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Forecasting of Days of Maturity Based on Growing Degree Days in Fingure Millet

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Abstract

Weather effects on crop yields are manifold, making their assessment challenging. Information on the extent to which crop stages particularly sensitive stages are affected by specific extreme weather events is important information for the prevention of weather driven losses. The growing degree days based forecasting of maturity days will act as good tool to control such losses in support of linking agronomic field decisions and effective use of the temporal and spatial weather prediction. In the present finger millet study, good relationship was found between accumulated growing degree days and maturity days in both Phule Nachani and KOPN 942 cultivars. In agriculture business, the duration from planting to maturity is important for properly timing and scheduling management practices. In this study the accumulated GDD has found significant role in forecasting of maturity days whichwill be helpful for farmers in the execution of farm decision, marketing the produce and ultimately reduce the risk.

Key words : Finger millet, Growing Degree Days, Maturity days , Forecasting.

Finger millet (*Eleusine coracana* L.) is an important food crop next to rice, wheat and maize, valued as a staple food. India produced 1.44 Mt of finger millet from 1.19 M ha with an average productivity of 1210 kg ha^{-1} (Anonymous, 2014).

In India it has the pride place of having highest productivity among millets. The optimum sowing time and selection of improved cultivars play are markable role in exploiting the yield potential of the crop under particular agro climatic condition. It governs the crop phonological development and the efficient conversion of biomass into economic yield. Delay in sowing caused early maturity resulting drastic reduction in yield as compare to normal sowing which has a longer growth duration which consequently provides an opportunity to accumulate more biomass. Growing of suitable varieties at an appropriate time is an essential for ensuring optimum crop productivity.

Temperature is an important environmental factor influencing the growth and development of crop plants. It influences the crop phenology and yield of crop (Bishnoi *et al*., 1995). Plants have a definite temperature requirement to attain phenological stages. Hence, it becomes imperative to have knowledge of the exact duration of phonological stages especially maturity stages in a particular crop-growing environment. The Growing Degree Day (G.D.D.), is a heat index that can be used to predict when a crop will reach maturity. The Growing Degree Days calculation allows producers to predict the plants pace toward maturity. Daily growing degree day values are added together from the beginning of the season, providing an indication of the energy available for plant growth. Growing degree day totals are used for comparing the progress of a growing season to the long-term average and are useful for estimating crop development stages and maturity dates. Therefore in order to predict the date of maturity, present study has been taken.

Materials and Methods

The actual study area was located in Kolhapur district of Maharashtra which geographically lies between 16.70 N latitude, and 74.24 E longitude. A field experiment was conducted during 2009 to 2017 at Zonal Agricultural Research Station, Shenda Park, Kolhapur. Finger millet Varieties named as KOPN 942 and Phule Nachani were selected for the present study. The agronomic information such as maturity period of these varieties was collected from the institute.

Growing Degree Days : The average of minimum and maximum daily temperatures is the most common in agricultural and phenological research (McMaster & Wilhelm 1997, Dwyer *et al*. 1999, Matzarakis et al. 2007, Fealy & Fealy 2008). Growth and development in plants and invertebrates is temperature dependent. At one extreme, development does not occur unless temperatures exceed a lower base temperature (TBASE) and at the other extreme, development ceases as temperatures exceed an upper threshold (TUPPER) (Trudgill *et al*. 2005). Growing degree days is a way of assigning a heat value to each day. The values are added together to estimate of the amount of seasonal growth of selected Okra varieties for this study. The weather data for Kolhapur district for the study period was collected from national Data Center (NDC) Pune. The base temperature (T_{base}) for finger millet was taken 13.0°C. The GDD was calculated daily basis and s accordingly season wise accumulated GDD was calculated for each variety using following formula.

Growing Degree-day accumulation = [(Max. Temp. + Mini. Temp.) / 2] - T^{base} ,

Where (T_{base} = Minimum threshold temperature)

Statistical Analysis : To examine the relationship between the Calculated GDD and Days Of Maturity Spearmen correlation analysis was conducted and further to calculate predict days of maturity, regression analysis was conducted where Days of Maturity act as dependent variable and calculated GDD was independent variable for both the cultivars.

