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# Crop weather model for sustainable groundnut production under dry land condition

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**ABSTRACT**

A crop weather model to predict the growth and pod yield of groundnut based on the dry matter accumulation at each growth stages has been developed. The multiple linear regression equations relating to GDD, SSH and AET with the accumulated dry matter production during each growth stage and also the final pod yield of kharif crop were generated by using the field experimental data for the period of 2000-2008. The coefficient of determinants indicate that the climatic parameters and the initial TDM used to estimate the final TDM in each stage and could be able to predict an extent of 77 to 98 per cent (coefficients of determinants) in different growth stages. Comparison of the observed and the predicted yields indicates the close agreement between them in all the stages. Considering the observed TDM up to the first four stages and predicted the Total Dry Matter at the harvesting stage. The model has been validated for the year 2009, and there is a good agreement between the observed and the predicted crop yield. The favorable influence of AET at the beginning of peg initiation and peg formation stage, and higher GDD during pod formation and harvest stages were noticed. The increase in AET during pod filling stage did not favor to the pod yield.

***Key words:*** SSH, AET, GDD, dry matter multiple linear regression**,** groundnut

Groundnut is one of the most important oil seed crop of India. In Karnataka it is annually grown in about 10.4 lakh hectares with a production of about 5.96 lakh tons. Karnataka ranks third in area with more than 13 per cent of its total area under groundnut crop, (Directorate of Economics and Statistics, 2006-07). Among oil seed crops groundnut stood the first place in India due to its diversified characters such as it can withstand drought and best suitable for dry land farming and soil erosion resistant crop. Being a legume crop, it can fix the atmospheric Nitrogen with the help of nodule bacteria and thereby improves the soil fertility. It provides the good green manure for the succeeding crop. Its shell, skin, haulm and hay are all good for fodder. Groundnut cake is one of the chief feed product and feed to animals and it also used as manures. The plant stalks are fed to cattle in the form of green, dried and silage. It is an important cash crop and is useful as a rotational crop. Moreover, groundnut is an excellent money earner and a chief source of protein. These attributes groundnut an attractive choice for marginal semi-arid lands.

With sufficient moisture availability periods, groundnut crop exhibits luxuriant growth with profuse flowering, while stress or competition for moisture due to population density, reduce its effective flowering diverting the bio-mass partitioning in to the underground stem nodules. On the contrary, if the main stem is affected for any reason by biotic or abiotic stresses followed by favorable weather and soil moisture conditions, it can compensate its growth through better development of gynophore. In spite of these favorable attributes, under rainfed condition the crop yield fluctuates widely from year to year depending on the duration of moisture stress at different stages of the crop.

Several attempts were made by scientists (Gregory, 1926; Victor *et al*.,1991a; Victor *et al*.,1991b; Mathan, 1996) to relate weather parameters with the crop yield. The forecast equations have been developed by Shanker and Guptha (1987) to predict the yield of paddy and similarly Muralidhara and Rajegowda (2002) to predict the grain yield in fingermillet. Of the several crop weather models, stocheometric model is one wherein influence of weather on the performance of the crop in each growth stage is considered. As reported information on growth models for groundnut crop is meager, here an attempt is made to develop a Stocheometric crop growth model for groundnut crop. The influence of actual evapotranspiration (AET), growing degree days (thermal unit i.e., GDD) and bright sunshine hours (SSH) prevailing during each stage of the crop and finally on the pod yield have been studied.

## MATERIALS AND METHODS

The field experiment was conducted during the period of 2000-2009 at GKVK Campus (Altitude 924 m amsl, longitude 77°34' and latitude 13°05') at Bengaluru, Karnataka .The groundnut was raised under rainfed condition during *khraif* season on red sandy loam soils with a soil depth of more than two meter following the recommended package of practices . Every year the crop rotation was followed by using the redgram crop after groundnut. The experiment was laid out in randomized complete block design with two dates of sowing on cultivar - JL-24 and it is replicated eight times The data on meteorological parameters from the adjacent agro meteorological observatory was used for the study. The GDD has been worked out using 10°C as base temperature during the crop growth period.

The daily GDD was calculated and summed up to a particular crop at different phenological stages. SSH was calculated from the data recorded in the agrometeorological observatory for different phenological stages of the crop growth

***Water balance***

The AET was computed by following the procedure suggested by FAO water balance method (Doorenbos and Pruit's 1977). Water holding capacity (WHC) of the soil is considered as 170 mm for every 100 cm depth of the soil and the permanent wilting point (PWP) as 1/3 of WHC at its field capacity. Therefore, it is estimated that only 69.3 mm of water would be available (AWC) for every 60 cm depth of the soil for the plant.

