CROP SIMULATION IN GROUNDNUT (*Arachis hypogaea* L.) USING DSSAT-CROPGRO MODEL

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KERALA, INDIA

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DECLARATION

I hereby declare that this thesis entitled **"Crop simulation in groundnut (*Arachis hypogaea* L.) using DSSAT-CROPGRO model"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title, of any other University or Society.

Vellanikkara

Date : 11/09/2020

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CERTIFICATE

Certified that the thesis entitled **"Crop simulation in groundnut (*Arachis hypogaea* L.) using CROPGRO-DSSAT model"** is a bonafide record of research work done independently by **Mr. Vinu K.S. (2018-11-113)** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to him.

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We, the undersigned members of the advisory committee of **Mr. Vinu K. S. (2018-11-113)**, a candidate for the degree of **Master of Science in Agriculture** with major field in Agricultural Meteorology, agree that this thesis entitled **"Crop simulation in groundnut (*Arachis hypogaea* L.) using CROPGRO-DSSAT model"** may be submitted by **Mr. Vinu K. S.** in partial fulfillment of the requirement for the degree.

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VINU. K. S

CONTENTS

LIST OF TABLES

LIST OF TABLES (Contd.)

LIST OF TABLES (Contd.)

LIST OF TABLES (Contd.)

LIST OF FIGURES

LIST OF PLATES

Introduction

1. INTRODUCTION

Groundnut (*Arachis hypogaea* L.), one of the important oil seed crops in India, popularly known as king of oil seed crops and also named as peanut or earthnut or monkey-nut. Groundnut is grown on a large scale in almost all the tropical and subtropical countries of the world. China is the largest producer as well as consumer of groundnut in the world with 166.24 lakh tones followed by India (68.6 lakh tonnes), Nigeria (30.3 lakh tonnes) and United States (25.8 lakh tonnes). It is an important source of edible oil and third most important source of vegetable protein. The crop maintains soil fertility by fixing the atmospheric nitrogen. Groundnut oil cake is used for both cattle feed and as fertilizer. According to SEA (Solvent Extractors Association) report, groundnut crop area in India is at 40.12 lakh ha in 2018-19 and it occupies first in terms of area and second position in terms of production. The major groundnut producing states in India are Gujarat, Andrapradesh, Karnataka, Tamilnadu, Maharashtra and Rajasthan. In Kerala groundnut is cultivated in an area of 274 ha.

The extent of influence of weather on crop growth mainly depends on its growth stages (IPCC, 2007). Hence, the impacts of climate on crop affects differently at different stages of its development. Groundnut is essentially a tropical plant. It requires a long and warm growing season. The most favorable climatic conditions for groundnut are a well-distributed rainfall of at least 50 centimeters during growing season, abundance of sunshine and relatively warm temperature. In India, groundnut is grown during rainy, winter and summer seasons. The effectiveness of rainfall in crop production depends mainly on commencement of sowing rains and amount and distribution of rainfall during the season as water deficit is a major constraint in groundnut production. Severe drought and continuous water stagnation during pegging and pod development are not suitable for the potential crop production. Groundnut has specific moisture needs due to its peculiar feature of producing underground pods. The crop yield in many countries of Asia has also declined due to rising temperature and extreme weather events.

The groundnut cultivation in summer season is gaining popularity under irrigation. Under irrigation scheduling, a climatological approach based on IW/CPE ratio (IW- irrigation water, CPE- cumulative pan evaporation) is following. The evaporation per day from an open pan evaporimeter is taking in to consideration. The ideal scheduling of irrigation depends up on soil, climate and plant characteristics. This approach integrates all the weather parameters that decide water use by the crop and is likely to increase production at least 15-20%. Optimum scheduling of irrigation led to an increase in pod yield and water use efficiency (WUE).

Crop simulation modeling has the potential for simulating growth and yield of crops. It is increasingly being used in agricultural research, crop management recommendations and policy formation. The Decision Support System for Agro technology Transfer (DSSAT) has been developed by K. J. Boote, J. W. Jones and Hoogenboom. In groundnut the simulation modelling work has been done to assess crop growth and yield prediction using "PNUTGRO and CROPGRO" crop simulation models. It considers the complex interactions between a range of factors that affect crop performance, including weather, soil properties and management. Only after extensive experimental calibration, a crop model becomes an actual working tool capable of providing guidance on the practical management of agricultural systems. Development and calibration of groundnut "CROPGRO" model can improve the understanding of the underlying processes in groundnut and hence, support strategic agricultural research on the crop.

Different crop weather relationship studies were conducted earlier in Department of Agricultural Meteorology, College of Horticulture, Vellanikkara. This study entitled "Crop simulation in groundnut (*Arachis hypogaea* L.) using DSSAT-CROPGRO model" was aimed to understand the crop weather relationship of groundnut at varying irrigation levels and to calibrate the genetic coefficient in variety TNAU CO-6 for DSAAT CROPGRO Peanut model.

Review of literature

2. REVIEW OF LITERATURE

Groundnut (*Arachis hypogaea* L.) is an important cash crop and annual legume oilseed crop**.** Genetically controlled characteristics of the cultivar, weather conditions, soil water regime and incidence of insect pests and diseases play an imperative role on the growth of peanut. Hence, in order to appraise the scope for groundnut production, we should have a better knowledge about yield potential and understand the factors restraining the yield of groundnut.

The relevant literature to the present experiment entitled "Crop simulation model in groundnut (*Arachis hypogaea* L.) using DSSAT-CROPGRO model" has been reviewed and presented in the chapter.

1. Significance of groundnut cultivation
2. Effect of weather parameters on growth and yield of groundnut
3. Effect of dates of planting on growth and yield of groundnut
4. Calibrating the genetic coefficient of groundnut for DSSAT-CROPGRO model
5. Crop weather relationship under varying irrigation level
6. Weather influences on the incidences of pest and diseases
7. Simulating groundnut yield using crop simulation models

2.1. Significance of groundnut cultivation

Groundnut (*Arachis hypogaea* L.), also mentioned as peanut, is grown in tropical, subtropical and warm temperate climatic regions of the world, is one of the world's principal oil seed crops (Sogut *et al*., 2016). The adaptability of peanut crop is confined to both rainfed and irrigated conditions, whereas more than half of the production area is in the rainfed region (Woli *et al*., 2013; Kambiranda *et al*., 2011). Peanut can be satisfactorily grown in regions with an annual rainfall of 500-700 mm. Effective use and timely supply of irrigation water is necessary for higher yields and which can be reached through judicious water management practices. Yield maximization in groundnut can be achieved by increasing the frequency of irrigation with a constant total quantity of irrigation water (Giri *et al*., 2017). The most important aspects to be taken up for increasing the productivity of groundnut crop include micro irrigation and their economization by following 4 R principles (right-quantity, place, stage and time) (Babalad and Kulkarni, 1993). Peanut (*Arachis hypogaea* L.) is an important legume cash crop for the farmers in arid and semi-arid regions that provides food for direct human subsistence with seeds having high amounts of edible oil (43-55%), protein (25-28%), and minerals (2.5%) (Abou Kheira, 2009).

The most favorable climatic conditions for groundnuts are long and warm growing seasons with a well-distributed rainfall of at least 50 centimeters, profusion of sunshine and relatively warm temperature throughout the growing season. Groundnut oil is mainly used for culinary purposes while it also destined largely for the preparations of soap, fuel, cosmetics, shaving cream, leather dressings, furniture cream, lubricants, butter, milk, candy and chocolate, chutney, groundnut pack, laddu, barfi (chukii), *etc.* The groundnut oil is used in making different types of medicated ointments, plasters, syrups and medicated emulsion. Vanaspati ghee and some fatty acids are also made from groundnut oil. The usage of groundnut shell as fuel, filler in cattle feed, hard particle board, cork substitute, activated carbon, etc. signifies its potential for commercial use. Groundnut straw is mainly used as animal feed and fuel and in preparation of compost. The green leaves and stems of plants are used as animal feed. The shells of pods obtained during threshing are also used as cattle feed. Groundnut haulms and leaves act as a rich source of cattle feed and raw material for silage preparation. Being a leguminous crop, groundnut has a major role in crop rotation and fixes atmospheric N at an amount of 100-120 kg of N in the field per hectare per season (Status and importance of groundnut crop and its world scenario, chapter II).

2.2. Effect of weather parameters on growth and yield of groundnut

Dreyer (1981) evaluated the temperature requirement of groundnut and reported that the soil temperature is influencing pod formation and development of groundnut and 31 ºC and 33 °C were the optimum soil temperature ranges. Above 33 ºC, significant reduction in the number of mature pods and seed yields were noticed.

Kudo and Syodai (1986) stated that there is a close relationship between seed yield and minimum air temperature. Pathak *et al*. (1988), Stirling *et al*. (1989), Meisner (1991) and Ramachandrappa *et al.* (1992) have been reported that the pod development stage is most sensitive to moisture.

Krishnamurthy (2000) evaluated that the ultimate pod yield and its attributes favored the reproductive phase during the rise in night temperature. Among the phenophases, pod filling was found to be the most sensitive and fluctuation in weather including water use during this phase decides the final yield.

Weiss (2000) reported that peanut is predominantly a tropical plant, which require a long and warm growing season. During the crop growing season, extreme sunlight and temperature of 25°C to 30°C and 50cm rainfall are ideal for vegetation development.

Krishnamurthy *et al*. (2000) evaluated the crop weather relationship of groundnut during two *kharif* season of 1989 and 1990 under split plot design. Two irrigation (rainfed and supplemental irrigation) treatment were given in the main plot and the subplot treatments were three dates of sowing (early, normal and mid) with two varieties of groundnut (TMV2 and Robust 33-1).

Reddy *et al.* (2003) reported that rain is the most important factor affecting peanut production. Most of the groundnut cultivated area are under semi-arid tropics. Both rainfall and prolonged drought are very important during the growing season of groundnut since both factors are more important to the average yield of groundnut.

Prasad *et al*. (2006) studied the temperature requirement of groundnut for various growth stages and reported that, the base temperature for germination of groundnut seeds was 10 ºC and the temperature needed for vegetative development were between 25 and 30 °C and 28–33 °C for flowering and maturity.

Thyagarajan *et al*. (2009) studied that productivity of groundnut have impact on rainfall as 70% peanut area is under semi-arid tropics, which is characterized by low and erratic rainfall. At the same time, yield as well as yield attributes, growth and development of groundnut is affected by soil moisture deficit or water stress, therefore optimum soil moisture maintenance at critical growth stages is an important aspect for attaining higher yield.

Shekh *et al.* (2013) evaluated the effect of weather condition on pod yield in groundnut. The weather parameters like mean relative humidity of 79%, 135 mm rainfall and 23.5 mmHg pressure have influence on the total pod yield. Whereas the maximum temperature of 32°C, 3.2 mm evaporation and bright sunshine hours of 4.8 were the reason for reduced pod yield of groundnut.

2.3. Effect of dates of planting on growth and yield of groundnut

Padma *et al*. (1991) used four varieties of groundnut (Gangapuri, JL-24, Kadari 3, and M 13) and was sown on three different dates (June 19, July 14 and August 8).They mentioned that delay in sowing will also affect the pod yield. This study was conducted in *kharif* season (June to October) in Hyderabad.

Rao and Reddy (1992) conducted a field study during summer season of 1990 at Jagital, Andhra Pradesh, with different dates of sowing starting from 10th January to 9th February at 10 days interval and the varieties used were ICGS 11 and K 3. Results of this experiment showed that delay in sowing after 20th January has been observed to increase pod yield and shelling percentage. Pod yield and test weight of peanuts were significantly higher when compared to other sowing dates than January 30th.

