The Andhra Agric. J 66 (1): 7-11, 2019

Application of GDD as Weather Health Indice and Simulation of Groundnut Yield in Bapatla Agroecological Region

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ABSTRACT

Projected changes in weather parameters, mainly temperature and its weather health indice GDD have already started to show its effect on groundnut production. To cope with the changing climatic scenarios, adoption of appropriate management strategies for optimum yields of groundnut are of paramount importance. Weather conditions are not always favorable for optimal growth, development and yields of groundnut. It is because the photoperiod influences only the development of groundnut whereas the temperature and its weather health indice GDD influences both growth and development. These two are varieties both in space and time. Therefore, field experiments must be repeated over time and space in order to obtain results that can reflect the average conditions of temperature and GDD of a specific area and season for groundnut . However, the Crop growth models (CGMs) and Decision Support Systems (DSS) are useful tools as a complement to expensive field research experiments. The CGMs have the ability to simulate a crop's response to different management scenarios under varying temperature and GDD conditions . Of the three seasons (kharif, rabi and summer) of groundnut grown in Bapatla of Guntur district of Andhra Pradesh the study revealed that the GDD as weather health indice required for optimum yields are 1720 for kharif, 1802 for rabi and summer 1901 . Of the three seasons tested for a consecutive period of five years from 2010 to 2014 the model predicted in harmony with a - 4.5 per cent deviation. Pod yield of crop season was estimated with RMSE ranging from 178.9 to 223.4 where the per cent deviation was from -5.3 to -15.5 percent. It was concluded that increase in air temperature shorten the effective growing season and higher temperatures have negative effect on Groundnut pod yields. The pod yields also decrease by 11 % for every 2 ^{o}C increase of air temperature in Bapatla agroecological region.

Key words: *Groundnut, GDD, CGMs, Simulation, Weather health indices*

Groundnut (Arachis hypogaea L.) belongs to the family Leguminaceae is an annual legume. It is also known as peanut, and earthnut. It is the fourth most important oilseed crop in the world. Its kernels contain 40-50 per cent oil, 20-50 per cent protein, and 10-20 per cent carbohydrates. Of the major oilseeds produced in the world, groundnut is essentially a tropical plant and requires a long warm growing season. Well distributed rainfall of 500 mm and temperature in the range of 25-30 ^{o}C is optimum for its growth and development. Temperature stress is one of the least well understood of all the abiotic adversities that affects groundnut yields and its weather health indice GDD is one of the major uncontrollable factors affecting groundnut growth, development and productivity (Murthy, 2016).

"Weather health" for crop production is defined as "The potential force through which weather elements perform their several and cooperative functions optimally for better crop health to produce potential yields" (Murthy 2015). By definition weather health indices are GDD, HTU, PTU etc and their efficiencies. These indices have potential for adoption and use in research on all the crops and groundnut as well. The GDD for groundnut relate crop growth, physiological development and yield. The concept of weather health indices assumes that there is a direct and linear relationship between growth of a crop plant and air temperature and its derived parameter GDD as weather health indice (Murthy, 2015). Estimation of yield gap based on the past crop yield and weather variables and subsequent weather based technical interventions may help to obtain potential yields (Boote *et al*., 1985). Therefore, an attempt is made to study the effect of seasons and GDD on growth, development and yield of popular groundnut varieties in Bapatla region of Andhra Pradesh, India .

MATERIAL AND METHODS

Weather analysis

The daily weather data of air temperature of Bapatla of Guntur District , Andhra Pradesh , the study area, from 1988 to 2014 was analysed (Zaman *et al*., 1982). As far as seasons are concerned Winter (January- February); Summer (March-May); Kharif/ SW monsoon (June- September); Rabi/ NE monsoon (October- December) are taken into consideration. However, the duration of rabi crop was taken from October to February. For summer season crop grown the weather was considered from January to April (Paulsen, 1994). The GDD was calculated as follows:

GDD =

$$\frac{\text{Maximum+Minimum temperature}}{2} - Tb$$

Tb = Base temperature

Units: ^{o}C day hour^{-1}

Murthy's Weather Health Monitor (MWHM)

The user friendly website with several agrometeorological tools for calculation and analysis of weather health indices and to a limited extent simulation of yield gap estimation of major crops grown in Andhra Pradesh was developed , in a project with full funding from World Meteorological Organisation, Geneva, Switzerland and Department of Science and Technology , Government of India. The steps involved are:

Step 1: Discover

In the first step the needs and goals were defined which was done by internet search engines such as Google, Yahoo, MSN etc. The website was designed with *search engine optimization* and good coding style right from the beginning. During this stage the objective was clearly stated and all the information needed to design was vested, to address any problem or issue. When design is completely satisfied with the proposed "look and feel," then moved forward with development**.**

Step 2 : Development

In the development phase, the web pages drawn up in the design phase were created and optimized. Import and conversion of all database information is done at this step. Great attention, care and precautions were taken into detail and utilized standard conventions for good programming style i.e., site-wide CSS style sheets, web-based content management systems, highly optimized graphics, *etc*. Functional beta versions of the site are created and every aspect of it is tested thoroughly before site launch. The final site optimization was done by hand using a text editor for every site that may be published.

Step 3: Deploy

In this final stage of the site's creation, once it is demonstrated that the web site is perfectly functioning as desired and outlined as per the agreed upon proposal, it is published on public Web server for use. Launches are pre-planned to ensure minimal interruption to the viewers. After successful deployment the site is submitted to search engines and directories.

Step 4: Monitoring and maintenance

Monitoring the site for errors, performance, and visitors statistics play an important role for long-term success. As the requirements of the project change, so too the needs of the site change. To make the web site successful and to meet the scientific requirements of the visitors day to day, year after year provisions were made to keep the web site up-to-date with fresh new content.

Step 5 : Detailed analysis of results indicating contributions made towards increasing the state of knowledge in the subject

Keeping in view all the goals and priorities graphic and layout were completed. The site's navigation structure is one of the main focus in this web as it must be highly optimized and quick and easy for visitors to browse. Provisions were made to create an alpha site often, without graphics to see if the site's navigation and ability to deliver content.

Agrometeorological tools and services

Several agrometeorological tools and services including a GDD calculate and other weather health indices were developed as per the WMO and IMD specifications and project goals and housed on the web.

Use of web site in the present investigation

The output of the statistically analysed weather data from 1984 to 2014 were used as inputs in the agrometeorological tools available in MWHM. Also, the abilities of CSM-CROPGRO-Peanut model and other models were used where a complex interaction among a range of factors that effect ground crop performance. Other data on crop were collected from reliable sources including government agencies. IBSNAT (1986) and Jones (1993)

RRESULTS AND DISCUSSION

In Bapatla descriptive statistics (Table 1.) shows that the lowest temperature (21.91^{0}C) value was recorded in January month and the highest temperature (34.71^{0}C) was recorded in june month. Negative kurtosis value indicates that the distribution has lighter tails than the normal distribution. If the kurtosis is positive then the temperatures are heavily tailed which means, highly variable and there is a larger probability of getting very large temperatures. Positive skewness indicates a long upper tail, so that large deviation in warm temperatures than deviation in cold temperatures. The strong positive skewness occurred in the month of December. November month has a skewness value of zero shows that there is no deviation in normal temperatures. The highest value for range was obtained in June month (4.39^{0}C) that indicates a greater dispersion in the temperatures and lowest value was obtained in June month (2.07^{0}C) indicates a lower

Table 1. Descriptive statistics for air Temperature of Bapatla from 1984 to 2014

Month (Variable)	Lowest (^{0}C)	Highest (^{0}C)	Kurtosis	Skewness	Range (^{0}C)	Mean (^{0}C)	Std. Dev.	Std. Error	C.V. (%)	Jarque Bera	χProb
JAN	21.91	24.87	1.1	0.21	2.96	23.46	0.59	0.09	2.52	2.1	0.35
FEB	23.56	26.63	-0.65	0.26	3.07	25.16	0.78	0.13	3.13	1.06	0.58
MAR	26.23	28.47	-0.42	0.14	2.24	27.28	0.57	0.09	2.1	0.38	0.83
APR	28.01	30.89	1.46	-0.79	2.88	29.85	0.57	0.09	1.92	6.96	0.03
MAY	30.16	34.66	0.23	0.26	4.50	32.65	0.93	0.15	2.86	0.49	0.78
JUN	30.32	34.71	-0.59	0.2	4.39	32.23	1.14	0.19	3.56	0.77	0.67
JUL	28.49	32.35	-0.31	0.41	3.86	30.32	0.95	0.15	3.14	1.17	0.55
AUG	27.95	31.09	-0.21	0.33	3.15	29.57	0.71	0.12	2.43	0.74	0.68
SEP	28.18	30.38	-0.29	0.27	2.20	29.17	0.52	0.08	1.78	0.57	0.74
OCT	26.85	28.92	0.59	0.52	2.07	27.79	0.45	0.07	1.64	2.18	0.33
NOV	24.52	26.76	-0.71	0	2.23	25.61	0.58	0.09	2.28	0.75	0.68
DEC	22.97	25.52	0.28	0.66	2.54	23.95	0.56	0.09	2.34	2.74	0.25

