples is found 10.95% which is overestimated. The sampling efficiency (figure 5) is found in between 9-13 % in 6 samples, below 5% in 2 samples i.e. Pingli 2.09% and Mohri Jagir 3.88% (Fig. 2).The R2 valueis more than 5 that show that there is agood relationship in between the sampling done at difference sites in the district Karnal.

Conclusion

The study shows that quadrate sampling actually reduced the sample quantity(average 51 tillers/acre) without the possession of any strong skill. The actual yield magnitude ranges from 3.95 t ha^{-1} to 6.03 t ha^{-1} whereas estimated is from 4.46 t ha^{-1} to 6.62 t ha^{-1}. The obtained results through quadrate sampling are satisfactory with an average 10.95% increased yield than the actual yield confirmed by the farmers. The 8 out of 11 sampling measurement shows theleast deviation from the straight line,thoseare lying in between 9-13%(average 9.33%) of sampling yield gap. The sampling result shows statistical significance with **R^2 value .5338** that depicts a good correlation between sampling points. Although the overall wheat yield magnitude is found overestimated, but this can be reduced with sampling repetition. This study also observed the impact of biasedness which has increased the yield estimation by 2.5-3.5 times. In concluded view quadrate sampling is economic, simple, minimum skill oriented and laborious.

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Table no. 1: Wheat yield components and yield gap estimation

Counts	District Blocks	Sampling Village	Latitude (°)	Longitude (°)	Tillers /m²	Seeds/ m²	Weight of 100 seeds (gm)	Estimated yield (t/ha)	Actual field yield (t/ha)	SYG=AY-EY/AY *100
1	Nissang	Nisaang	29⁰ 42' 07"	76⁰ 44' 20"	433	15167	4.1936	6.36	5.43	-17.13
2		Pingli	29⁰ 39' 47"	76⁰ 55' 12"	511	16356	3.5859	5.87	5.75	-02.09
3	Assandh	MardanKhera	29⁰ 31' 52"	76⁰34' 26"	444	17778	2.9318	5.21	4.74	-09.92
4		Chauchra	29 38' 23"	76⁰ 37' 39"	322	14178	3.1488	4.46	3.95	-12.91
5		Padha	29⁰ 34' 52"	76⁰ 46' 19"	300	13200	3.6455	4.81	4.25	-13.18
6	Gharaunda	Barsat	29⁰ 30' 04"	77⁰ 02' 54"	378	15111	4.3731	6.61	4.94	-33.81
7		Arinpura	29⁰ 33' 25"	77⁰ 00' 43"	333	14000	3.8946	5.45	4.35	-25.29
8	Indri	Indri	29⁰ 53' 13"	77⁰ 03' 18"	289	12422	4.3970	5.46	4.94	-10.53
9		Kalsaura	29⁰ 51' 32"	77⁰ 08' 10"	367	13200	4.5534	6.01	5.43	-12.34
10	Nilokheri	MohriJagir	29⁰ 47' 13"	76⁰ 46' 05"	389	16333	3.7741	6.16	5.93	-03.88
11	Karnal	ChauraKhalsa	29⁰ 47' 06"	77⁰ 07' 34"	356	16356	4.0503	6.62	6.03	-09.78
12	Karnal District Average		29°25'05"-29°59'20"	76°27'40"-77°13'08"	**375**	**14918**	**3.8680**	**5.73**	**5.07**	**-10.95**

Note: - EY= estimated yield, AY=actual yield, SYG=Sampling Yield Gap

Table no. 2: Average tillers/quadrat and seeds/ average spike

Partic-ulars	Nissang	Pingli	MardanKhera	Chauchara	Padha	Barsat	Arinpura	Indri	Kalsaura	MohriJagir	ChauraKhalsa	Karnal average
Average Tillers/Quadrat	39	46	40	29	27	34	30	26	33	35	32	34
Seeds/Avr. spike	35	32	40	44	44	40	42	43	36	42	46	40