Gajjar *et al*. (1994) from an experiment during summer season at Anand Agricultural University with two dates of sowing, 20th January and 5th February and two varieties (Robust 33-1 and GG -2) found that Robust 33-1 gives 50 percentage more pods and 27 percentage more haulm than GG- 2. The results revealed that pod yield and haulm yield is likely to be higher in robust 33-1 than GG-2 in summer farming.

Reddy *et al*. (1994) conducted a field study to assess the date of sowing of three types of groundnut cultivar depending on rainfall. In rain dependent condition the pod yield in all types of crops gradually decreases with delay in sowing due to reduction of number of pods / plants and shelling percentage. The difference in yield was due to sowing. Yield of July sowing was very small related to august sowing.

Karunakar *et al*. (2002) found high dry pod yields and progressive decline with delay in sowing. High temperature and high relative humidity positively impacted yield and yield characteristics during crop growth periods.

Girnar, JL-24, ICG-44, and ICG-76 are groundnut varieties which were planted in three different sowing dates *viz.*1^{st} and 20^{th} may and 10^{th} June. The study of crop weather relationship in peanut was conducted in this manner and the results of this study showed that the crop sown on May 1^{st} with high accumulation of thermal units was slightly affected the yield related characters than the yield of groundnut sown in remaining two dates. Here the low volume of heat units was too much influenced (Singh, 2004).

Sulochanamma *et al*. (2007) reported that the relative growth rate of the crop is relatively high during early growth and it decreases towards the maturity of the crop. Crop growth rates were highest in 1^{st} June sown crop and lowest in 20^{th} July sown crop.

Meena *et al*. (2015) conducted a field experiment to study the date of sowing of *kharif* groundnut (*Arachis hypogaea* L.) during 2009-2010. The experiment was designed in split plot. The subplot treatment is four dates of sowing such as 20^{th} April, 15^{th} May, 9^{th} June and 4^{th} July. The main plot treatment was two varieties (HNG 10 and TG 37 A). The harvest index of both varieties was high at the 4^{th} July sowing. The higher yield is observed in 9^{th} June and 4^{th} July sowing. TG37A showed a much earlier flowering rate than HG10A**.**

Raagavalli *et al*. (2019) conducted a field experiment to evaluate the four groundnut varieties GKVK-5, GPBD-4, G2-52 and TMV-2 and four sowing dates 2^{nd} fortnight of June, 1^{st} fortnight of July, 2^{nd} fortnight of July and 1^{st} fortnight of august. The results of this experiment revealed that the crop sown during 2^{nd} fortnight of June recorded significantly higher pod yield. He concluded that the ideal season for groundnut planting is the month of July.

2.4. Calibrating the genetic coefficient of groundnut for DSSAT-CROPGRO model

White and Hoogemboon (1996) demonstrated the ability of the CROPGRO cultivation coefficient to mimic the specific combination of four genes affecting photoperiod sensitivity successfully.

Sahay *et al*. (2005) studied the yield stability of some groundnut (*Arachis hypogaea* L.) involving 67 groundnut genotype. In which he observed that the ICGV 87867 is the most stable species in different environment. Most genotypes like ICGV 86326, ICGV 88338 and ICGV 87415 performed well in favorable conditions while NRCG 1752 performed well in adverse conditions.

Songari *et al*. (2009) reported the relationship between specific leaf area (SLA) and spad chlorophyll meter reading (SCMR) of groundnut. The genotypes capable of sustaining high SCMR and low SLA under drought stress should be more drought tolerant. There for maintain high WUE in severe drought conditions.

Sing *et al*. (2012) used groundnut CROPGRO models to evaluate the genetic traits of Virginia and Spanish types of groundnut for various climatic scenario of India. The analysis revealed that groundnut productivity can be increased in the current and future climate by adjusting the length of various life cycle stages like seed filling to physiological maturity and these results suggest that the CROPGRO model can be used to predict the individual or combination of potential.

Yadav *et al*. (2012) conducted a field experiment at Anand agricultural university during the *kharif* season of 2005-2008 to calibrate the genetic coefficients of groundnut cv. Rubust 33-1 and cv.GG 2 using the PNUTGRO model under two different environmental condition like D_1 (onset of monsoon) and D_3 (15 days after D_1). Validation studies showed a better model of cv. Robust 33-1 at the start of monsoon sowing than cv. GG 2. Days for the first pod and the yield of first seed are underestimated at $D_{1.}$ D_1V_1 days are calculated according to the model, while the days to maturity are shortened by the D_1V_2 treatment as expected so that the validated PNUTGRO model can be further used for applications such as prediction of crop growth, phenology, water management, potential and actual yield.

Thakur *et al*. (2013) evaluated twenty five groundnut genotypes in three replications of a randomized complete block design *viz*., ICGV-99171, ICGV-98089, ICGV-97100, Baidehi, ICGV-00440 and B-4 for drought tolerance with high pod yield by using the traits such as SCMS, SLA, root to shoot ratio and drought tolerance score. They also suggested that the genotype can be used as a parent in breeding programs to develop drought tolerant groundnut farming.

2.5. Crop weather relationship under varying irrigation level

Reddy *et al*. (1980) and Reddy *et al*. (1980) reported that periodic irrigation retains soil moisture in the root zone of the crop and thereby yields a high yield of groundnut. Reddy *et al.* (1980) revealed that irrigation once in five days under 40 mm cumulative pan evaporation recorded more pods per plant and 100 kernel weight of summer peanut pod yield. Between different drip irrigation levels with IW/CPE ratio 0.5, 0.7, 0.9, 1.10 and 1.0; and surface irrigation of 397 mm, 515 mm, 634 mm, 73 mm and 700 mm respectively, 643 mm of water lead to maximum yield by saving 9.5 % over surface irrigation (Manavadariya, 1995).

Irrigation scheduled at 75 mm CPE recorded more pod yield than irrigation scheduled at 50 mm and 100 mm CPE (Mahakulkar *et al*., 1990). Scheduling irrigation at 0.5 ratio during flowering to 0.70 ratio at pegging stage showed increased number of branches, number of pods, 100 pod weight and 100 kernel weight in peanut crop (Senthilkumar, 1990). For maximum dry pod yield, haulm yield, harvest index, shelling percentage and 100 kernel weight the optimum irrigation schedule for irrigated summer groundnut was nine (Geethalakshmi *et al.*, 1994).

Selvaraju (1994) observed that the stomatal conductance and transpiration rate increased from 25-50 DAS and thereafter reduced up to maturity stage. Due to more frequent and adequate water availability high stomatal conductance and transpiration rates were associated with irrigation scheduling based on 0.75 IW/CPE ratio.

Patel *et al.* (1995) observed that scheduling irrigation through consecutive increasing ratios of IW/CPE from 0.40 to 1.0 improved different growth parameters and as a result, overall crop growth in terms of dry matter accumulation happened.

Patel and Patel (1995) observed higher shelling percentage, haulm yields and oil content at IW/CPE ratio at 1.0 and 1.2 than irrigation at 0.8 IW/CPE ratio. Increase in levels of irrigation to four days interval has considerable effect on the plant height, number of nodules per plant and nodule dry weight.

Samantha and Patro (1996) conducted a field study to know the effect of moisture utilization pattern in summer groundnut at Orissa University of Agricultural Technology during 1993.The treatment comprised of different irrigation schedule with IW/CPE ratios 0.6, 0.8 and 1.0 and the result of this experiment revealed that highest pod yield was observed in 0.8 IW/CPE ratio than other treatment.

Mishra (1997) from his field experiment conducted at Zonal Agricultural Research Station, Khargone during summer season, reported that scheduled irrigation at 10 days interval was found to be superior with high haulm yield, plant height, number of mature pods per 100 kg weight and shelling percentage compared to irrigation applied at 15 days interval and highest dry pod yield of 1650 kg ha^{-1} was obtained by irrigation in 10 days interval.

Tiwari *et al.* (1997) conducted a field experiment to evaluate the growth and water use by summer groundnut during 1993-1994 at College of Agriculture. The treatment was comprising three irrigation schedule with IW/CPE ratios 0.4, 0.7 and 1.0. The result of this experiment showed that IW/CPE ratio of 0.7 gave significantly higher pod yield and water use efficiency than other treatment during both the years.

Tiwari and Dhakar (1997) pointed that scheduling of irrigation with increased IW/CPE ratio from 0.4 to 1.0 enhanced various growth parameters viz., plant height, branches per plant, LAI, nodule per plant and crop growth rate.

Narang (1998) observed higher yield of groundnut for irrigation schedule based on 90 per cent ASM depletion from 25 cm soil depth. Gulati *et al*. (1999) and Deshpande

(1999) noticed that plant height and number of branches per plant of groundnut were increased progressively with increasing IW/CPE ratios viz., 0.2, 0.4, 0.6, 0.8, 1.0 and 1.2.

A field study was conducted at Agriculture research station, Tamilnadu Agricultural University during summer season of the year 1994-1995 by Lourdraj (2000) and he observed that irrigation schedule at IW/CPE ratio of 0.75 influenced the plant height, number of branches per plant, dry matter production and higher pod yield.

Taha and Gulati (2001) revealed that an increased IW/ CPE ratio can lead to an increased pod yield in groundnut. The maximum yield of 22.4 q/ha was obtained at 1.4 IW/CPE with 525 mm evapotranspiration. A significantly high dry pod yield of 34.08 q/ha was observed at an irrigation scheduling of 75 mm CPE to summer groundnut (Raskar and Bhoi ,2003).

Bandyopadhyay *et al*. (2005) conducted a field experiment on bunchy variety of peanut having IW/ CPE ratio of 0.9, 0.7 and 0.5. Result revealed that the total pod yield and water productivity were recorded higher in 0.9 IW/ CPE ratio compared with 0.7 and 0.5 IW/ CPE.

Rank (2007) conducted a field experiment to assess the crop performance of groundnut during summer season to different irrigation schedule based on IW/CPE ratio of 0.6, 0.7, 0.8, 0.9, 1.0 and 1.2 .The results of the experiment showed that the highest pod yield of 2250 kg ha^{-1} was observed in IW/CPE ratio 0.9 and the lowest pod yield 1471kg ha^{-1} in IW/CPE ratio 0.6.

Suresh *et al*. (2013) conducted a study to asses the comparative efficiency of sprinkler irrigation over check basin irrigation at IW/CPE ratio of 0.6, 0.8, and 1.0. The result of this experiment recorded the higher pod yield under sprinkler method of irrigation system (2020 kg ha^{-1}) as compared to check basin irrigation (1762 kg ha^{-1}). Irrigation of the sprinkler method was scheduled as beneficial to groundnut crop as compared to check basin method of irrigation.

Lokhande *et al.* (2018) conducted a field experiment to study the effect of different irrigation schedules on the productivity of summer groundnut grown in vertisole. The treatment comprising of four irrigation schedule IW/CPE ratio 0.6, 0.8, 1.0 and canal rotation interval during both year using summer groundnut variety Tag 24. The depth of irrigation was maintained 60 mm per irrigation in each treatment. The summer groundnut performed significantly better throughout the growth stages and recorded the higher value of dry pod, haulm, kernel oil, biological yield and bio energy under irrigation schedules at IW/CPE ratio 1.0 and 0.8 as compared with 0.6. During both years of study the highest mean, daily and total consumptive use of water was recorded with an IW/CPE ratio 1.0 and the lowest yield was recorded by canal rotation interval.