Table 2. Descriptive statistics for GDD of Bapatla from 1984 to 2014

Month (Variable)	Lowest (^{0}C)	Highest (^{0}C)	Kurtosis	Skewness	Range (^{0}C)	Mean (^{0}C)	Std. Dev.	Std. Error	C.V. (%)	Jarque Bera	χProb
JAN	16.91	19.87	1.1	0.22	2.96	18.46	0.59	0.09	3.2	2.1	0.35
FEB	18.56	21.31	0.1	0.25	2.75	19.95	0.61	0.1	3.08	0.41	0.81
MAR	16.23	18.47	-0.42	0.14	2.24	17.29	0.57	0.09	3.32	0.38	0.82
APR	18.01	20.89	1.47	-0.79	2.88	19.85	0.57	0.09	2.9	6.96	0.03*
MAY	20.16	24.67	0.24	-0.26	4.5	22.66	0.93	0.15	4.13	0.49	0.78
JUN	20.32	24.71	-0.59	0.2	4.39	22.23	1.15	0.19	5.16	0.77	0.68
JUL	18.49	22.35	-0.31	0.41	3.86	20.32	0.95	0.15	4.69	1.18	0.55
AUG	17.94	21.09	-0.21	0.34	3.15	19.57	0.72	0.12	3.68	0.75	0.69
SEP	18.18	20.38	-0.29	0.27	2.2	19.17	0.52	0.08	2.72	0.57	0.75
OCT	16.85	18.92	0.59	0.52	2.07	17.79	0.46	0.07	2.57	2.19	0.33
NOV	19.53	21.76	-0.71	0	2.23	20.61	0.58	0.09	2.83	0.75	0.68
DEC	17.96	20.52	0.26	0.63	2.54	18.96	0.56	0.09	2.96	2.52	0.28

Table 3. Observed and simulated kernel yield (Kg ha^{-1}) as influenced by varieties and different seasons from 2010 to 2014.

Variety	O	S	Per cent Deviation	O	S	Per cent Deviation	O	S	Per cent Deviation
	(Kharif)			Rabi			Summer		
TMV-2	1893	2052	-8.3	1789	2005	-12	1914	2090	-14.9
TAG-24	2213	2354	-6.3	1978	2013	-17.6	1946	2249	-6.9
Kadiri-6	1938	2113	-9	2183	2339	-7.1	2046	2486	-17.7
Mean	2014.6	2123	-5.3	2347	2566.3	-9.3	1968.6	2275	-15.5
RMSE	213.4			178.9			223.4		
SD	178.9	93.4	13.4	89	297.9	4.5	94.5	310.9	8.7
CV	8.8	4.3	-252.8	3.7	11.6	-48.3	4.8	13.6	-56.1
O= Observed, S= Simulated									

dispersion in the temperatures. Highest mean value was recorded in May (32.65 ^{0}C) due to high temperatures and lowest mean value was recorded in January (23.46 ^{0}C) due to low temperatures. Low standard deviation value indicates that the data points tend to be very close to the mean value of the temperature. High standard deviation value indicates that the data points are away from mean value of the temperature due to large range of values of the temperature. The coefficient of variation was highest in June with 3.56 per cent, therefore, greater level of dispersion in temperatures. The lowest value of the coefficient of variation was recorded in October with 1.64 per cent indicates the dispersion of temperatures are less. In April month the Jarque beta test shows a value of 6.96 and it is significant at 0.10 per cent level and remaining months has lesser Jarque beta test value and are not significant at 0.10, 0.05 and 0.01 per cent levels.