Result and Discussion

In finger millet, plant development depends on temperature. Plants require a specific amount of heat to develop from one point in their life-cycle to another. The ability to predict a specific crop stage, relative to insect and weed cycles, permits better management.

Agronomic Charachterstics : The agronomic charachteristics such as maturity was found related to the Growing Degree days. In Table 1, Seasonal accumulated growing degree days, maturity of KOPN 942 and Phule Nachani is mentioned. For the KOPN 942 variety, the GDD range was between 1196 and 1388. The lowest GDD was observed during year 2014 whereas highest was in year 2013. In case of maturity date, this variety was found to be mature between 100 to 115 days. The early date of maturity was oberved during year 2010 and 2014 (100 days) and the late maturity date was oberved during the year 2013 (115 days).

Table 1. Seasonal accumulated Growing Degree Days and maturity Details of KOPN 942 and Phule Nachani

Variety	Year	2009	2010	2011	2012	2013	2014	2015	2016	2017
KOPN 942	GDD	1309	1270	1360	1371	1388	1196	1288	1267	1352
	Maturity	105	100	107	113	115	100	102	106	108
Phule Nachani	GDD	1691	1699	1807	1715	1539	1430	1606	1521	1543
	Maturity	134	133	136	132	132	127	130	128	130

In case of the Phule Nachani variety, the GDD range was between 1430 and 1807. The lowest GDD was observed during year 2014 and highest was in year 2011. In case of maturity date, this variety was found to be mature between 127 to 136 days in which the early date of maturity was oberved during year 2014 (127 days) where as late maturity date was oberved during the year 2011(136 days).

Estimation of days of maturity : Actual and estimated days of maturity of KOPN 942 was calculated (Table 2). The predicted days of maturity was calculated based on regression analysis. In case of predicted days of maturity, the minimum Percentage of error was found in year 2009 while highest was found in 2013.

In Table 3, actual and estimated days of maturity of Phule Nachani variety is mentioned. In case of predicted days of maturity, the minimum Percentage of error was found in year 2014 while highest was found in year 2012.

Forecasting days of maturity : For fingermillet cultivars, empirical model was developed for forecasting maturity days. Empirical model has shown good results with induvial cultivar. The Phule nachni cultivar has shown minimum stand error (1.166.) compared to the KOPN 942 cultivar (3.519). the actual and forecasted days of maturity of KOPN 942 was calculated (Table 4 and Fig. 1) and further predicted days of maturity was calculated based on regression analysis. In case of predicted days of maturity for KOPN942, the minimum Percentage of error was found in year 2017 while highest was found in 2016 whereas for Phule Nachani cultivar (Table 5 and Fig. 2), minimum Percentage of error was found in year 2017 while highest was found in year 2016.

Empirical model for forecasting of days of maturity : The GDD based studies has motivated many researchers found beneficial for the agronomic management and yield prediction (Srivastava 2005, Zajanc and Weber 2009, Oner Canavar and Mustafa Ali Kaynak 2010,

Table 2. Actual and estimated days of maturity and yield of KOPN 942

Year	Days of maturity for KOPN 942	Days of maturity estimated by Model	Accumulated GDD for KOPN 942	Error in number of days	Percentage of error for days of Maturity
2009	105	106	1309	1	1.34
2010	100	103	1270	3	3.31
2011	107	110	1360	3	3.22
2012	113	111	1371	-2	-1.49
2013	115	111	1368	-4	-3.41
2014	100	97	1196	-3	-2.56

Table 3. Actual and estimated days of maturity and yield of Phule Nachani

Year	Days of maturity phule Nachani	Estimated days of maturity	Accumulated GDD phule Nachani	Error in number of days	Percentage of error for days of Maturity
2009	134	133	1691	-1	-0.49
2010	133	133	1699	0	0.35
2011	136	135	1807	-1	-0.65
2012	132	134	1715	2	1.29
2013	132	131	1539	-1	-0.74
2014	129	129	1430	0	0.27