ET requirement (ETi) by the crop has been computed using the equation.

$$ET_i = Kc_i \text{ x } PET_i$$

Where, $ET_i$ = Evapotranspiration by the crop during $i^{th}$ day
Kci = Crop coefficient during $i^{th}$ day and
$PET_i$ = Potential Evapotranspiration during $i^{th}$ day

Actual Evapotranspiration ($AET_i$) by the crop depending upon the availability of moisture in the soil has been calculated using the procedure adopted by Frere and Popov (1979). Soil water storage (mm) at the end of $i^{th}$ day has been calculated following the FAO water balance method using the equation

$$S_i = S_{i-1} + P_i - AET_i$$

Where, $S_i$ = Water retained (mm) in the soil at the end of $i^{th}$ day
$S_{i-1}$ = Water available (mm) in the beginning of the $i^{th}$ day
$P_i$ = Precipitation (mm) during the $i^{th}$ day
And $AET_i$ = Actual amount of water available to crop during $i^{th}$ day

where

$AET_i = ET_i$, when $S_{i-1} > ET_i$ and
$AET_i < ET_i$, when $S_{i-1} < ET_i$ and
$AET_i = 0$, when $S_{i-1} = 0$

The phenological growth stage of the groundnut crop has been grouped into 5 stages.

1. 30 days after sowing
2. 50% flowering stage
3. Pod initiation stage
4. Pod filling stage and
5. Harvesting stage.

In the stocheometric crop weather model, it is necessary to consider the initial status of the crop to know the influence of weather parameter on further accumulation of the dry matter at different stages (gms/plant). Therefore, while generating the model for the prediction of dry matter at any particular stage, the initial bio-mass (Total Dry Matter-TDM) of the crop available for exposure to the environment has been considered as one of the independent parameter along with the GDD,SSH and AET to know the bio-mass accumulated at the end of each stage( Model is forced through origin to avoid constants). To know the influence of these important parameters on the growth of crop in each stage, the following types of multiple linear regression equations (noted below) considering parameters i.e., GDD, SSH and AET and the initial TDM as independent parameters and the total dry matter accumulated at the end of each stage as dependent parameter for all the stages have been generated.

$$T_1 = (A_1X_1+B_1Y_1+C_1Z_1)$$
$$T_2 = T_1S_2 + (A_2X_2+B_2Y_2+C_2Z_2)$$
$$T_3 = T_2S_3 + (A_3X_3+B_1Y_3+C_3Z_3)$$
$$T_4 = T_3S_4 + (A_4X_4+B_4Y_4+C_4Z_4)$$
$$T_5 = T_4S_5 + (A_5X_5+B_5Y_5+C_5Z_5)$$

Where,

Subscript indicates the respective stages,

$T_1 \ldots T_5$ are the accumulated bio-mass or Total Dry Matter at the end of respective stage

A, B and C are the coefficient of determinants of the variables X, Y and Z (GDD, SHH and AET), S is the coefficients of determinants of input accumulated bio-mass.

The pod yield as influenced by the accumulated bio-mass at the end of each stage is related in the equation of the type

$$Yg = IT_1(O) + JT_2(O) + KT_3(O) + LT_4(O) + MT_5(P)$$

Where, $T_1(O)$, $T_2(O)$, $T_3(O)$ and $T_4(O)$ are the observed total dry-matter at the end of first four stages and $T_5(P)$ is the predicted total dry-matter for $5^{th}$ stage. I, J, K, L, M and N are the coefficients. With the help of such equation the pod yield could be estimated well before the harvest of the crop.

**Table 1:** Coefficients of variable and coefficient of determination ($R^2$) of fitted equations for different stages

| Stages of crops | Initial TDM | GDD | SSH | AET | $R^2$ |
|---|---|---|---|---|---|
| 30 DAS | | 0.0065 | 0.0119 | -0.0284 | 0.7724 |
| 50% flowering stage | 1.8585* | 0.0013 | -0.0112 | 0.0668 | 0.9608 |
| Pod initiation stage | 1.6820* | 0.0633 | 0.0066 | -0.1461 | 0.9353 |
| Pod filling stage | 0.9036* | -0.0133 | 0.0561 | 0.0056 | 0.9433 |
| Harvesting stage | 1.0541* | 0.0196 | -0.0515 | 0.0189 | 0.9795 |

