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Soybean and wheat crop yield forecasting based on statistical model in Malwa agroclimatic zone

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Abstract
Pre harvest crop yield forecast is required for storage, pricing, marketing, import, export etc. weather is the main factor which affects crop yield. Variability in weather causes the losses in the yield. Use of weather can be done for crop production forecast. Weather plays important role in crop growth. Therefore model based on weather parameters can be provide reliable forecast in advance for crop yield. In this study, the focus was on the development of crop yield forecast model through stepwise regression technique using weather variables and historic crop yield. The model uses, maximum and minimum temperature, rainfall, relative humidity and relative humidity II during crop growing period and long term yield data of soybean and wheat crop. Yield prediction was carried out for soybean and wheat in 8 districts of Malwa agro climatic zone during 2017-18. Accuracy of these models are tested with coefficient of determination (R^2).

Keywords: Soybean, wheat, forecast crop yield, stepwise regression

Introduction
India has a huge arable land area of 159.7 million hectares (394.6 million acres) standing second in the world after the United States. The agricultural history of India over the past four decades has been quite impressive and successive with a gross irrigated crop area of 82.6 million hectares (215.6 million acres). Agriculture has played major role in improving the Indian economy and will continue to be the same in the future *(Abrol, 2002)*. As of 2012, India has huge and various agricultural sectors, accounting, on average, for about 28% of GDP and 10% of export earnings and providing employment up to 60% of the total population. Innovation of new varieties and techniques in agricultural crops are increasing the productivity which in turn helped in improving the feeding capacity of the society. This dramatic productivity increase happened in 70s and 80s which is called as the “Green Revolution” era. India has second rank in agricultural productivity among the world countries and also has first rank in fisheries, fibrous crops, vegetables, major spices and fruits productivity. As per the statement of Food and Agricultural Organization (FAO), India is World’s second largest producer of wheat, rice and major food staples and also ranked within five largest producers in cash crops like coffee and cotton in the world.

Crop acreage estimation and crop yield forecasting are the two components which are crucial for proper planning and policy making in the agriculture sector of the country. Regional level estimations of crop yield are the basis for planning crop production prospects at national level. Madhya Pradesh occupies an outstanding position in India with respect to soybean and wheat production. It leads the country in soybean production ranking first position and contributes about 50 per cent of the total production of the country. Madhya Pradesh is also known as soybean state of India. In post rainy season wheat is the major crop grown after soybean and soybean-wheat is one of the major cropping sequences of the state. The state is self-sufficient in food production and good weather conditions, produces exportable surplus. Production estimations of these major crops in advance are essential for state level planning.

In Madhya Pradesh, soybean and wheat are the major crops and grown in a large area of the state. Variation in weather parameters is attributed to year to year variation in production. This emphasized the need for advance estimation of crop production for major crops which will ultimately enable planners and decision makers to predict how much to import in case of shortfall or optionally to export in case of surplus. It also enables government to put in place, strategic contingency plans for redistribution of food during times of famine.

Therefore, monitoring of crop development and crop growth and early prediction are generally important. In India, there is also growing need for micro level planning and particularly the demand for crop insurance, which leads to the need for field level yield estimation.

Material and Method

The AMFU- Indore centre is located in central highlands (*Malwa*) Gujarat Plain Kathiawar peninsula semi-arid eco-region (*AESR 5.1*). It represents *Malwa* region of Madhya Pradesh which is situated at $76^0 54'$ E longitudes and 20^0 43' N latitudes at an altitudes of 567 m above MSL. Districts included are Indore, Ujjain, Dewas, Shajapur, Ratlam, Neemuch and Mandsour (Table1) eight districts were selected for developing district wise crops yield forecasting equations for soybean and wheat crops. The daily weather data of the past 30 years (1989-2017) of maximum & minimum temperature (°C), relative humidity (%) morning and afternoon and rainfall (mm) were collected from Meteorological center IMD-Bhopal and the College of Agriculture, Indore (M.P.).