Kamble *et al*. (2018) conducted a field experiment during 2013-2014 to study the response of summer groundnut to different irrigation level and the experiment was designed in split plot design in which the main plot treatment comprising four irrigation schedule with IW/CPE ratio 0.6,0.8,1.0 and 1.2. The results revealed that the IW/CPE ratio 1.0 provided the ideal condition for better yield and resulting in a significant increase in dry pod yield and haulm yield per hectare under IW/CPE 1.0 than 0.6, 0.8 and 1.2.

Naresh *et al*. (2018) conducted a field experiment during 2013-2014 to study the influence of three irrigation level having IW/CPE ratio 0.6, 0.8 and 1.0. The results of the experiment revealed that highest yield, yield attributes and quality of groundnut recorded with IW/CPE ratio 1.0.

2.6. Weather influences on the incidences of pests and diseases

Hammons (1977) reported that Rust (*Puccinia arachidis)* is the main disease of groundnut which can be devastating in the event of high rainfall and humidity and the disease will be severe at the end of the rainy season or when the snow fall is abundant. Now the disease is of great economic importance in almost all peanut growing areas of the world.

Rath and Grewal (1981) revealed that the temperature of 22.5°C is generally suitable for the development of peanut rust and tikka disease. Also, the number of days with more sunshine was generally favorable for disease development.

Jayanthi *et al*. (1993) reported that there is a positive correlation between thrips population with temperature, sunshine hours, rainfall and morning relative humidity as well as the negative correlation with relative humidity of the evening and wind speed over the groundnut crop.

Naidu and Chandrika (1997) evaluated that the highest yield came from the sowing of groundnut at normal *kharif* season. The normal and early *kharif* sowing is the best sowing time in the region to avoid the late leaf spot, rust and obtain higher pod yield. The early sown groundnut crops had less leaf and rust disease due to low inoculum potential.

Hazarika (2000) reported that in both seasons there was leaf spots and rust in the peanut crop by mid may. The late sown crop *viz.* June 24 and July 4, has the highest number of leaf spot and rust. The highest pod yield was recorded from crops sown on May 5 (earlier), June 24 (mid), and July 4 (late) sown crops. There is significant and positive correlation between humidity and climate factor for both the diseases. However it showed a negative correlation with pod yield.

Saminathan *et al.* (2003) reported that the abiotic factors such as temperature, relative humidity, sunlight and rainfall are highly dependent on insect population. Change in various weather condition will affect the survival of insect because of the insect development. Survival and reproduction are related to different weather parameters (Pedigo, 2004).

Pal (2004) observed that the peanut attack was higher in summer season and periodically noticed the groundnut leafhopper. The leaf hopper attack of groundnut was observed in 30 days after sowing (Rao, 2005) and the hopper attack continued up to 60 days after sowing during Rabi season.

Samuai *et al*. (2005) conducted a study at Gujarat region on weather based forewarning model for the incidence of groundnut tikka disease. The results showed that the humidity and temperature is favorable for the tikka leaf spot disease. The range of favourable forenoon and afternoon humidity is above 82% and 78% respectively and maximum and minimum temperature below 34 °C and 22 °C respectively. This weather based results will be useful in future cultivation.

Hasan *et al*. (2009) observed that maximum temperature, dew point and sunlight duration in different ecosystem were positively correlated with aphid population. Whereas minimum temperature, relative humidity, and wind speed were negatively correlated with aphid population. High cloudiness, relative humidity, and dew point were reported to favour aphid population, while light rain reported a decline in the aphid population in peanut crop.

Vijayalakshmi *et al.* (2010) developed regression equation for peanut diseases using linear and nonlinear models and found that maximum temperature, evaporation and age of the crop was mainly influenced by leaf spot and rust.

The increasing temperature and low relative humidity favoured the attack of leaf minor (Arunachalam and Kavitha, 2012). Rainfall and sunshine hours showed significant positive correlation with the incidence of rust (*Puccinia arachidis*) and leaf diseases (*Mycosphaerella arachidis*) in groundnut (Galgunde and Kurundkar, 2002).

Ahir *et al*. (2017) conducted a study of seasonal incidence of tobacco caterpillar (*Spodoptera litura*) infesting groundnut and the results of this experiment showed occurrence of tobacco caterpillar (0.20 caterpillar/plant) seemed 2nd week of September and in the 2nd week of October. The population of *Spodotera litura* gradually increased (1.40 caterpillar/plant) in this time and the mean temperature is 26 °C and 56 percent relative humidity. Then the population of *Spodotera litura* slightly decreased during 4th week of November. The overall results of this study is that there is a negative and significant correlation with relative humidity and total rainfall, while with temperature was a negative non-significant relation.

Basavala *et al*. (2018) during his field experiment of evaluating the influence of weather on severity of leaf spot on selected groundnut genotype during *kharif* 2016-2017 at Agricultural College farm Bapatla revealed that late leaf spot PDI (per plant disease incident) of K-6 showed significant positive correlation with sunshine hour (r = 0.592*) and negative correlation with minimum temperature (r = -0.819*), rainfall (r = -0.568*). RSB-87, Kisan, Vemana, GG-2, K-9, AVT-1638, Abhaya, Anantha, JCG-88, AVT-1666, ALR-1 and ALR-3 were moderately resistant and other two genotypes (K-6 and Narayani) were susceptible to late leaf spot. AVT-1666 genotypes showed moderate resistance reaction against late leaf spot. They reported that K-6 variety recorded highest AUDPC (Area under Disease Progress Curve) value (2812.95) of late leaf spot while the lowest value was recorded in AVT-1666 (1480.67).

Nayak *et.al.* (2019) reported that the sucking pest attack is higher in groundnut crop. Aphid (*Aphis craccivora*), thrip (*Scirtothrips dorsalis*) and hoppers (*Empoasca kerri*) are the major sucking pests in groundnut and these three pests appeared in 2nd week of August. The higher population of aphid were observed in the 1st week of September and the higher population of thrips and hoppers were observed in the 2nd week of September. The population of hoppers *(E. kerri)* and thrips (*S. dorsalis)* indicated significant positive association with minimum temperature and mean temperature. In the case of aphids (*A . craccivora*), significant positive correlation was with minimum temperature and mean relative humidity. The study was conducted during *kharif* 2018 at Research Cum Instructional Farm at IGKV, Raipur.

2.7. Simulating groundnut yield using crop simulation model

Bootie *et al.* (1987) reported that the productivity of groundnut agreeable due to biotic and abiotic stresses and weather is one of the important factor which affect all growth stages of groundnut and finally the yield. The crop growth simulation models show considerable potential to evaluate crop varieties, cropping pattern and genetic potential pattern for yield.

Boote *et al*. (1991) reported that the improvement of PNUTGRO model including the addition of photosynthesis sub model to improve response line spacing and growth habits. They included the penman equation for combining the steam pressure deficit and wind speed to calculate the evaporation of a dry area.

Johns (1993) concluded that these crop simulation model can be used effectively for the research studies, decision making and its yield response. Sing *et al*. (1994) reported that row spacing and plant population were influenced by light interception, canopy growth, dry matter production and yield of groundnut as predicted for the model used. DSSAT is a microcomputer software that combines the production and use of various crops, their possibilities as well as the soil and crops date base (Jones *et al*., 1998). The CROPGRO model is mainly used to increase the productivity of groundnut, measure the impact of climate change as well as evaluate various agronomic conditions (Boote,1998).

Hoogenboom (2000) observed a significant influence of climate and management factors on crop growth and development was observed in the crop simulation model. He said that the model could be used to help farmers to make better management decision and to provide farmers with alternate option for their farming system.

Pandey *et al*. (2001) validated the CROPGRO model for groundnut during the *kharif* season from 1997-2000 at Anand. The results showed that the observed phenological dates were similar to those of the simulated ones. The model illustrated the reduction in pod yield by delayed sowing as seen in experiment. This model can be used to accurately predict yield under normal rainfall and different management condition.

DSSAT crop growth model and CROPGRO-Peanut are generic grain legume models that computes crop growth processes viz., phenology, photosynthesis, plant nitrogen, carbon demand and growth partitioning. In addition, the plant development and growth module is linked to soil-plant-atmosphere modules. Hence, the model has the potential for large area yield estimation by input of soil and daily weather data (Gracia *et al.*, 2006).

Suriharan *et al*. (2008) reported that CROPGRO peanut model R1 (planting to first flowering), slightly underestimated the R3 (Planting to first pod) and R5 (Planting to first seed) stages during the rainy season. Mukhesh (2008) inferred that the simulation performance of the model in terms of pod yield was found to be acceptable at the level of dry matter production, LAI and haulm yield predicted by the model.

Thorp *et al*. (2008) reported that DSSAT has modules that allow the user to build model input files for spatial simulations across predefined management zones, calibrate the models to simulate historic spatial yield variability, validate the models for seasons not used for calibration and estimate the crop response and environmental impacts of nitrogen, plant population, cultivar and irrigation prescriptions.

CROPGRO peanut model was used by Parmar *et al*. (2013) to simulate the phenological events, yield and yield attributing characters of groundnut cultivars GG 2 and GG 20 in Gujarat. They found per cent error were between ± 13.2 % for phenological stages and between ± 14 % for yield and yield attributing characters of groundnut cultivars.

Singh *et al.* (2014) suggested that CROPGRO-Peanut model could be used to quantify the impact of climate change on groundnut productivity in different regions of India. It could also be used to quantify the possible benefits and prioritization of various agronomic adaptation options, individually or in combinations, to enhance and sustain groundnut productivity under climate change.

Peanut growing area in India (Anantapur, Mahboobnagar and Junagadh) showed the prevalence of climate change that was likely to be influenced on groundnut using CROPGRO peanut model was studied. The results of this study proved that the maximum yield achieved during delayed sowing. Many agricultural practices evaluated under climate change. Significant increase in temperature in these three locations decreased the pod yield of groundnut by 2050. It is concluded that the relative contribution and ranking of agronomic practices to increase groundnut yield under climate change varied with the location and the CROPGRO-Peanut model was useful in computing such benefits (Singh *et al.*, 2014).

Materials and methods

3. MATERIALS AND METHODS

The study on "Crop simulation in groundnut (*Arachis hypogaea* L.) using DSSAT-CROPGRO model" was carried out during 2019-2020 at the Department of Agricultural Meteorology, College of Horticulture, Vellanikkara, Thrissur.

3.1. DETAILS OF THE EXPERIMENT

3.1.1. Location of experiment

The field experiments were conducted during November 2019 to April 2020 at the Instructional farm Vellanikkara, Kerala Agricultural University, Thrissur. The station is located at 10.31 °N latitude and 76. 13 °E longitudes at an altitude of 22 m above mean sea level.

3.1.2. Soil Characters

It was found that the soil texture of the experimental field was sandy soil. Table 3.1 shows the physical properties of soil.