*: significant at 5% significance level

**Table 2:** Observed variables, observed and predicted values at different stages for first date of sowing (03-08-2009)

| | | | | TDM | | Pod yield (gram) | |
|---|---|---|---|---|---|---|---|
| Stages of crops | GDD °C | SSH (hrs) | AET (mm) | Observed | Predicted | Observed | Predicted |
| 30 DAS | 412.40 | 157.60 | 43.20 | 3.96 | 3.31 | | |
| 50% flowering stage | 161.50 | 25.20 | 27.10 | 6.01 | 9.08 | | |
| Pod initiation stage | 251.90 | 77.20 | 63.80 | 31.45 | 17.24 | | |
| Pod filling stage | 137.50 | 90.40 | 43.10 | 23.45 | 31.90 | | |
| Harvesting stage | 357.00 | 190.70 | 72.80 | 20.56 | 23.33 | 5.45 | 6.43 |

**Table 3:** Observed variables, observed and predicted values at different stages for second date of sowing (20-08-2009)

| | | | | TDM | | Pod yield (gram) | |
|---|---|---|---|---|---|---|---|
| Stages of crops | GDD °C | SSH (hrs) | AET (mm) | Observed | Predicted | Observed | Predicted |
| 30 DAS | 444.20 | 116.00 | 43.00 | 3.35 | 3.03 | | |
| 50% flowering stage | 134.20 | 47.60 | 24.50 | 7.54 | 7.49 | | |
| Pod initiation stage | 258.40 | 135.40 | 73.00 | 19.24 | 19.26 | | |
| Pod filling stage | 125.60 | 43.40 | 33.90 | 14.89 | 18.34 | | |
| Harvesting stage | 454.90 | 238.60 | 69.50 | 13.46 | 13.63 | 3.51 | 4.72 |

## RESULTS AND DISCUSSION

All the five multiple linear regression equations fitted to know the influence of GDD, SSH, AET on initial dry matter accumulation and dry matter at different stages were found to be significant. It indicates from the fitted equations, it can be seen that GDD, SSH and AET determines the dry matter accumulation to extent of 77.24% at 30 DAS, because dry matter accumulation in initial stages depends on nutrients uptake, soil moisture along with above climatic factors. Similarly 96.08%, 93.5%, 94.35% and 97.95% at the remaining stages respectively.

Pod yield prediction model was developed by using the observed total dry-matter at the end of first four stages and predicted total dry-matter for 5th stage as independent variables and observed pod yield as dependent variable to predict the pod yield, the equation is as fallows

$$Yg = 1.4275\, T_1(O) - 0.0307\, T_2(O) - 0.4205\, T3(O) - 0.0276\, T_4(O) + 0.6358\, T_5(P)$$

This equations was found to be significant, and about 87.74% variation in the pod yield can be explained by the independent variables. Coefficients of variables and coefficient of determination ($R^2$) of fitted equations for different stages were shown in Table 1.

### *Validation of the model for the year 2009*

The equations were further validated for the groundnut crop grown during 2009 *kharif* for two dates of sowing. The bio-mass accumulated at different the end of each stage of the crop have been estimated using the weather parameter and these estimated values were in good agreement with the realized yield and they are tabulated along with the pod yield in Table 2 and Table 3.

Hence, this stocheometric crop weather model could be used to predict the pod yield along with their dry matters well before harvest of the crop. This helps the planners for future action.

## REFERENCES

Directorate of economics and statistics Bengaluru, (2007). Fully revised estimates of Principal crops of Karnataka for the year 2006-2007.

Doorenbos, J. and Pruitt, W O.(1977). Guidelines for predicting crop water requirements. F.A.O. *Irrigation and Drainage Paper.*, 24 : 35-41.

Ganeshan, G.S. and Ahobala Rao, H.R. (1989). Duration of light at the time of flowering in relation to selected weather parameters – A study in the case of Ragi over Bangalore. *Mausam*, 40(3) : 259-262.

Gregory, P.G. (1926). The effect of climatic conditions on the growth of barley. *Annals. Bot*., 40 : 1-26.

Frere, M.and Popov,G.F.(1979). Agro meteorological crop monitoring and forecasting. FAO Plant Prod. Prot paper No.17, FAO, Rome, 64 p.

Muralidhara, K.S.and Rajegowda, M.B. (2002). Stocheometric Crop Weather Model to predict the Finger millet Grain yield. *J. Agrometeorol.*, 4(1); 53-57

Shanker, U.and Guptha, B.R.D. (1987). Forecasting of paddy at Chisurah in West Bengal using multiple regression technique. *Mausam*, 38: 415-418.

Victor,V.S, Srivastava, N.N.and Ramana Rao, B.V. (1991a). Application of crop water use models under rainfed conditions in seasonally Arid Tropics. *Intl. J. Ecology Environment Sciences*. 17 : 129-137.

Victor,V.S, Srivastava,N.N.and Ramana Rao,B.V. (1991b). Selection of crops and cropping system using water balance model. *Intl. J. Ecology Environment Sciences*. 17 : 11-18.

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