Table 1: Geographical location of districts

Place	Longitude	Latitude	Altitude
Indore	75.8577° E	22.7196° N	553m
Dewas	76.0508° E	22.9623° N	535m
Ujjain	75.7849° E	23.1793° N	494m
Shajapur	76.2730° E	23.4273° N	443m
Neemuch	74.8624° E	24.4764° N	452m
Ratlam	75.0376° E	23.3342° N	480m
Mandsaur	75.0693° E	24.0768° N	440m
Rajgarh	76.7337° E	23.8509° N	491m

The yield data of soybean and wheat for the period of year 1991-2016 were collect from Commissioner, Land Records, Gwalior (M.P.). Weather indices were generated using weekly cumulative value for rainfall and weekly average value of the other weather parameters as suggested by Ghosh *et al*. (2014). After this the weekly data for all the weather variables selected weeks from sowing to post flowering (44^{th}-12^{th} standard meteorological weeks for wheat; weeks for soybean) were used for developing models with crop yield data.

The yield forecast model were developed based on modified Hendricks and Scholl model (Agrawal *et al*. 1986) [1] using composite weather indices (Ghosh *et al*. 2014). The model finally recommended was of the form

$$Y = A_o + \sum_{i=1}^{p}\sum_{j=0}^{1} a_{ij} Z_{ij} + \sum_{i\neq i'}^{p}\sum_{j=0}^{1} a_{ij'j} Z_{ii'j} + cT + e$$

Where,

$$Z = \sum_{w=1}^{m} r_{iw}^{j} X_{iw}$$

$$Z = \sum_{w=1}^{m} r_{iw}^{j} X_{iw} X_{i'w}$$

r_{iw} = is correlation coefficient of yield with i^{th} weather variables (x) in w^{th} period.

r_{iiw} = is correlation coefficient of yield with product of i^{th} and i^{th} weather variables (x) in W^{th} period.

m = is period of forecast

p = is number of weather variables used

e= is random error distributed as N (O, σ^2)

T= is technology factor

For each weather variables, two variables were generated-one as simple accumulation of weather variable and the other one as weighted accumulation of weekly data on weather variables, weights being the correlation coefficients of weather variables, in respective weeks with yield. Similarly, for joint effect of weather variables, weekly interaction variables were generated using weekly products of weather variables were generated using weekly products of weather variables taking two at a time. Step wise regression was used to select significant generated variable Z_{ij} and Z_{iiJ} (Table. 2). Model performance was evaluated by calculating the different statistical parameters viz. standard error (SE), correlation coefficient etc.

Table 2: Weather indices used in models using composite weather variables

	Simple weather variables					Weighted weather variables				
	T_{max}	T_{min}	RF	RH_1	RH_{11}	T_{max}	T_{min}	RF	RH_1	RH_{11}
T_{max}	Z10					Z11				
T_{min}	Z120	Z20				Z121	Z21			
RF	Z130	Z230	Z30			Z131	Z231	Z31		
RH_1	Z140	Z240	Z340	Z40		Z141	Z241	Z341	Z41	
RH_{11}	Z150	Z250	Z350	Z450	Z50	Z151	Z251	Z351	Z451	Z51

Result and Discussion

Soybean Crop

The forecast model developed for soybean crop at pre-harvest stage had R^2 values in a range of 0.03 to 0.75 (Table 3). It was less for Rajgarh, Dewas, Ratlam, Shajapur and Indore districts, where crop management practices apart from rainfall and weather parameters also play a role in soybean production. The standard error of % between predicted and reported yield for years 2015 was positive in Neemuch and Rajgarh district. As model is purely weather based, excess rainfall in 2015 followed by low rainfall in 2016 along with more dry weeks situation that could be the reason for yield variation, as similar findings was also observed by Rajegowda *et al*. (2014). And Giri *et al*. (2017) [4].