Table 3.1. Mechanical composition of soil of the experimental field

Sl. No.	Particulars	Value
1	Coarse sand (%)	44.37
2	Fine sand (%)	50.59
3	Silt (%)	0.06
4	Clay (%)	0.56

Table 3.2. Weekly weather parameters during the period of experiment 2019-2020

Week No.	Tmax (°C)	Tmin (°C)	RH I (%)	RH II (%)	VPD I (mm Hg)	VPD II (mm Hg)	WS (km hr^{-1})	BSS (hrs)	RF (mm)	RD (days)	EVP (mm)	TR (°C)	Tmean (°C)	RH mean (%)
44	31.8	19.7	89.9	65.9	20.5	21.5	3.3	4.8	93.2	4.0	2.7	12.1	25.7	77.9
45	32.9	21.7	92.6	71.3	23.2	24.2	1.0	6.9	64.8	1.0	2.4	11.1	27.3	81.9
46	33.2	21.2	81.7	56.0	20.8	20.8	2.9	8.0	72.0	1.0	3.0	11.9	27.2	68.9
47	33.3	22.6	75.6	55.1	19.8	20.2	6.1	8.7	0.0	0.0	4.3	10.7	27.9	65.4
48	32.0	22.9	79.4	61.6	20.4	20.7	7.6	4.8	9.9	2.0	3.8	9.1	27.4	70.5
49	32.0	22.7	70.6	52.1	18.0	17.7	10.9	5.9	0.3	0.0	4.6	9.2	27.3	61.4
50	32.6	21.4	71.7	51.0	17.4	17.5	7.5	7.9	1.4	0.0	4.3	11.2	27.0	61.4
51	32.1	22.6	69.3	52.1	17.2	17.6	11.0	7.3	0.0	0.0	5.5	9.4	27.3	60.7
52	32.6	21.7	76.8	49.6	18.5	18.0	6.8	7.4	0.0	0.0	4.5	10.9	27.1	63.2
1	34.2	22.9	85.1	45.7	20.2	17.8	4.3	9.2	0.0	0.0	4.2	11.2	28.5	65.4
2	33.3	22.0	73.1	44.0	16.3	16.2	6.2	9.3	0.0	0.0	5.0	11.3	27.6	58.6
3	33.8	22.0	74.6	44.0	17.4	16.9	6.2	9.3	0.0	0.0	4.8	11.8	27.9	59.3
4	34.4	22.8	74.3	38.3	16.9	14.7	8.3	9.6	0.0	0.0	5.8	11.6	28.6	56.3
5	35.0	22.7	79.6	40.7	18.4	16.0	3.6	9.0	0.0	0.0	4.7	12.3	28.8	60.1
6	34.7	22.6	74.7	40.7	17.8	16.0	4.8	9.3	0.0	0.0	5.1	12.1	28.6	57.7
7	35.8	23.4	65.1	34.0	15.6	14.2	4.4	9.9	0.0	0.0	6.2	12.3	29.6	49.6
8	35.5	23.5	69.1	35.4	16.8	14.7	7.6	9.7	0.0	0.0	6.8	12.0	29.5	52.3
9	36.3	24.3	78.9	40.5	20.0	17.1	3.6	8.9	0.0	0.0	5.2	12.0	30.2	59.7
10	35.5	24.6	89.6	52.9	23.2	21.3	2.2	8.3	11.6	1.0	4.4	10.9	30.0	71.2

Table 3.2 Weekly weather parameters during the period of experiment 2019-2020 (Contd.)

Week No.	Tmax (°C)	Tmin (°C)	RH I (%)	RH II (%)	VPD I (mm Hg)	VPD II (mm Hg)	WS (km hr^{-1})	BSS (hrs.)	RF (mm)	RD (day)	EVP (mm)	TR (°C)	Tmean (°C)	RH mean (%)
11	37.3	24.2	78.9	36.4	21.4	16.3	3.7	9.1	0.0	0.0	5.4	13.0	30.7	57.6
12	36.4	23.9	87.0	55.7	23.2	22.7	2.8	8.6	21.8	1.0	4.7	12.5	30.1	71.4
13	37.1	24.6	84.7	38.3	23.0	18.0	2.7	8.4	0.0	0.0	5.0	12.5	30.8	61.5
14	36.5	24.5	88.0	58.7	23.7	24.1	2.5	7.8	11.6	1.0	4.7	11.9	30.4	73.4
15	36.6	24.8	83.3	48.0	22.9	20.8	2.9	9.3	3.7	1.0	4.6	11.8	30.6	65.6
16	36.8	25.2	83.6	52.1	24.0	22.4	2.5	8.8	0.0	0.0	4.9	11.6	30.9	67.9
17	35.8	24.1	89.1	62.0	24.3	23.1	2.3	6.4	29.4	2.0	4.0	11.6	29.9	75.6
18	35.8	25.2	86.6	55.4	25.4	23.9	2.0	7.7	0.0	0.0	4.1	10.6	30.5	71.0
19	36.4	25.0	87.9	60.6	24.6	25.1	2.2	6.2	0.0	0.0	4.2	11.3	30.7	74.2
Mean/total	34.6	23.1	80.0	49.9	20.3	19.2	4.7	8.0	319.7	14	128.9	11.4	28.9	64.9

T max - Maximum temperature
T min - Minimum temperature
RH I - Forenoon relative humidity
RH II - Afternoon relative humidity
VPD I - Forenoon vapour pressure deficit
VPDII - Afternoon vapour pressure deficit
WS - Wind speed
BSS - Bright sunshine hours
RF - Rainfall
RD - Rainy days
Epan - Pan Evaporation
TR - Temperature range
Tmean - Temperature mean
RH mean- Mean relative humidity

3.1.3. Climate

The area selected for the experiment is a typical warm humid tropical region. Both southwest and northeast monsoons provide rain to the area and this location experienced a mean maximum temperature of 34.6 ^{0}C and a mean minimum temperature of 23.1 ^{0}C during the experimental period. The average sunshine received during experiment was 8.0 hrs day^{-1}. The mean forenoon relative humidity was 80.0 % and the mean afternoon relative humidity was 49.9 %, the total rainfall was 319.7 mm and the average wind speed was 4.7 km h^{-1}. Table 3.2 represents the details of the weekly weather parameters during the experiment.

3.2. EXPERIMENTAL MATERIALS AND METHODS

3.2.1. Variety

The variety used for the study was TNAU CO-6 which is a famous long duration variety of groundnut released by Tamil Nadu Agricultural University with duration of 125-130 days. The variety was developed in 2012 by Tamil Nadu Agricultural University. This is a derivative cross of CS 9 and ICGS 5, and the special features of this variety is resistance to leaf spot and rust, tolerance to drought, bunchy pods, and high oil content.

3.2.2. Design of the experiment

The experiment was laid out in split plot design with four dates of planting (from 1st November to 15th December 2019) as the main plot treatments and three irrigation levels (IW/CPE 0.6, 0.8 and 1.0) as sub plot treatments this was replicated five times. Depth of irrigation was 3cm. The details of treatment are given in table. 3.3

Table 3.3. Treatments used in the experiment

MAIN PLOT TREAMENT	SUB PLOT TREATMENT
Dates of planting	**Irrigation level**
D_1 : 1st November, 2019	I_1- IW/CPE 0.6
	I_2- IW/CPE 0.8
	I_3- IW/CPE 1.0
D_2 : 15th November, 2019	I_1 - IW/CPE 0.6
	I_2 - IW/CPE 0.8
	I_3- IW/CPE 1.0
D_3 : 1st December, 2019	I_1- IW/CPE 0.6
	I_2- IW/CPE 0.8
	I_3- IW/CPE 1.0
D_4 : 15th December, 2019	I_1- IW/CPE 0.6
	I_2- IW/CPE 0.8
	I_3- IW/CPE 1.0

3.2.3. Layout of the experiment

The field layout is shown in Fig 3.1. The treatments included were four dates of planting starting from 1st November 2019 to 15th December 2019 at 15 days interval and three irrigation levels IW/CPE 0.6, 0.8 and 1. The field was divided into 60 plots of 5 x 2 m^2 size each. The spacing adopted was 15 x 15 cm. (Fig 3.1)

3.3. CROP MANAGEMENT

3.3.1. Land preparation and planting

The land was ploughed 15-20cm depth with a tractor using disc plough and then rotovator was used to achieve optimum tilth. Stubbles of the previous crop were collected and cleaned the field and then experimental layout was done.

3.3.2. Application of manures and fertilizers

Farm yard manure was applied in the field at the rate of 2 t ha $^{-1}$ during land preparation. To supply the required nutrients 10 N: 75 P_2O_5: 75 K_2O kg ha $^{-1}$ fertilizers like urea, rajphos and muriate of potash were used. Entire quantity of cattle manure or compost and recommended quantity of fertilizer were applied as a basal dressing and incorporated well into the soil. Lime was also applied at the rate of 1-1.5 t ha $^{-1}$ at the time of flowering of crop and incorporated in to soil by light hoeing and raking.

3.3.3. After cultivation

The weeding was done at 10-15 days after germination by light hoeing and at the time of application of lime. The soil was kept undisturbed after 45 days of sowing.

3.3.4. Scheduling irrigation

The first irrigation was given immediately after sowing of crop. Then irrigation was executed as per IW/CPE ratio 0.6, 0.8 and 1.0, for 3 cm depth, the cumulative pan evaporation (CPE) values were calculated from daily pan evaporation observed with the help of Class A open pan evaporimeter installed at the Principal Agromet Observatory, College of Horticulture, Vellanikkara.

The 30 mm irrigation water was applied for each irrigation treatment based on IW/CPE ratio of 0.6, 0.8 and 1, when there were CPE of 50, 37.5 and 30 mm evaporation respectively. The number of irrigation and total quantity of water applied during the crop period are given in the Table 3.4 respectively.

$D_2 I_3$	$D_4 I_2$	$D_1 I_1$	$D_3 I_2$
$D_2 I_2$	$D_4 I_3$	$D_1 I_2$	$D_3 I_3$
$D_2 I_1$	$D_4 I_1$	$D_1 I_3$	$D_3 I_1$

$D_3 I_3$	$D_1 I_3$	$D_2 I_1$	$D_4 I_2$
$D_3 I_1$	$D_1 I_2$	$D_2 I_3$	$D_4 I_3$
$D_3 I_2$	$D_1 I_1$	$D_2 I_2$	$D_4 I_1$

$D_1 I_3$	$D_2 I_1$	$D_4 I_3$	$D_3 I_3$
$D_1 I_1$	$D_2 I_2$	$D_4 I_1$	$D_3 I_2$
$D_1 I_2$	$D_2 I_3$	$D_4 I_2$	$D_3 I_1$

$D_3 I_1$	$D_2 I_2$	$D_4 I_3$	$D_1 I_3$
$D_3 I_3$	$D_2 I_3$	$D_4 I_1$	$D_1 I_2$
$D_3 I_2$	$D_2 I_1$	$D_4 I_2$	$D_1 I_1$

$D_4 I_3$	$D_1 I_2$	$D_2 I_3$	$D_3 I_2$
$D_4 I_1$	$D_1 I_1$	$D_2 I_1$	$D_3 I_3$
$D_4 I_2$	$D_1 I_3$	$D_2 I_2$	$D_3 I_1$

Fig. 3.1. Lay out of the experimental plot in split plot design

D1 - November 1st, D2 - November 15th, D3 - December 1st, D4 -December 15th

I_1 -IW/CPE Ratio 0.6, I_2 -IW/CPE Ratio 0.8, I_3 - IW/CPE Ratio 1.0

Table 3.4. Number of irrigation and total quantity of water applied during the crop period

Treatment	**Total number of irrigation**	**Total irrigated water (mm)**
D_1 I_1	12	360
D_1 I_2	16	480
D_1 I_3	20	600
D_2 I_1	15	450
D_2 I_2	18	540
D_2 I_3	23	690
D_3 I_1	13	390
D_3 I_2	18	540
D_3 I_3	22	660
D_4 I_1	12	360
D_4 I_2	17	510
D_4 I_3	21	630

D_1 - November 1st , D_2 - November 15th , D_3 - December 1st, D_4 - December 15th

I_1 -IW/CPE Ratio - 0.6, I_2- IW/CPE Ratio - 0.8, I_3 - IW/CPE Ratio - 1.0

3.4. OBSERVATIONS

The biometric and phenological observation were recorded from randomly selected five plants from each replication of each treatment by avoiding border plants.

