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A MATHEMATICAL MODEL FOR PREDICTING THE YIELD OF MAIZE UNDER MOISTURE DEFICIT

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ABSTRACT

Yield prediction of maize grown under different levels of moisture over a range of sowing times during summer and *kharif*, using a mathematical model was attempted. The growth stage model involving yield response ratio could predict the yield of maize with minimal prediction error indicating the suitability of the model for predicting maize yields under varied levels of moisture deficit through different phenophases.

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Yield prediction of crops using mathematical models has been the endeavour of crop scientists in recent years. Different models of varied complexities have been succesfully used for various crops. Suitability of a model for a given experimental data largely depends upon the parameters estimated during the conduct of the trial. Necessary alterations and refinements are however, necessary to fit the experimental data to an existing model. A growth stage model suggested by Stewart et al. (1976) for prediction of yield of grain crops has been chosen for the present study. An attempt is made to fit the data of trials conducted on maize and verify the suitability of the model for predicting yields of maize under varying levels of moisture supply.

MATERIALS AND METHODS

Field experiments were conducted during **kharif** and summer seasons of 1984 at Tamil Nadu Agricultural University, Coimbatore to study the influence of agromet factors and irrigation schedules through phenophases on maize crop. Investigations were carried out in a split-plot design replicated thrice with three irrgation schedules assigned to main plots and six sowing dates to sub-plots. The three irrigation schedules were adequate irrigation throughout the crop period (I_1) consisting of eight irrigations, mild stress(I_2)consisting of six irrigations and moderate stress (I_3)consisting of five irrigations and six times of sowing at fortnightly intervals (December 1 to February 16 during summer and June 1 to August 16 during **kharif.**

The data obtained on bio-mass production at various growth stages and at harvest was taken for fitting the model suggested by Stewart **et.al.** (1976). The model is:

$$Y_A = Y_M - Y_M \sum_{i=1}^{n} Kyi \left(\frac{ET_{Mi} - ET_{Ai}}{ET_M} \right)$$

where,

Y_A= predicted actual yield

Y_M= Maximum yield of the genotype in question in the particular environment assuming that no other management factor is limiting.

ETm= Seasonal total ET requirement

ETmi= ET requirement for the growth period i

ET_{Ai}= Actual ET during the growth period i

K_{yi} = Yield reduction ratio (yield reduction per unit ET deficit) for the growth period i

$$K_y = \frac{\left(1 - \frac{Ya}{Ymax}\right)}{\left(1 - \frac{ETa}{ETmax}\right)}$$

where,

ya = yield actual (kg ha^{-1})

Ymax = yield maximum (kg ha^{-1})

ETa = ET actual (mm)

ET max = ET maximum (mm)

The ET from the highest moisture regime has been considered as ET max and corresponding yield as Ymax. The ET from the other moisture regimes for comparison and corresponding yields were considered as ETa and Ya, respectively, for the treatments in question.

Table 1 : Yield prediction using Stewart's growth stage model.

Summer					
Treatments		Experimental yield	Predicted yield	Production error	
Sowing date	Irrigation schedule	(kg ha^{-1})	(kg ha^{-1})	(kg ha^{-1})	%
December 1	I_1*	6190	---	----	---
	I_2	5983	5827	156	-2.6
	I_3	5321	5220	101	-1.9
December 16	I_1*	5736	---	---	---
	I_2	5669	5720	51	+0.9
	I_3	4939	4835	104	-2.1
January 1	I_1*	5553	---	---	---
	I_2	5288	5457	169	+3.2
	I_3	4873	4644	229	-4.7
January 16	I_1*	5230	---	---	---
	I_2	4585	4384	201	-4.4
	I_3	3941	4090	149	+3.8
February 1	I_1*	4479	---	---	---
	I_2	3448	3272	176	-5.1
	I_3	2241	2138	103	-4.6
February 16	I_1*	3095	---	---	---
	I_2	2673	2039	166	+6.2
	I_3	1656	1589	67	-4.0

*ET max and Y max are from treatment I_1

Considering the growth stages chosen for the study in maize, the growth stage model assumes the following format.

$$Y_A = Y_M - Y_M \left\{ K_y(I)\left[\frac{ET_M(I) - ET_A(I)}{ET_M}\right] + K_y(GG)\left[\frac{ET_M(GG) - ET_A(GG)}{ET_M}\right] + K_y(F)\left[\frac{ET_M(F) - ET_A(F)}{ET_M}\right] + K_y(GD)\left[\frac{ET_M(GD) - ET_A(GD)}{ET_M}\right] \right.$$

where,

ET_M (I); ET_M (GG); ET_M (F) and ET_M (GD)= ET requirements during initial, grand growth, flowering and grain development stages, respectively.

Grain yield of maize was predicted using the model for all the sowing times in summer as well as **kharif.** Yield response ratios for the four growth stages were developed based on dry matter accumulation during the corresponding growth stages.

Table 2 : Yield prediction using Stewar's growth stage model

Treatments		Experimental yield	Predicted yield	Production error	
Sowing date	Irrigationschedule	(kg ha^{-1})	(kg ha^{-1})	(kg ha^{-1})	%
June 1	I_1	6290	---	---	---
	I_2	5467	5270	197	-3.6
	I_3	4403	4509	106	+2.4
June 16	I_1	5343	---	---	---
	I_2	4514	4730	216	+4.8
	I_3	3594	3709	115	+3.2
July 1	I_1	5491	---	---	---
	I_2	4644	4384	260	-5.6
	I_3	3881	4024	143	+3.7
July 16	I_1	5822	---	---	---
	I_2	5309	4985	324	-6.1
	I_3	4526	4653	127	+2.8
August 1	I_1	6324	---	---	---
	I_2	5826	5663	163	-2.8
	I_3	5095	5177	82	+1.6
August 16	I_1	6405	---	---	---
	I_2	5907	5990	83	+1.4
	I_3	5347	5411	64	+1.2

*ET max and Y are from treatment I_1

RESULTS AND DISCUSSION

The actual experimental yields obtained and yields predicted are presented in table 1 and 2 for summer and **kharif** seasons, respectively. Comparison of actual and predicted yields were made over entire range of six times of sowing in both the seasons tried. The predicted yields were very closely related to the actual yields in both the seasons of study. The prediction error over the entire range of sowing dates in both the seasons was very low (ranging from + 6.2 to - 4.7 per cent for summer crop and +4.8 to -6.1 per cent for the **kharif** crop) indicating the suitability of growth stage model for predicting the yields of maize with nearly perfect precision.

Extrapolation of the suitability of this model to other grain crops grown under identical moisture supply as that of the present study, however needs further cofirmation.

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