Table 3: District wise soybean yield (kg/ha) Forecast model of Mawa Agroclimatic zone

S. No	District	Equation	Weather Parameters in the equation	R^2	F	Std. Error	Forecast Yield (2017-18) (kg/ha)	Actual yield		Forecast yield		% of error	
								2015	2016	2015	2016	2015	2016
1	Indore	=1105.45 + (0.731 X Z131)	Z131 = Tmax X RF	0.34	12.68	192.30	1083	763	1056	1106	1108	-4.28	-31.14
2	Dewas	=1328.53 + (-18.46 X Time)	Time	0.15	3.00	251.21	959	521	675	996	978	-321	-457
3	Mandsaur	= 3602.11 + (-8.147 X Z20)	Z20= T min	0.54	7.42	312.85	610	790	722	723	610	-45.01	-0.12
4	Neemuch	=1348.93 + (Z151 X 0.257) + (Z41 X 2.56) + (17.55 X Time) + (0.062 X Z120)	Time Z151 = T max X RH1 Z41 = RH1 Z120 = T max X T min	0.75	16.11	163.49	806	812	625	803	693	1	-10
5	Rajgarh	=772.82 + (6.50 X Time)	Time	0.03	0.72	292.86	948	509	1352	935	942	417	-433
6	Ratlam	= (-3126.97) + (Z40 X 3.449)	Z40= RH1	0.23	5.05	229.77	1390	881	894	1221	1218	-27.87	-26.63
7	Shajapur	= 4159.78 + (Z120 X -0.178) + (Z51 X 6.893)	Z120 = T max X T min Z151 = T max X RHII	0.31	5.08	202.25	1363	779	659	1152	987	-32.41	-33.23
8	Ujjian	= 1629.91 + (Z251 X 0.393)	Z251=T min X RHII	0.21	6.72	288.23	838	692	714	903	898	-23.34	-20.52

Table 4: District wise wheat yield (kg/ha) Forecast model of Mawa Agroclimatic zone

S. No.	District	Equation	Weather Parameters in the equation	R^2	F	Sted. Error	Forecast Yield (2017-18) (kg./ha.)	Actual Yield		Forecast yield		Standard Error (%)	
								2015	2016	2015	2016	2015	2016
1.	Indore	=14961.59 + (109.01 X Z11) + (-0.439 X Z350)	Z11= Tmax	0.48	12.35	645.28	2672	4016	4425	2901	3116	38.46	42.02
2.	Dewas	=9603.982 + (72.589 X Z21) + (-10.872 X Z10) + (0.289 X Z341)	Z21= T min Z10= T max Z341= RF X RHI	0.73	16.74	314.49	3248	3340	4096	3102	3828	8	7
3.	Mandsaur	=9425.62 + (67.03 X Z11)	Z11= T max	0.48	15.49	521.68	3621	3742	3269	4160	3596	-10	-9.08
4.	Neemuch	=1547.804 + (79.056 X Time)+ (40.343 X Z11)	Time , Z11= Tmax	0.53	15.21	612.36	4154	4016	4425	4031	4011	0.12	9
5.	Rajgarh	= 7529.15 + (-6.58 X Z10) + (24.84 X Time) + (0.802 X Z141) + (0.165 X Z140)	Z10 = T max, Time, Z141 = T max X RHI, Z140 = T max X RHI	0.72	15.60	269.05	2233	3162	2541	2631	2105	20	21
6.	Ratlam	= 5049.75 + (188.83 X Z11) + (18.45 X Time)	Z11= T max, Time	0.64	23.41	320.0	2585	2882	3399	2987	3203	-3.5	6.1
7.	Shajapur	= (-52.10) + (11.51 X Z41) + (0.89 X Z50)	Z41= RHI Z50= RHII	0.38	8.25	347.54	2927	3396	3020	2879	2832	17.97	6.63
8.	Ujjain	=12342.119 + (44.419 X Z10) + (44.419 X Z10) + (58.62 X Time) + (180.98 X Z11)	Time, Z10= Tmax Z11= Tmax	0.65	15.70	379.50	3205	3084	3509	3011	3119	2	12

The districts wise maximum soybean crop yield forecast year 2017-18, in Ratlam will be 1390 (kg/ha) with R^2 (0.23) followed by Shajapur 1363 (kg/ha) & R^2 (0.31) and minimum forecast yield will be in Mandsaur 610 (kg./ha) & R^2 (0.54).