3.4.1. Biometric characters

3.4.1.1. Plant height

The plant height recorded at weekly intervals and measured in cm. It was measured using a meter scale.

3.4.1.2. Number of leaves

The number of leaves were recorded at weekly intervals. For this fully opened green leaves were considered.

3.4.1.3. Leaf area

The observation of the leaf area of each irrigation levels was recorded at an interval of 15 days. Only one plant sample was collected from each plot. The leaf area (cm^2) of fresh sample was recorded using the leaf area meter.

3.4.1.4. Dry matter production

Biomass production or dry matter accumulation was estimated by taking observation of the plants at 15 days interval after sowing. One healthy plants was randomly selected from the field and uprooted from each experimental sub plot. Then it was cleaned and dried in sun followed by oven drying at a temperature of 80 ^{0}C to a constant weight. The weight was taken and recorded in grams per plant.

Plate 1. Ploughing

Plate 2. Layout

Plate 3. Field preparation

Plate 4. Sowing

Plate 5. 20 Days after planting

Plate 6. Recording observation

Plate 7. Liming and earthing up

Plate 8. Harvesting

Plate 9. Overall field view

3.4.2. Phenological observations

3.4.2.1. Days to germination

Number of days taken for germination were counted and recorded for each date of planting.

3.4.2.2. Days to first flowering

Number of days taken for first flowering were counted and recorded in each date of planting.

3.4.2.3. Days to 50 % flowering

Number of days taken for 50% flowering were counted and recorded in each date of planting.

3.4.2.4. Days to pegging

Number of days taken for first pegging were counted and recorded in days for each date of planting.

3.4.2.5. Days to pod formation

Number of days taken for pod formation were counted and recorded for each date of planting.

3.4.2.6. Days to physiological maturity

Number of days taken for physiological maturity were counted and recorded for each date of planting.

3.4.3. Yield and yield attributes

3.4.3.1. Pod yield (kg ha^{-1})

Pod yield of groundnut for each treatment from the experimental plots were recorded by weighing the actual quantity of pod and it was converted in to the weight of the pods on hectare basis.

3.4.3.2. Harvest index (%)

The harvest index reflect the proportion of assimilate distribution between economical and total biomass. The following equation was used for calculation of harvest index.

$$\textit{Harvest index} = \frac{\textit{Economic yield}}{\textit{Biological yield}} \times 100$$

3.4.3.3. Shelling percentage (%)

The shelling percentage estimate is one of the yield quality measure for groundnut. To calculate shelling percentage, 1000 gm pods were taken from each plots, shells were removed from seed and then convert into percentage by following formula.

$$\textit{Shelling percentage} = \frac{\textit{Weight of kernel}}{\textit{Weight of pods}} \times 100$$

3.4.4. Soil analysis

Soil samples were collected from the experimental field at 15 cm depth before planting. These samples were dried and powdered separately and were analyzed for pH, electrical conductivity, available phosphorous, available potassium, available calcium, available magnesium, available sulphur and organic carbon content. Table 3.5 showed the results of chemical analysis.

3.4.5. Weather data

Observation of different weather parameters on daily basis (maximum temperature, minimum temperature, relative humidity, rainfall, number of rainy days, bright sunshine hours, wind speed evaporation) were collected from the Agromet observatory of College of Horticulture, Vellanikkara and weekly converted data was used for the study. The different weather parameters used in the study are presented in the Table 3.6.

Table 3.5. Chemical properties of the soil

Sl. No.	**Parameter**	**Values** **0 - 15cm (sampling depth)**	**Remarks**
1	Organic carbon (%)	0.96	Medium
2	Soil pH	4.2	Extremely acidic
3	Electrical conductivity (dS m^{-1})	0.07	Normal
5	Available phosphorous (kg ha^{-1})	5.36	Low
6	Available potassium (kg ha^{-1})	228.48	Medium
7	Available magnesium (kg ha^{-1})	83.5	Deficient
8	Available sulphur (kg ha^{-1})	19.38	Sufficient
9	Available calcium (kg ha^{-1})	348.5	Sufficient

Table 3.6. Weather parameters used in the experiment

Sl. No.	**Weather parameter**	**Unit**
1	Maximum temperature (Tmax)	^0C
2	Minimum temperature (Tmin)	^0C
3	Rainfall (RF)	mm
4	Rainy days (RD)	Days
5	Relative humidity (RH) Forenoon relative humidity (RH I) Afternoon relative humidity (RH II)	%
6	Forenoon vapour pressure deficit (VPD I) Afternoon vapour pressure deficit (VPD II)	mm Hg
7	Bright sunshine hours (BSS)	hr
8	Wind speed (WS)	km hr^{-1}
9	Evaporation (Epan)	mm

3.5. STATISTICAL ANALYSIS

Statistical analysis of the experimental data was done using the standard procedure for split plot design given by Fisher (1947). The existence of significant difference between main plot treatments (dates of planting) and sub plot treatments (irrigation level) and their interaction were analyzed by performing ANOVA. When significant difference was found for the above, the computed critical differences were used for the pair wise comparison.

Critical difference for comparing two main plot treatments (dates of planting) was calculated as,

$$CD_1 = t_1 \times SE_1$$

Where t_1 = t value at degrees of freedom for main plot error

SE_1 = standard error of difference between two main plot treatment means

$$SE_1 = \sqrt{\frac{2E_1}{rb}}$$

Where, E_1 = Mean square for main plot error in ANOVA

r = Number of replications

b = Number of sub plot treatments

Critical difference for the comparison of two subplot treatments (irrigation level)

$$CD_2 = t_2 \times SE_2$$

Where, t_2 = t value at degrees of freedom for sub plot error

SE_2 = Standard error of difference between two sub plot treatments

$$SE_2 = \sqrt{\frac{2E_2}{ra}}$$

Where, E_2=Error mean square value of sub plot treatments in ANOVA

r = Number of replications

a = Number of main plot treatments

Critical difference value for the comparison of three subplot treatment at a given level of main plot treatment was computed an

$$CD_3 = t \times SE_3$$

Where, t_2 = t value at degree of freedom for subplot error

$$SE_1 = \sqrt{\frac{2E_2}{r}}$$

E_2 and r are defined above.

CD_3 was used for comparing irrigation levels at each dates of planting

To study the impact of weather parameters on biometric and phenological characters of the crop, correlation analysis was carried out with average of weather parameters experienced during different stages of the crop. Weather variables were worked out from the daily weather data and correlated with the important crop growth and yield characters obtained from field experiment.

Various statistical analyses were carried out using different software packages like Microsoft – excel, SPSS and R statistical software.

3.6. CROP GROWTH SIMULATION

Crop growth simulation models have become accepted tools for agricultural research. It simulates the crop growth and its development as a function of crop management, weather conditions and soil conditions. These crop simulation models have wider applicability in agricultural fields for assessing the yield in the changing climatic conditions and also helpful in modifying the management practices so as to get an optimum yield. The Decision Support System for Agro technology Transfer (DSSAT) has been developed by K. J. Boote, J. W. Jones Hoogenboom (1998) at University of Florida and University of Georgia and which forms the basis of International Benchmark Site Network for Agrotechnology Transfer (IBSNAT) encompasses process – based computer models that predict growth, phenology and yield as a function of local weather, soil conditions, crop management scenarios and genetic information. Decision Support System for Agro technology Transfer and its crop simulation models can be used for this purpose as a research and teaching tool. The inputs required for these crop simulations include the daily weather data, soil surface and profile information and detailed crop management information.

DSSAT has the potential to reduce substantially the time and cost of experimentation necessary for the proper evaluation of new cultivars and new management systems. DSSAT contains crop specific file including the genetic information of the crop, whereas the cultivar or variety information is to be given by the user in a separate file. The crop simulation models has to be integrated with the weather, soil and crop management files provided by the user to give simulated output. DSSAT also evaluates the simulated outputs with that of experimental data.

3.6.1. DSSAT CROPGRO- Peanut model

Crop simulation modelling has the potential for simulating growth and yield of crops. It increasingly used in agricultural research and crop management recommendation.

"CROPGRO" also consider the complex interactions between a range of factors that affect crop performance including weather, soil properties and crop management.

The files are organized into input, output and experiment performance data file. The experiment performance file are needed only when simulated results are to be compared to the data recorded in a particular experiment. In some cases they can be used as input file to reset some variable during the course of simulation run.

3.6.1.1. Input files and experiment data files

The DSSAT CROPGRO - peanut model uses input files and experiment data files to run the model which is given in Table 3.6.

3.6.1.2. Output files

The output files helps the users to select the information required for a specific application which is listed in Table 3.7

3.6.2. Running the Crop Simulation Model

Once, all the desired files were created carefully, the model was run for all the treatments.

The output files helps the users to select the information required for a specific application which is listed in Table 3.7.

3.6.2.1. Calibration of DSSAT CROPGRO- Peanut model

Data obtained from the experiments carried out with groundnut cultivars CO-6 under four dates of sowing were used for estimating the genetic parameters. The genetic coefficients that influence the occurrence of developmental stages in the DSSAT CROPGRO– Peanut model were derived by manipulating the relevant coefficients to achieve the best possible match between the simulated and observed phenological events as well as the model was calibrated for yield parameter.

The genetic coefficients of DSSAT CROPGRO – Peanut model are given in the Table 3.8. The Root Mean Square Error (RMSE), Mean Absolute Percentage Error (MAPE) and d-stat index were used to evaluate the model performances.

Table 3.7. Input files of DSSAT CROPGRO-Peanut model

<table>
<tr><th colspan="2">Internal file name</th><th>External description</th><th>Example file name</th></tr>
<tr><td>Experiment</td><td>FILEX</td><td>Experiment details file for a specific experiment (e.g. Peanut IFCH1901): Contains data on treatments, field conditions, crop management and simulation controls</td><td>IFCH1901.TMX</td></tr>
<tr><td rowspan="2">Weather and soil</td><td>FILEW</td><td>Weather data, daily, for a specific (e.g., GDNT) station and time period (e.g., for one year)</td><td>GDNT1901.WTH</td></tr>
<tr><td>FILES</td><td>Soil profile data for a group of experimental sites in general (e.g., SOIL.SOL) or for a specific institute (e.g., CHLATRITE.SOL)</td><td>SOIL.SOL</td></tr>
<tr><td rowspan="2">Crop and cultivar</td><td>FILEC</td><td>Cultivar/variety coefficients for a particular crop species and model; e.g., groundnut for the ‘CROPGRO’ model, version 046</td><td>PEANUT046.CUL1</td></tr>
<tr><td>FILEE</td><td>Ecotype specific coefficients for a particular crop species and model; e.g., groundnut for the ‘CROPGRO’ model, version 046</td><td>PEANUT046.ECO</td></tr>
</table>

	FILEG	Crop (species) specific coefficients for a particular model; e.g., groundnut for the ‘CROPGRO’ model, version 046	PEANUT046.SPE1
	FILEA	Average values of performance data for a groundnut experiment. (Used for comparison with summary model results.)	IFCH1901.TMA
	FILET	Time course data (averages) for groundnut experiment. (Used for graphical comparison of measured and simulated time course results.)	IFCH1901.PNX
These names reflect a standard naming convention in which the first two spaces are for the crop code, the next three characters are for the model name, and the final three are for model version.			

