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Wheat Yield Prediction through Agro Meteorological Indices for Ardebil District

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***Abstract*—**Wheat prediction was carried out using different meteorological variables together with agro meteorological indices in Ardebil district for the years 2004-2005 & 2005—2006. On the basis of correlation coefficients, standard error of estimate as well as relative deviation of predicted yield from actual yield using different statistical models, the best subset of agro meteorological indices were selected including daily minimum temperature (Tmin), accumulated difference of maximum & minimum temperatures (TD), growing degree days (GDD), accumulated water vapor pressure deficit (VPD), sunshine hours (SH) & potential evapotranspiration (PET). Yield prediction was done two months in advance before harvesting time which was coincide with commencement of reproductive stage of wheat (5th of June). It revealed that in the final statistical models, 83% of wheat yield variability was accounted for variation in above agro meteorological indices.

***Keywords*—**Wheat yields prediction, agro meteorological indices, statistical models.

I. INTRODUCTION

THE prediction of product yield in every region in order to planning &policy making future for food providing distribution, pricing and also its import and export is so important since product yield is as result of different processes interaction in plant and these processes are influenced by weather factors, and studying their relationship and product yield are necessary to product-climate models extraction.

Product climate analyzing are practical instruments to analyze plant reaction analyzing models are practical instruments analyze plant reaction to climate changes. Common statistical processes based on regression relations are used to evaluate coefficients which relate plant reactions to climate indices [1].

Ball., through multiple regression using climate parameters as independent variables of statistical model in Punjab India in 2004, indicated that 69% wheat yield changes is as are cult of changes' in daily minimum temperature and growing degree-days'. Badger teal [2] indicated that there is most correlation between wheat yield and minimum and maximum temperature, accumulated hello thermal unit, accumulated difference in daily minimum & maximum temperature and evaporation amount rising from basin in hoshgarpoure roopenger towns located in Punjab, India. In this study, we want to establish a correlation relation between meteorological parameters and Agro meteorological indices and wheat yield in last years at the other hands, to predict above product yield for future years.

II. METHODOLOGY

In order to extract statistical models of wheat yield prediction, 19 years (from 1984-1985to 2002-2003) statistic of wheat yield cultivated by dry farming in Ardebil prepared by agricultural organization – were used.

Wheat growth season was divided in phonological stages, from October 30th (planting time) to July 29th (the harvest). These stages are involved: initial growth stage (from October 30th to December 5th), first stage of growth before sleep (from December 6 to January 17th), sleep period (from January 12th to march 15), and second stage of growth after sleep period (from march 16th to may 27th), generating growth stage (from May 28 to June 28) and physiological growth (from June 29 to July 29) to obtain final model of product yield prediction. Statistical analysis was done for 6 stages and at last one of stages was chosen as yield production time statistical information which was chosen and used for chosen climate period, as obtained from Ardebil meteorological station. Homogeneity statically tests and statistical a degree was done using existed date.

To choose final meteorological parameters and agro meteorological indices as independent variables of regression statistical models, different statistical methods were used. Linear simple regression linear multiple regression stair to stair methods were used date & results of these methods in every phonologic stage haven't been represented because of brevity. According to simple (r)[1] and multiple (R)[2] correlation coefficients meaning …. Test 1% and 5% levels , standard error of estimate (SEOS)[3] and relative deviation (RD)[4] of estimated date in different regression models, best group am any meteorological parameters and agro meteorological indices were considered as independent variables of final

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[1] Simple linear Correlation Coefficient
[2] Multiple linear Correlation Coefficient
[3] Standard Error of Estimate
[4] Relative Deviation

models for wheat yield prediction through dry farming in Ardebil meteorological parameters.

III. Methodological Parameters

Meteorological daily data obtained from Ardebil station with north $38°15'$ east $48°43'$ and 1335 meter height above sea level form 19833-1984 to 2005-2006, were used. Meteorological parameters including maximum temperature (Tmax), minimum temperature (Tmin), daily rain (p), evaporation from basin (E) and sun hours (SH) were used in statistical analysis. In this section, used indices and their calculation quality will be revered.