Wheat Crop

The forecast model equations developed for wheat crop at pre-harvest stage had R^2 in range of 0.38 to 0.73 at different locations (Table 4.). Some districts with R^2 value suggested other factors like crop management practices, varital potential, or soil types that may influence practices, yield beside weather parameters. The standard error % between predicted and reported yield for year 2015 and 2016 (Table4.) was positive in Indore, Dewas, Neemuch, Rajgarh, Sharjapur and Ujjain and, for negative in Mandsaur district in both the years while it was negative in one year and postive in other year in distict Ratlam. Overall, the deviation was less than 15 per cent in both the years. These deviations with different trends may be due to the presence of climatic aberrations like heat wave at grain formation stage, unseasonal rains by mid-March or hailstorm that may influence reported yield. Adverse impact of temperature on wheat yield was reported by Lobell *et al.* (2012), Giri *et al.* (2017) [4]. This condition may be prevalent in western M.P. due to sowing of late-maturing soybean varieties during Kharif season, which delay sowing time of wheat and it matures by the end of March there by coincide with high temperature phase.

The districts wise maximum wheat crop yield forecast, in Neemuch will be 4154 (kg/ha) with R^2 (0.53) year 2017-18, standard error of per cent year 2015 (0.12%) and 2016 (9%) while minimum forecast yield will be in Rajgarh 2233 (kg. /ha) with R^2 (0.72) & standard error of per cent year 2015 (20%) and 2016 (21%).

Conclusion

The districts wise maximum soybean crop yield forecast year 2017-18, in Ratlam will be 1390 (kg/ha) with R^2 (0.23) followed by Shajapur 1363 (kg/ha) & R^2 (0.31) and minimum forecast yield will be in Mandsaur 610 (kg./ha) & R^2 (0.54). The districts wise maximum wheat crop yield forecast, in Neemuch will be 4154 (kg/ha) with R^2 (0.53) year 2017-18, standard error of per cent year 2015 (0.12%) and 2016 (9%) while minimum forecast yield will be in Rajgarh 2233 (kg. /ha) with R^2 (0.72) & standard error of per cent year 2015 (20%) and 2016 (21%).

Reference

1. Agrawal R, Jain RC, Jha MP. Models for studying rice crop-weather relationship. Mausam. 1986; 37(1):67-70.
2. Baweja PK. Predicting grain yield in maize: canopy temperature based regression indices. J Agrometeorol. 2002; 4(2):177-179.
3. Diwan UK, Puranik HV, Das GK, Chaudhary JL. Yield prediction of wheat at pre-harvest stage using regression based statistical model for 8 district of Chhattisgarh, India. Int. J Curr. Microbiol. App. Sci. 2018; 7(1):2180-2183.
4. Giri AK, Bhan M, Agrawal KK. District wise wheat and rice yield prediction using meterolgical variables in eastern Madhya Pradesh. J of Agrometerology. 2017; 19(4):367-369.
5. Gill KK, Sandhu SS, Kaur Prabhjyot, Babuta Ritu, Bhatt Kavita. Wheat yield prediction using weather based statistical model in central Punjab. Journal of Agricultural Physic. 2015; 15(2):157-162.
6. Gupta Smita, Singh Ajit, Kumar Ashok, Shahi UP, Sinhga Nishant K, Roy Sumana. Yield forecasting of wheat and mustard for western Uttar Pradesh using statistical model. J of Agrometerology. 2015; 20(1):66-68.
7. Singh KK. Crop yield forecasting using Agromet model: Indian experience India Meterlogical Deparmtne, New Delhi, India. MNCFC, India (PPT).
8. Singh Manmohan. Sharma Sangita Forecasting the maize yield in Himacha Pradesh using climatic variables. J of Agrometerology. 2017; 19(2):167-169.
9. Pandey KK, Rai VN, Sisodia BVS, Bhart AK, Gairola KC. Pre-Harvest forecast models base on weather variables and weather indices for Eastern U.P. Advances in Bioresearch. 2013; 4(2):118-122.