Table 3.8. Output files of DSSAT CROPGRO-Peanut model

Internal file name	**External description**	**File name**
OUTO	Overview of inputs and major crop and soil variables.	OVERVIEW.OUT
OUTS	Summary information: crop and soil input and output variables; one line for each crop cycle or model run.	SUMMARY.OUT
SEVAL	Evaluation output file (simulated vs. observed)	EVALUATE.OUT
OUTWTH	Daily weather	Weather. OUT
OUTM	Daily management operations output file	MgmtOps. OUT
ERRORO	Error messages	ERROR.OUT
OUTINFO	Information output file	INFO.OUT
OUTWARN	Warning messages	WARNING.OUT

Table 3.9: Genetic coefficients for the DSSAT CROPGRO-Peanut model

Growth and development aspects of The groundnut crop	Description of parameter coefficients controlling development aspects
CSDL	Critical short day length below which reproductive development progresses with no day length effect (for short day plants) (hours)
PPSEN	Slope of the relative response of development to photoperiod with time (negative for long day plants) (1/ hour)
EM-FL	Time between plant emergence and flower appearance (R1) (photothermal days)
FL-SH	Time between first flower and first pod (R3) (photothermal days)
FL-SD	Time between first flower and first seed (R5) (photothermal days)
SD-PM	Time between first seed (R5) and physiological maturity (R7) (photothermal days)
FL-LF	Time between first flower (R1) and end of leaf expansion (photothermal days)

LFMAX	Maximum leaf photosynthesis rate at 30 C, 350 vpm CO_2 and high light (mg CO_2 / m^2 / s)
SLAVR	Specific leaf area of cultivar under standard growth conditions (cm^2 /g)
SIZLF	Maximum size of full leaf (three leaflets) (cm^2)
XFRT	Maximum fraction of daily growth that is partitioned to seed + shell
WTPSD	Maximum weight per seed (g)
SFDUR	Seed filling duration for pod cohort at standard growth conditions (photothermal days)
SDPDV	Average seed per pod under standard growing conditions
PODUR	Time required for cultivar to reach final pod load under optimal conditions (photothermal days)
TRESH	Threshing percentage. The maximum ratio of (seed/ (seed+shell)) at maturity. Causes seeds to stop growing as their dry weight increases until shells are filled in a cohort.
SDPRO	Fraction protein in seeds (g (protein)/g(seed))

Results

4. RESULTS

Results obtained from the study "Crop simulation in groundnut (*Arachis hypogaea* L.) using DSSAT-CROPGRO model" carried out at the Department of Agricultural Meteorology, College of Horticulture, Vellanikkara during 2019-2020, were described here.

4.1 PHENOLOGY OF GROUNDNUT

Growth and development of groundnut was significantly influenced by complex uncontrolled environmental factors. The ideal diurnal air temperature for photosynthesis and vegetative growth of groundnut was between 30 °C and 35 °C (Prasad *et al*., 2000 and (Craufurd *et al*., 2002), the optimum diurnal temperature for reproductive growth and final yield is somewhat cooler between 25 °C and 28 °C (Ketring, 1984). In the case of groundnut, the total life cycle is having six different growth phases from emergence to physiological maturity which are known as phenophases and these are listed below.

a. Sowing to germination (P1)
b. Germination to first flowering (P2)
c. First flowering to fifty per cent flowering (P3)
d. Fifty per cent flowering to pegging (P4)
e. Pegging to pod formation (P5)
f. Pod formation to physiological maturity (P6)

All these phenophases comes under different growth periods such as vegetative phase, reproductive phase and maturity phase. The development stages includes sowing to germination (P1), germination to first flowering (P2), first flowering to fifty percentage flowering (P3), fifty per cent flowering to pegging (P4), pegging to pod formation (P5) and pod formation to physiological maturity (P6).

4.2. THE PHENOLOGICAL STAGES (NUMBER OF DAYS) TAKEN FOR VARIOUS BIOTIC EVENTS WERE DESCRIBED BELOW.

4.2.1. Number of days for germination

The number of days from sowing to germination for different date of sowing and irrigation scheduling was given in Table (4.1). The result indicated that, the days taken for the germination was higher (8 days) in December 15th planting and it was lesser (5 days) in November 1st planting and the days taken for the germination for second and third dates of planting germination were 7 and 8 days respectively.

Table 4.1 Number of days for germination

Crop Stage	Dates of planting											
	1st November			15th November			1st December			15th December		
	I_1	I_2	I_3	I_1	I_2	I_3	I_1	I_2	I_3	I_1	I_2	I_3
Germination	5	5	5	7	7	7	7	7	7	8	8	8

4.2.2. Number of days for first flowering

The days taken for first flowering was shown in Table (4.2). The results showed that, the number of days taken for first flowering was more (30 days) in November 1st planting and was less (26 days) for November 15th planting.

Table 4.2 Number of days for first flowering

Crop Stage	Dates of planting											
	November 1st			November 15th			December 1st			December 15th		
	I_1	I_2	I_3	I_1	I_2	I_3	I_1	I_2	I_3	I_1	I_2	I_3
First flowering	30	30	29	27	26	27	29	29	27	29	27	27

4.2.3. Number of days for fifty percentage flowering

The days taken for fifty per cent flowering was shown in Table 4.3. The November 15th planting showed less number of days (32 days) to attain fifty percentage flowering in I_2 irrigation scheduling. The first dates of planting showed a comparatively more days for flowering (38 for I_1 and I_2).

Table 4.3 Number of days for fifty percentage flowering

Crop Stage	Dates of planting											
	November 1st			November 15th			December 1st			December 15th		
	I_1	I_2	I_3	I_1	I_2	I_3	I_1	I_2	I_3	I_1	I_2	I_3
50% flowering	38	38	36	34	32	34	35	35	32	36	34	34

4.2.4. Number of days for pegging

The number of days for pegging was more (42 days) in November 1st planting under I_1 and I_2 and it was less (38 days) in December 1st planting under I_2 treatment. In the December 1st planting showed less number of days (38 days under I_3).

Table 4.4 Number of days for pegging

Crop Stage	Dates of planting											
	November 1st			November 15th			December 1st			December 15th		
	I_1	I_2	I_3	I_1	I_2	I_3	I_1	I_2	I_3	I_1	I_2	I_3
Pegging	42	42	41	41	39	41	41	41	38	41	40	40

4.2.5. Number of days for pod formation

The number of days taken for pod formation was higher (72 days under I_1 and I_2) in November 1st planting and lower (69 days) under I_2 during Nov 15th and Dec 15th planting.

Table 4.5 Number of days for pod formation

Crop Stage	Dates of planting											
	November 1st			November 15th			December 1st			December 15th		
	I_1	I_2	I_3	I_1	I_2	I_3	I_1	I_2	I_3	I_1	I_2	I_3
Pod formation	72	72	71	71	69	71	71	71	69	71	69	69

4.2.6. Number of days for Physiological maturity

Number of days for attaining physiological maturity was presented in Table (4.6). The study showed that, December 1st planting took higher days (149) while November 1st planting observed in lower days (142) for attaining physiological maturity.

Table 4.6 Number of days for physiological maturity

Crop Stage	Dates of planting											
	November 1st			November 15th			December 1st			December 15th		
	I_1	I_2	I_3	I_1	I_2	I_3	I_1	I_2	I_3	I_1	I_2	I_3
Physiological maturity	142	142	142	146	146	146	149	149	149	148	148	148

4.3. OBSERVED WEATHER DURING CROP GROWING PERIOD

Weather conditions prevailed during different stages of crop growth were given from Table 4.7 to 4.12.

4.3.1. Weather conditions prevailed during the crop period from germination to flowering stage in different dates of planting

Weather conditions prevailed during the crop period from germination to flowering stage in different dates of planting was given in Table 4.7

4.3.1.1. Temperature (Maximum temperature, Minimum temperature, Mean temperature and Temperature range)

Highest (33.9 °C) value of maximum temperature, in November 15th planting and lowest (31.4 ^{o}C) value of in December 1st planting were observed. Higher minimum (22.6 ^{o}C) temperature recorded during December 1st planting, whereas the lowest (19.7 ^{o}C) minimum temperature was noticed during November 1st planting. Mean temperature values ranged from 25.7 ^{o}C to 28.0 ^{o}C wherein lowest value was recorded during November 1st planting and the highest during November 15th planting. The highest temperature range value 12.8 ^{o}C in November 1st planting and lowest value of 8.8^{o}C in December 1st planting were observed respectively.

4.3.1.2. Relative Humidity (RH I, RH II and RH mean) and Vapour pressure deficit (VPD I and VPD II)

Forenoon relative humidity varied from 69.1 % to 93.8 % in which the lowest humidity was recorded during December 15th and the higher value recorded during noticed during November 15th plantings , Afternoon relative humidity was lowest for December 15th planting with a value of 50.8% and the higher (60.0%) value of was recorded during November 1st planting. Mean relative humidity ranged from 62.3% to 71.5%. Higher mean relative humidity value was recorded for December1st planting and the lowest recorded during December 15th planting. Forenoon vapour pressure deficit showed a decreasing trend the maximum value of forenoon vapour pressure deficit was observed during November 1st planting with the values 21.3 mm Hg and the minimum value 17.2 mm Hg recorded during December 15th planting, Then Afternoon vapour pressure was lowest for December 15th planting with a value of 17.4% and the higher value (22.0%) was recorded during November 1st planting.

4.3.2.3. Rainfall (RF) and Rainy days (RD)

Amount of rainfall received was higher during the November 1st planting with a quantity of 61 mm and least (0 mm) during November 15th planting the number of rainy days showed a decreasing trend 2 days for November 1st planting and 0 days for November 15th and December 15th planting.

4.3.2.4. Bright sunshine hours (BSS)

Bright sunshine hours showed an increasing trend towards November 1st planting and a decreasing trend with delayed planting. A higher value of 8.8 hrs. Bright sunshine hours were noticed during November 15th planting and lower values of 3.9 hrs was recorded in December 1st planting.

4.3.2.5. Pan evaporation (Epan)

Pan evaporation showed a range in between 2.6 mm to 5 mm the values showed an increasing trend towards the delayed planting the higher value of 5 mm and lower value of 2.6 mm were recorded during December 15th and November 1st plantings respectively.

4.3.2.6. Wind speed (WS)

Wind speed showed an increasing trend towards the delayed planting and the higher during December 15th planting with a maximum recorded value of 10.4 km $hr^{-1.}$ Minimum value of wind speed was recorded during November planting with 1.2km hr^{-1} for both the varieties.