A. Agro Meteorological Indices Growing Degree Days (GDD)[5]

Temperature unit or growing degree days are used to express the relationship between period of every phonological; stage and temperature degree. In this definition, it is assumed that there is liner relation between growth and temperature [3]. In a research in Punjab, India, it was indicted that growing degree days can be used as best indices to predict different stages of wheat phenology [4] one growing degree days or one temperature unit means average daily temperature higher than basic temperature, which can be calculate mathematically, follow as:

$$GDD = \sum_a^b \{[\frac{T_{\max} + T_{\min}}{2}] + T_b\} \quad (1)$$

Which in: GDD=growing degree day (^oCday)

$T_{\max}$ & $T_{\min}$ = Daily maximum & minimum temperature (^oC)

T_a = Beginning time of phonological stage

b = End time of phonological stage

T_b = Basic phonological stage ^oC

If must be mentioned basic temperature is lowest temperature which there is no growth in temperature lower than basic. In this study for calculating GDD .basic temperature that is 5 ^oC for different growth stays was considered, if daily average temperature was equal to or lower than basic temperature, GDD=0 would considered [5]-[6]. Daily maximum and minimum temperature difference (TD) accumulated daily maximum and minimum temperature difference (T), in regression equation which is calculated:

$$TD = \sum_a^b (T_{\max} - T_{\min}) \quad (2)$$

B. (PTU)[6] *Photo Thermal Units and (HTU)*[7] *Helio Thermal Units*

Since phonological changes are as a result be used to predict exactly maturation and (flowering stage [7]. in general ,PTU means GDD multiplied by sun hours which is potentially influenced by region geographical width (N) and HTU means GDD multiplied by real or actual sun hours(n). so PTU&HTU are calculated follow as:

$$HTU = \sum_a^b (GDD \times n) \quad (3)$$

$$PTU = \sum_a^b (GDD \times N) \quad (4)$$

Which in:

PTU= accumulated photo thermal units (day hours ^oC)

GDD= growing degree day (day ^oC)

N= Maximum (potential) possible sunshine, a function of region geographical width

a=Beginning of phonological stage

n= real sun hours (actual)

b= End time of phonological stage

IV. Vapor Pressure Deficit (VPD)[8]

Vapor pressure deficit has a main role in plant evaporation and transpiration. In fixed temperature; atmosphere moisture changes have an affection plant evapotranspiration through in flunking real vapor pressure (ea) and Vapor pressure graclient from leaf toward air [8]-[9]. The difference between sat rated Vapor pressure (es) and its real amount was considered as vapor pressure deficit which is calculated by these equations:

$$e_a = (KH_{mean} \times e_s)/100 \quad (5)$$

$$VPD = e_s - e_a \quad (6)$$

RH_{mean} = mean relative humidity

e_a = real vapor pressure (military)

e_s = started vapor pressure as function of average temperature

V. Potential Vapor Transpiration (PET)[9]

Bayer and Robertson [10] indicted that in comparison with meteorological variables like rain or temperature, product yield has a more correlation with physical parameters in environment like potential evapotrans piration and soil moisture .crop wat software (window 412 model) which had been introduced by clerk teal [11] in 1998, was used to calculate plant evapotranspiration during different growth stages cropwat is a program which in reformed method of panman-mantice is used to calculate the plant evapotranspiration. This method is or alternative to dorenbos and perowt [12] method (FAo irrigation and drainage, vol:24) which in minimum and maximum temperature average relative hum… , sunshine and wind speed in 2m height were used as input to program.