Table 4. Actual and Forecasted days of maturity and yield of KOPN 942

Year	Days of maturity for KOPN 942	Days of maturity Forecasted by Model for KOPN 942	Accumulated GDD for KOPN 942	Error in number of days	Percentage of error for days of Maturity
2015	102	105	1288	3	2.68
2016	106	103	1267	-3	-2.76
2017	108	110	1352	2	1.68

Table 5. Actual and estimated days of maturity and yield of Phule Nachani

Year	Days of maturity for phule Nachani	Days of maturity Forecasted by Model	Accumulated GDD for phule Nachani	Error in number of days	Percentage of error for days of Maturity
2015	130	132	1606	2	1.57
2016	128	131	1521	3	2.14
2017	130	131	1543	1	0.83

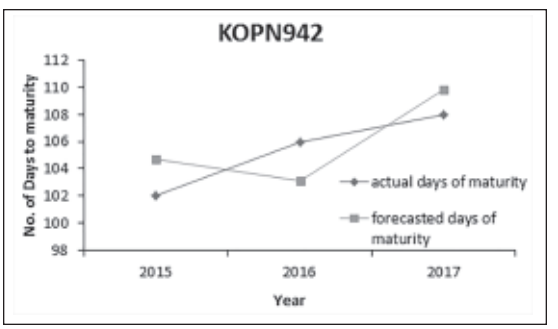

Fig. 1. Actual Days of maturity vs Days of maturity Forecasted by Model for KOPN942

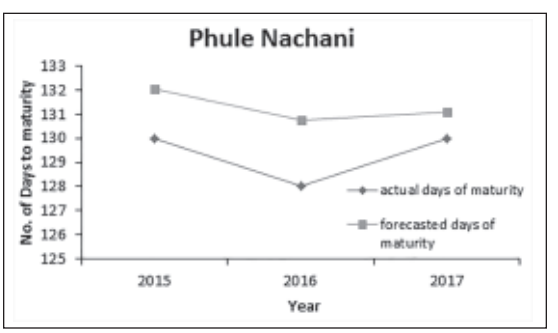

Fig. 2. Actual Days of maturity vs Days of maturity Forecasted by Model for Phule Nachani

Kara and Burhan 2011, Taruna *et al*. 2013, Aslam *et al*. 2017). In the present study, both KOPN 942 and Phule Nachani varieties, found that accumulated GDD has significant role in forecasting of maturity days and will be helpful for farmers for farm decision making, marketing the produce and ultimately reduce the risk. In India, majority of the farmers are not getting the expected crop yield due to several reasons. The agricultural yield is primarily depends on weather conditions. In this context, the farmers necessarily requires a timely advice to predict the future maturity dates and an analysis is to be made in order to help the farmers to maximize the crop production in their crops. Also it will be beneficial for farmers for better labour management and amount of farm produce introduce in the market based on market fluctuation which ultimately leads to increase in cost benefit ratio. Yield prediction is an important agricultural problem. Every farmer is interested in knowing, how much yield he is about expect and it is highly variable component which influenced by agronomic and environmental factors and accurate prediction of maturity days will be helpful farmers take weather based farm decisions.

Conclusion

The goal of the study is to forecast GDD based maturity days for finger millet varities so that farmers can take better farm decisions, marketing the produce and can prevent weather driven losses by linking agronomic practices with the regional temporal scale weather forecasting. During the experiment, both the cultivars has shown good relationship between accumulated growing degree days and maturity days. Maturity days was found increasing with increase in GDD. Further, In Both KOPN 942 and Phule Nachani cultivars, it was found that accumulated GDD has significant role in forecasting of maturity days using regression analysis. Forecasted maturity days given by both the models was found much closer to the actual dates which shown minimum standard error, therfore performance of both model was found acceptable for the forecasting of maturity dates. Further, in the more field trials and identification of significant other agronomic and weather parameters will improve reduce the error in prediction of Days of Maturity in the finger millet.

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