Table 4.7. Weather condition experienced by the crop from sowing to germination

Dates of planting	Irrigation treatment	Tmax °C	Tmin °C	Tmean °C	TR °C	RH1 %	RH2 %	RH mean %	Rainfall mm	RD Days	BSS hrs	WS km hr^{-1}	Epan mm	VPD1 mm Hg	VPD2 mm Hg
D1	I_1	32.5	19.7	25.7	12.8	93.8	60.0	68.8	61.0	2.0	7.7	1.2	2.6	21.3	22.0
	I_2	32.5	19.7	25.7	12.8	93.8	60.0	68.3	61.0	2.0	7.7	1.2	2.6	21.3	22.0
	I_3	32.5	19.7	25.7	12.8	93.8	60.0	68.3	61.0	2.0	7.7	1.2	2.6	21.3	22.0
D2	I_1	33.9	22.2	28.0	11.8	81.6	55.5	62.4	0.0	0.0	8.8	3.5	3.5	21.2	20.9
	I_2	33.9	22.2	28.0	11.8	81.6	55.5	62.4	0.0	0.0	8.8	3.5	3.5	21.2	20.9
	I_3	33.9	22.2	28.0	11.8	81.6	55.5	62.4	0.0	0.0	8.8	3.5	3.5	21.2	20.9
D3	I_1	31.4	22.6	27.0	8.8	76.6	57.7	71.5	3.0	1.0	3.9	9.6	3.8	19.2	19.4
	I_2	31.4	22.6	27.0	8.8	76.6	57.7	71.5	3.0	1.0	3.9	9.6	3.8	19.2	19.4
	I_3	31.4	22.6	27.0	8.8	76.6	57.7	71.5	3.0	1.0	3.9	9.6	3.8	19.2	19.4
D4	I_1	31.9	22.3	27.1	9.6	69.1	50.8	62.3	1.4	0.0	6.0	10.4	5.0	17.2	17.4
	I_2	31.9	22.3	27.1	9.6	69.1	50.8	62.3	1.4	0.0	6.0	10.4	5.0	17.2	17.4
	I_3	31.9	22.3	27.1	9.6	69.1	50.8	62.3	1.4	0.0	6.0	10.4	5.0	17.2	17.4

D1 – November 1st , D2 – November 15th, D3 – December 1 st, D4 – December 15th

I_1 - IW/CPE 0.6, I_2 - IW/CPE 0.8, I_3 - IW/CPE 1.0

4.3.2. Weather conditions experienced during the crop period from germination to first flowering

Weather conditions prevailed during the crop period from germination to first flowering stage in different dates of planting was given in Table 4.8

4.3.2.1. Temperature (Maximum temperature, Minimum temperature, Mean temperature and Temperature range)

From germination to flowering stage the maximum temperature experienced during different planting dates showed a variation from 32.1 ^{0}C to 33.4 ^{0}C. The maximum value for the maximum temperature was 33.4 ^{0}C observed during December 1st planting. Minimum temperature varied from 22.0 ^{0}C to 22.8 ^{0}C wherein higher value were recorded during November 15th planting and the lower value was observed during December 1st planting, The mean temperature values ranged from 27.2 ^{0}C to 27.8 ^{0}C in which higher value recorded during December 15th planting and lower value was recorded during December 1st planting. The higher value of temperature range of 11.1^{0}C during December 15th planting.

4.3.2.2. Relative humidity (RH I, RH II and RH mean) and Vapour pressure defici (VPD I and VPD II)

Highest values of forenoon and afternoon relative humidity recorded were 80.6% and 60.2% this value recorded for I_1 and I_2 During November 1st planting and lowest forenoon and afternoon relative humidity ranges from 71.3% and 46.7% the higher value recorded for the I_3 during December 15th planting, The highest mean relative humidity observed in I_1 and I_2 during November 1st planting, Slight changes were observed in the forenoon vapour pressure deficit in between different planting dates with a maximum of 20.9 mm Hg and 17.54 mm. A maximum forenoon vapour pressure deficit of 20.9 mm

Hg were noted in I_3 during November 1st planting. Afternoon vapour pressure values ranged from 21.3 mm Hg (I_3 during November 1st planting) to 17.4 mm Hg (I_1 during December 15th planting).

4.3.2.3. Rainfall (RF) and Rainy days (RD)

From germination to first flower stage the highest rainfall (144 mm) was received in I_1 and I_2 during November 1st planting, and least (0 mm) during December 15th planting. The number of rainy days showed a decreasing trend 3 days for November 1st planting and 0 days for December 1st and December 15th planting.

4.3.2.4. Bright sunshine hours (BSS)

The highest bright sunshine hours recorded for 8.5 hrs. Was received in $I_{1,}$ I_2 and I_3 during December 15th planting and the lowest BSS (6.1 hrs.) was received in I_2 during November 15th planting.

4.3.2.5. Pan evaporation (Epan)

The pan evaporation were recorded during the crop period from germination to first flowering. An evaporation of 3.6 mm was experienced in $I_{1,}$ I_2 and I_3 during November 1st and the highest recorded 4.8 mm it was experienced for $I_{1,}$ I_2 and I_3 during December 1st planting whereas all other planting dates were experienced by an evaporation of 3.5-4.0 mm range for all irrigation schedule.

4.3.2.6. Wind speed (WS)

Wind speed exhibited a range from 9.3 km $hr^{-1}$to 4.6 km hr^{-1} from germination to first flowering. The lowest speed of 4.6 km hr^{-1} was experienced for 1_3 during November 1st planting and higher speed of 9.3 km hr^{-1} was experienced for I_2 during the second dates of planting (November 15th). All other planting dates were experienced by a wind speed of 4.6 – 6.0 km hr^{-1}.

Table 4.8 Weather condition experienced by the crop from germination to first flowering

Dates of planting	Irrigation treatment	Tmax °C	Tmin °C	Tmean °C	TR °C	RH1 %	RH2 %	RH mean %	Rainfall mm	RD Days	BSS hrs	WS km hr^{-1}	Epan mm	VPD1 mm Hg	VPD2 mm Hg
D1	I_1	33.0	22.2	27.6	10.8	80.6	60.2	72.0	144.0	3.0	7.5	4.7	3.6	20.8	21.2
	I_2	33.0	22.2	27.6	10.8	80.6	60.2	72.0	144.0	3.0	7.5	4.7	3.6	20.8	21.2
	I_3	33.0	22.2	27.6	10.8	81.0	60.0	71.2	136.8	2.0	7.6	4.6	3.6	20.9	21.3
D2	I_1	32.1	22.7	27.5	9.4	73.6	55.6	64.9	10.2	2.0	6.3	9.2	4.5	18.8	19.1
	I_2	32.1	22.8	27.5	9.3	73.7	56.1	65.1	10.2	2.0	6.1	9.3	4.5	18.9	19.2
	I_3	32.1	22.7	27.5	9.4	73.6	55.6	64.9	10.2	2.0	6.3	9.2	4.5	18.8	19.1
D3	I_1	32.4	22.0	27.2	10.4	71.7	50.9	61.5	1.4	0.0	7.5	8.7	4.8	17.6	17.7
	I_2	32.4	22.0	27.2	10.4	71.7	50.9	61.5	1.4	0.0	7.5	8.7	4.8	17.6	17.7
	I_3	32.4	22.1	27.2	10.3	71.3	51.4	61.2	1.4	0.0	7.3	8.9	4.8	17.5	17.7
D4	I_1	33.4	22.3	27.8	11.1	78.4	46.7	61.9	0.0	0.0	8.5	6.0	4.5	18.5	17.4
	I_2	33.4	22.2	27.8	11.1	79.7	47.5	62.1	0.0	0.0	8.5	6.0	4.5	18.9	17.6
	I_3	33.4	22.2	27.8	11.1	79.7	47.5	62.1	0.0	0.0	8.5	6.0	4.5	18.9	17.6

D1 – November 1st, D2 – November 15th, D3 – December 1st, D4 – December 15th

I_1 - IW/CPE 0.6, I_2 - IW/CPE 0.8, I_3 - IW/CPE 1.0

4.3.3. Weather conditions experienced during the crop period from first flowering to fifty percentage flowering

Weather conditions prevailed during the crop period from first flowering to fifty percentage flowering stage in different dates of planting was given in Table 4.9.

4.3.3.1. Temperature (Maximum temperature, Minimum temperature, Mean temperature and Temperature range)

During first flowering stage to fifty percentage flowering there was an increasing trend the maximum temperature of different planting dates showed a variation from 31.5 ^{0}C to 33.6 ^{0}C. The higher value was observed for I_1 and I_2 during December 1st planting with a value 33.6 ^{0}C. And lower values of 31.5 ^{0}C was noticed for I_3 respectively during November 1st planting. In the case of Minimum temperature showed a decreasing trend towards November 1st & 15th planting, then again increased during December 1st planting. Higher value of 22.5 ^{0}C and a lower value of 21.2 ^{0}C were obtained as minimum temperature. The higher value observed 0.6 (I_2) and 0.8 (I_1) during the November 1st planting and the lower value recorded for I_2 and I_3 it was observed during December 15th planting.

The Mean temperature values highest for third dates of planting (December 1st) ranged from 27.0^{0}C to 27.9^{0}C in which maximum value was recorded for I_1 and I_2 during December 1st planting and lowest mean temperature values were recorded for I_3 during November 1st planting temperature range showed an increasing trend, ranged from 9.3 to 11.9.

4.3.3.2. Relative humidity (RH I, RH II and RH mean) and Vapour pressure deficit (VPD I and VPD II)

Highest forenoon and afternoon relative humidity recoded was 84.0% and 58.6% and it was noticed for I_1 and I_2 during November 1st planting in lowest forenoon and afternoon humidity relative humidity recoded was 71.6 % and 44.8 % the higher value recorded for I_1 and I_3 it was observed during December 1st planting the lower value observed for I_2 and I_3 during December 15th planting. The mean relative humidity showed a range from 58.1% to 70.7% and showed decreasing as well as increasing trend as the planting date was delayed. High forenoon vapour pressure deficit (19.7 mmHg) was experienced in the I_1 and I_2 durig December 1st planting and lowest (16.1 mmHg) observed value was for I_2 and I_3 during December 15th planting. Highest afternoon vapour pressure deficit (19.6 mmHg) for I_3 treatment observed for November 1st planting ad lowest afternoon vapour pressure deficit was 16.3 mmHg observed for I_2 and I_3 during December 15th planting.

4.3.3.3. Rainfall (RF) and Rainy days (RD)

From first flower stage to fifty percentage flowering the amount of rainfall showed decreasing trend. Highest (10.2 mm) rainfall was received in I_3 during November 1st planting whereas no rainfall was received during December 1st and 15th planting. The highest rainy days (2 days) showed an I_3 treatment during November 1st planting.

4.3.3.4. Bright sunshine hours (BSS)

Bright sunshine hours exhibited an increasing trend the higher value of 9.2 hrs. Bright sunshine hours were noticed for I_1 and I_2 during December 1st planting whereas lower values of 4.0 hrs. and 4 hrs. Were recorded in November 1st planting.

4.3.3.5. Pan evaporation (Epan)

Pan evaporation showed a range in between 3.8 mm to 4.7 mm the higher value of 4.7 mm were recorded for I_2 and I_3 during December 15th planting in the lower value of 3.8 mm were observed for I_3 during November 1st planting.

4.3.3.6. Wind speed (WS)

Wind speed showed increasing trend towards the delayed planting the higher value of 9.5 was recorded for I_1 and I_2 during November 1st planting and lower value of 4.7 km hr^{-1} was observed for I_1 and I_2 during December 1st planting.