[5] Growing Degree Days

[6] Photo thermal Units

[7] Hello thermal Units

[8] Vapour pressure Deficit

[9] Potential Evapotranspiration

Relative deviation estimation (RD)[10]

In order to estimate yield error estimated by different statistical models, Relative deviation (RD) from its real yield for 2004-2005 and 2005-2006 was calculated, too;

$$RD = \frac{\text{estimate yield by model - real yield}}{\text{real yeild}} \times 100 \quad (7)$$

VI. Discussion and Conclusions

So best time to predict yield were beginning of generation period that is May 27 (two months before harvest) and–using meteorological data) second stage of growth after sleep period (Esfand 26 to khordad 6) best meteorological parameters and agro meteorological indices which were used for independent variables of final model, were: daily min temperature (Tmin), accumulated difference between (GDD), accumulated vapour pressure deficit (VPD), sunshine's (SH) and potential vapor transpiration (PET). Final regression equation to predict wheat yield through dry farming (y) follow as:

$$R = 7140.665 - 985.988 T_{\min} - 7.034 TD + 14.929 GDD + 1.251 VPD - 429.499 SH + 172.858 PET$$

R=0.909 $R^2 = 0.826$ $F = 7.45^{**}$
SEOE=114.73kg/ha $n = 19$

(Above two stars indicate meaning full equation in 1 % level) it is seen that 83% product yield changes are a result of changes in independent variables of above regression equation. that is 83% product yield changes during growth period is because of changes in daily min temperature ,accumulated difference in min &max temperatures ,growing degree days, vapor pressure deficit, sunshine and potential vapor transpiration during second growth stage (after sleep period) above equation is meaning full in 1% level and it's standard error in each hectares equal to 115 kg. It must be mentioned that after testing above statistical modeled results from others statistical models, we decided to choose it as final model for yield prediction that model evaluation (test) will be discussed later regarding obtained result and coefficient of every equation independent variable, it is observed that there is a negative correlation between daily minimum temperature (Tmin) and yield and probably because higher minimum temperature cause to respiration speed and a reduction in photosynthesis and materials transmission from leaf to seed, consequently, reduction in yield [13]-[14]. There is a positive correlation between growing degree days and yield that indicates that how much growing degree days and yield that indicates that how much growing degree days is more growth period will be longer, so there will be more opportunity for filling seed and increase in yield [4]. Agro meteorological indices VPD and PET have a positive linear with yield because VPD is increased and consequently PET is increased during days, so openings (stoma) will be closed (in order to plant escape from water stress) and vapor transpiration will be limited so that water consuming will be increased (WUE) and yield will be increased, too [15]-[16].

Regarding obtained results, it can be said that 83% product yield change can be due to changes in independent variables of equation that is Tmin, TD, GDD, VPD, SH, PET. In order to test model and compare estimated yield by model for 1383-84 and 1384-85 9these years weren't involved in regression calculation to excavate yield prediction model) with real amount, independent variables are placed in regression equation, and a product estimated yield by model is obtained and using (7) equation relative deviation of model is calculated (Table I)

TABLE I
Evaluation of Wheat Yield by Regression Model of 2004-2005 and 2005-2006

	2005-2004	2006-2005
(kg/ha) real yield	1120	522
(kg/ha) estimated yield	622	489
(%) RD	-44	-6

As it is observed wheat estimated yield by statistical model for both years is lower than real amount, however estimated amount in 2005-2006 is near to real yield (6% devotion) in compression with 2004-2005 (44% deviation). Regarding real yield in 2004-2005 (1120 kg/ha) and it's comparison average long term wheat yield through dry farming (69 kg/ha) during 1362-63 to 2005-2006, it can be concluded that 2004-2005 hasn't been a normal year and above statistical model isn't able to predict wheat yield in years which in climate condition caused extremely high and low yield, plant behavior in climate condition during growth stage, isn't always some and this behavior is different in different ranges of climate variables [17].

In this study, it can be concluded that when in flauntier climate parameters and obtained Agro meteorological indices are composed in statistical model, wheat yield prediction (before harvest)

[10] Relative Deviation

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