In Bapatla descriptive statistics for GDD (Table 2) shows that the highest GDD (24.71) was accumulated during June month and the lowest (16.85) GDD was accumulated during October month. If the kurtosis is positive then the GDD was heavily tailed which means, highly variable and there is a larger probability of getting very high GDD accumulation. Negative kurtosis value indicates that the distribution has lighter tails than the normal distribution. Positive skewness indicates a long upper tail, so that large deviation in GDD occurs. The strong positive skewness occurred in the month of December. November month has a skewness value of zero shows that there is no deviation in GDD accumulation. The highest value of range for GDD was accumulated in May month (4.50) that indicates a greater dispersion in the GDD and lowest value was accumulated during October month (2.07) indicates a lower dispersion in the GDD. Highest mean value of GDD was accumulated in May (22.66) and lowest mean value was accumulated during January (18.46). Low standard deviation value indicates that the data points tend to be very close to the mean value of the GDD. High standard deviation value indicates that the data points are away from mean value of the GDD due to large range of values in accumulation of GDD. The coefficient of variation was highest in June with 5.16 per cent therefore, greater level of dispersion in GDD accumulation. The lowest value of the coefficient of variation was accumulated in October with 2.57 per cent indicates the dispersion of GDD is less. In April month the Jarque beta test shows a value of 6.96 and it is significant at 0.10 per cent level and remaining months has lesser Jarque beta test value and are not significant at 0.10, 0.05 and 0.01 per cent levels.

The data on observed and simulated seed yields of crop season are presented in Table 3. In Kharif sowings, the average error computed by root mean square error (RMSE) with 213.4 kg ha^{-1} with co-efficient of variation (CV) of 8.8 per cent for observed seed yield and 14.3 per cent for simulated model yield. The model under estimated seed yields with a mean of -5.3 per cent deviation.

In Rabi season, RMSE was observed with 178.9 kg ha^{-1} with CV of 3.7 per cent among observed yields and 11.6 per cent of simulated seed yield. The mean percent deviation for Rabi was observed and the model over estimated seed yields with -9.3 per cent (Table 3).

The RMSE was 223.4 with CV of 4.8 per cent for observed seed yield and 13.6 per cent for simulated seed yields for summer sowing. The mean percent deviation for second date of sowing was observed and the model over estimated seed yields with -15.5 per cent (ICRISAT, 1994) and (Loague and Green, 1991).

Of the three dates of sowing model predicted in harmony with a - 4.5 per cent deviation. Among varieties, Kadiri-6 recorded with highest over estimated seed yield by the model.

CONCLUSION

In the present investigation for Bapata (Guntur district) it was found for groundnut crop that:

A. Increase in air temperature will shorten the effective growing season

B. Higher temperatures have negative effects on groundnut pod yields

C. Pod yields decrease by 11% for each 2 ^{0}C increase in seasonal (kharif, rabi and summer) temperature.

LITERATURE CITED

Boote K J, Jones J W, Mishoe J W and Wilkerson G G 1985 Modeling growth and yield of groundnut. In Proc. International Symposium on Agrotechnology of Groundnut. 21-26 August 1985, Niamey, NIGER.

IBSNAT 1986 Decision Support System for Agrotechnology Transfer version 2.1. (DSSAT V 2.1). Dept. of Agronomy and Soil Sci., College of Trop.Agr. and Human Resources, University of Hawaii, Honolulu, USA.

ICRISAT 1994 ICRISAT West Africa Programs Annual Report 1993. ICRISAT Sahelian Center, Niger.

Jones J W 1993 Decision Support Systems for agricultural development, In: Penning de Vries, F.W.T., Teng, P. and Metselaar, K. (eds.) Systems, Approach for sustainable agricultural development Vol. 2. Klumer Academic Publishers. Dordrecht. The Netherlands pp. 459-471.

Loague K M and Green R E 1991 Statistical and graphical methods for evaluating solute transport model. Journal of Contaminated Hydrology. 7: 51-73.

Murthy V R K 2015 Climate change-weather health indices as tools and services in Agriculture. Andhra Agricultural Journal. 62(4):737-745.

Murthy V R K 2016 Principles and practices of agricultural disaster management. B.S. Publications, Koti, Hyderabad , Telangana, Pp:111-127.

Paulsen G M 1994 High temperature responses of crop plants. *In* Physiology and Determination of Crop Yield. Eds K J Boote, JM Bennett, T R Sinclair and G M Paulsen. pp 365–389. American Society of Agronomy, Wisconsin, USA.

Wilkerson G G, Jones J W, Boote K J, Ingram K T and Mishoe J W 1983 Modeling soybean growth for management. Transactions of the American Society of Agricultural Engineers (ASAE) 26(1): 63-73.

Xevi E, Gilley J and Feyen J 1996 Comparative study of two crop yield simulation models. Agricultural Water Management. 30: 155-173.

Zaman S M H, Kammal R and Mcintosh H 1982 Simple lessons rom Biometry. Bangladesh Rice Research Institute, Dhaka, Bangladesh.

Received on 01.08.2017 and revised on 08.11.2018