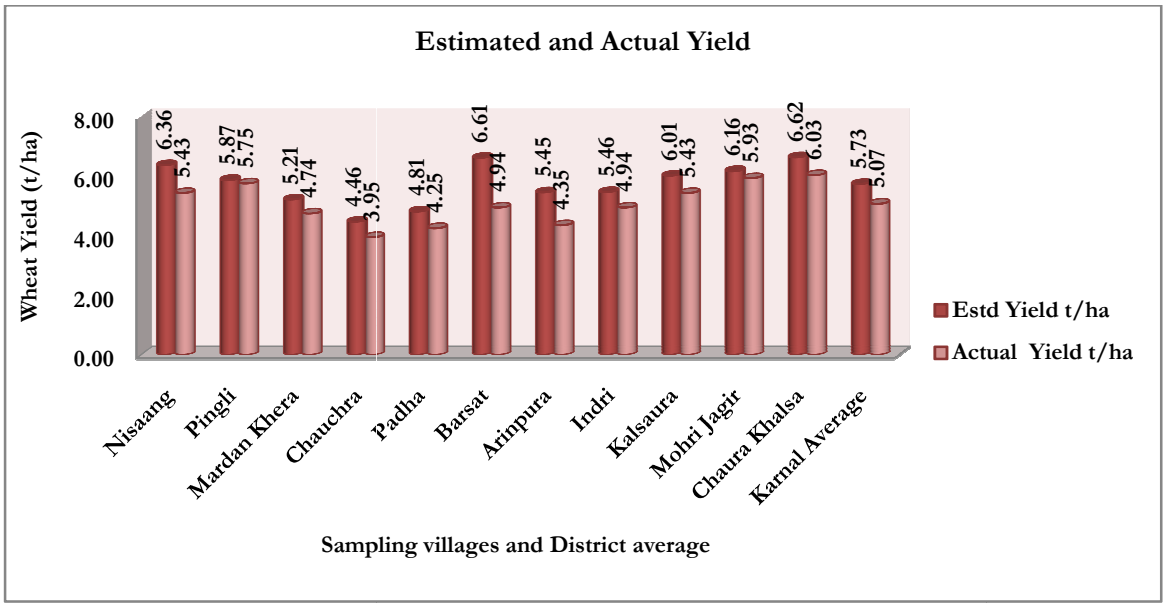

Fig. 1: Comparison of estimated yields with the actual yields of the sampling sites in district Karnal

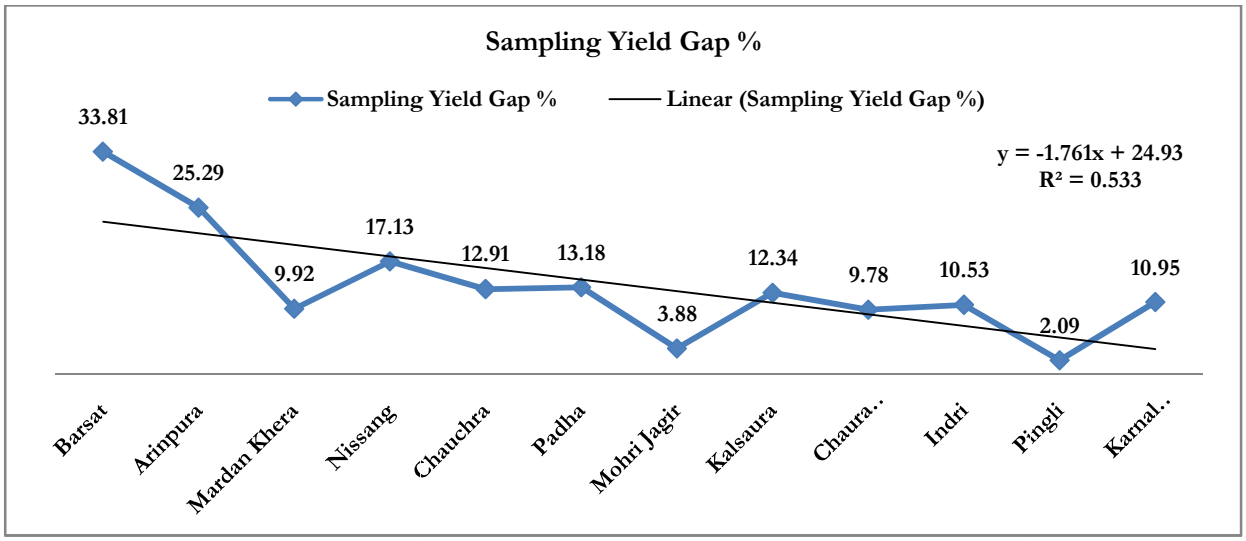

Fig. 2: Sampling yield gap % and sampling efficiency of the district Karnal