Table 4.9 Weather condition experienced by the crop from first flowering to fifty percentage of flowering

Dates of planting	Irrigation treatment	Tmax °C	Tmin °C	Tmean °C	TR °C	RH1 %	RH2 %	RH mean %	Rainfall mm	RD Days	BSS hrs	WS km hr^{-1}	Epan mm	VPD1 mm Hg	VPD2 mm Hg
D1	I_1	31.8	22.5	27.1	9.3	74.9	55.2	69.9	3.0	1.0	4.8	9.5	4.1	18.8	18.8
	I_2	31.8	22.5	27.1	9.3	74.9	55.2	69.9	3.0	1.0	4.8	9.5	4.1	18.8	18.8
	I_3	31.5	22.4	27.0	9.1	75.9	58.6	70.7	10.2	2.0	4.0	9.2	3.8	19.2	19.6
D2	I_1	32.4	21.7	27.1	10.7	71.6	53.1	60.8	1.4	0.0	7.6	7.5	4.3	17.5	17.7
	I_2	32.7	21.4	27.0	11.3	72.3	52.2	58.1	1.4	0.0	7.6	6.8	4.1	17.6	17.7
	I_3	32.4	21.7	27.1	10.7	71.6	53.1	60.8	1.4	0.0	7.6	7.5	4.3	17.5	17.7
D3	I_1	33.6	22.1	27.9	11.5	84.0	47.2	62.8	0.0	0.0	9.2	4.7	4.2	19.7	17.9
	I_2	33.6	22.1	27.9	11.5	84.0	47.2	63.5	0.0	0.0	9.2	4.7	4.2	19.7	17.9
	I_3	33.0	21.3	27.2	11.7	78.4	46.2	63.5	0.0	0.0	9.0	6.1	4.5	18.4	17.5
D4	I_1	33.3	21.4	27.3	11.9	76.6	46.6	58.6	0.0	0.0	9.1	5.5	4.6	17.4	17.5
	I_2	33.0	21.2	27.1	11.8	72.8	44.8	58.6	0.0	0.0	9.1	5.7	4.7	16.1	16.3
	I_3	33.0	21.2	27.1	11.8	72.8	44.8	58.7	0.0	0.0	9.1	5.7	4.7	16.1	16.3

D1 – November 1st , D2 – November 15th, D3 – December 1 st, D4 – December 15th

I_1 - IW/CPE 0.6, I_2 - IW/CPE 0.8, I_3 - IW/CPE 1.0

4.3.4. Weather conditions experienced during the crop period from fifty percentage flowering to pegging.

Weather conditions prevailed during the crop period from fifty percentage flowering stage in different dates of planting was given in Table 4.10.

4.3.4.1. Temperature (Maximum temperature, Minimum temperature, Mean temperature and Temperature range)

From fifty percentage flowering to pegging stage there was an increasing trend in temperature towards the last dates of planting. The maximum value observed for IW/CPE ratio 0.6 (I_1) during December 15th planting with a value 34.6 ^{0}C and the minimum value 32.1 ^{0}C noticed for I_1, I_2 and I_3 it was observed during November 15th planting. The minimum temperature recorded showed an increasing trend towards the last dates of planting. Minimum temperature showed a higher value of 24.0 ^{0}C during December 15th planting in I_1 treatment and a lower value of 21.4 ^{0}C during November 1st plantings for I_1 and I_2. The mean temperature values ranged from 27.3 ^{0}C to 29.3 ^{0}C in which maximum value was recorded for I_1 treatment during December 15th planting. Temperature range also showed variation from 9.5 ^{0}C to 11.6 ^{0}C and it varied according to different dates of planting.

4.3.4.2. Relative humidity (RH I, RH II and RH mean) and Vapour pressure deficit (VPD I and VPD II)

The highest forenoon and afternoon humidity recorded was 85.7 % and 52.1 % and it was noticed for I_3 during December 1st and I_1, I_2 and I_3 during November 15th planting respectively. Lowest forenoon and afternoon humidity relative humidity recoded were 69.3 % and 39 % for I_2 during November 15th and I_1 during December 15th planting respectively. The mean relative humidity showed a range from 57 % to 65.7 %. Forenoon vapour pressure deficit showed an increasing trend, the higher value of forenoon vapour pressure deficit was recorded for I_3 during December 1st planting with the values 20.4 mm while minimum value of 16.9 mm Hg was recorded for I_1 and I_2 during November 1st planting. Afternoon vapour pressure deficit values ranged from 15.3 mm Hg to 17.7 mm Hg wherein the lowest value noticed in December 15th planting.

4.3.4.3. Rainfall (RF) and Rainy days (RD)

There were no rainfall and rainy days during this period.

4.3.4.4. Bright sunshine hours (BSS)

Bright sunshine hours exhibited a higher value of 9.9 hrs noticed during November 1st planting in I_1 and I_2 and December 15th planting in I1 treatment. Whereas lower value of 5.7 hrs was recorded in November 15th planting for both I_1 and I_3.

4.3.4.5. Pan evaporation (Epan)

Pan evaporation showed a range in between 4.3 mm to 6.4 mm. Higher value (6.4 mm) was recorded in I_1 treatment during December 15th planting and a lower value of 4.3 mm was recorded in I_3 during December 1st planting.

4.3.4.6. Wind speed (WS)

The higher value of 11.0 km hr^{-1} noticed for I2 during November 15th planting and lower value of 4.3 km hr^{-1} were observed for I_3 during December 1st planting.

4.3.5. Weather conditions experienced during the crop period from pegging to pod formation ((Results are shown in table 4.11)

4.3.5.1. Temperature (Maximum temperature, Minimum temperature, Mean temperature and Temperature range)

From pegging to pod formation stage higher value of maximum temperature observed for I1 treatment during December 15th planting with a value 35.1 ^{0}C and the minimum value 32.9 ^{0}C noticed for I_1 and I_2 treatment during November 1st planting. The minimum temperature varied from 22.2 ^{0}C and 22.8 ^{0}C. Higher value of 22.8 ^{0}C was observed in I_1 treatment during December 15th planting. The mean temperature ranged from 27.6 ^{0}C to 29.6 ^{0}C in which maximum value was recorded during I_1 in December 15th planting, Temperature range varied from 10.7 ^{0}C to 12.4 ^{0}C.

Table 4.10. Weather condition experienced by the crop from fifty percentage of flowering to pegging

Dates of planting	Irrigation treatment	Tmax °C	Tmin °C	Tmean °C	TR °C	RH1 %	RH2 %	RH mean %	Rainfall mm	RD Days	BSS hrs	WS Km hr^{-1}	Epan mm	VPD1 mm Hg	VPD2 mm Hg
D1	I_1	33.0	21.4	27.2	11.6	70.7	46.7	57.0	0.0	0.0	9.9	8.2	4.9	16.9	17.3
	I_2	33.0	21.4	27.2	11.6	70.7	46.7	57.0	0.0	0.0	9.9	8.2	4.9	16.9	17.3
	I_3	32.9	22.0	27.5	10.9	69.5	46.3	60.0	0.0	0.0	9.0	9.8	5.2	17.1	16.9
D2	I_1	32.1	22.4	27.3	9.7	70.9	52.1	59.8	0.0	0.0	5.7	10.2	5.1	17.6	17.7
	I_2	32.1	22.6	27.3	9.5	69.3	52.1	62.9	0.0	0.0	7.3	11.0	5.5	17.2	17.6
	I_3	32.1	22.4	27.3	9.7	70.9	52.1	59.8	0.0	0.0	5.7	10.2	5.1	17.6	17.7
D3	I_1	34.2	22.8	28.5	11.5	80.3	43.7	65.7	0.0	0.0	9.4	5.8	4.7	18.7	16.7
	I_2	34.2	22.8	28.5	11.5	80.3	43.7	65.7	0.0	0.0	9.4	5.8	4.7	18.7	16.7
	I_3	34.4	23.2	28.8	11.2	85.7	45.7	65.6	0.0	0.0	9.4	4.3	4.3	20.4	17.7
D4	I_1	34.6	24.0	29.3	10.5	70.4	39.0	58.8	0.0	0.0	9.9	10.0	6.4	17.2	15.3
	I_2	34.3	23.2	28.8	11.2	73.6	42.1	60.2	0.0	0.0	9.7	8.0	5.5	17.6	16.6
	I_3	34.3	23.2	28.8	11.2	73.6	42.1	60.2	0.0	0.0	9.7	8.0	5.5	17.6	16.6

D1 – November 1st , D2 – November 15th, D3 – December 1 st, D4 – December 15th

I_1 - IW/CPE 0.6, I_2 - IW/CPE 0.8, l_3 - IW/CPE 1.0

4.3.5.2. Relative humidity (RH I, RH II and RH mean) and Vapour pressure deficit (VPD I and VPD II)

The highest forenoon and afternoon humidity recorded were 77 % and 49.1 % respectively. Forenoon relative humidity of 77 % noticed for I_2 treatment during November 15th planting and afternoon relative humidity of 49.1 % noticed in I_3 during November 1st planting. Lowest forenoon and afternoon relative humidity recoded was 72.8 % and 37.9 %, both these values were recorded for I_1 treatment during December 15th planting. The Mean relative humidity showed a range from 55.8 % to 62.6 %.

Forenoon vapour pressure deficit showed an increasing trend towards delayed planting. Higher value of forenoon vapour pressure deficit was recorded for I_1 and I_2 during December 1st planting (21.9 mm Hg). Minimum value of 18.0 mm Hg was recorded for I_1 and I_3 treatment during November 15th planting. Afternoon vapour pressure deficit values ranged from 15.1 mm Hg to 17.6 mm Hg. Lowest value noticed in December 15th planting for I_1 treatment and higher value was recorded for I_3 during November 1st planting.

4.3.5.3. Rainfall (RF) and rainy days (RD)

From pegging to pod formation stage, 1.4 mm of rainfall was received during November 1st planting whereas no rainfall was received during November 15th, December 1st and December 15th planting.

4.3.5.4. Bright sunshine hours (BSS)

Bright sunshine hours exhibited an increasing trend towards delayed dates of planting. The higher value of 9.5 hrs recorded for December 15th planting in all the treatments. Whereas lower values of 8 hrs recorded in November 1st planting in all the treatments.

4.3.5.5. Pan evaporation (Epan)

Pan evaporation showed an increasing trend towards the delayed planting. Ranges from 4.6 mm to 5.6 mm. Higher value of 5.6 mm noticed for I_1 treatment during December 15th planting and lower value of 4.6 mm observed for I_3 treatment during November 1st planting.

4.3.5.6. Wind speed (WS)

Wind speed showed deceasing trend towards delayed dates of plating. Higher wind speed of 7.2 km hr^{-1} noticed in I_1 and I_2 treatments during November 1st planting and lower value of 4.9 km hr^{-1} were observed for I_2 and I_3 treatments during December 15th planting.

4.3.6. Weather conditions experienced during the crop period from pod formation to physiological maturity (Results are shown in table 4.12)

4.3.6.1. Temperature (Maximum temperature, Minimum temperature, Mean temperature and Temperature range)

During pod formation stage to physiological maturity there was an increasing trend of maximum temperature towards delayed planting dates. Higher value observed for I_1, I_2 and I_3 treatments during December 15th planting (36.4 ^{0}C). Lower values of 35.3 ^{0}C noticed for I_3 treatment during November 1st planting. Minimum temperature showed an increasing trend towards delayed dates of planting. Higher value of 24.6 ^{0}C and a lower value of 23.3 ^{0}C were noticed during all treatments in November 1st planting and I_2 and I_3 treatments in December 15th planting respectively. Higher value of mean temperature observed December 15th planting (30.5 ^{0}C).

Table 4.11. Weather condition experienced by the crop from pegging to pod formation

Dates of planting	Irrigation treatment	Tmax °C	Tmin °C	Tmean °C	TR °C	RH1 %	RH2 %	RH mean %	Rainfall mm	RD Days	BSS hrs	WS km hr^{-1}	Epan mm	VPD1 mm Hg	VPD2 mm Hg
D1	I_1	32.9	22.3	27.6	10.7	75.6	48.9	62.6	1.4	0.0	8.0	7.2	4.7	18.1	17.5
	I_2	32.9	22.3	27.6	10.7	75.6	48.9	62.6	1.4	0.0	8.0	7.2	4.7	18.1	17.5
	I_3	33.0	22.2	27.6	10.8	76.0	49.1	62.3	1.4	0.0	8.0	7.1	4.6	18.2	17.6
D2	I_1	33.6	22.4	28.0	11.2	76.8	44.9	61.8	0.0	0.0	9.3	6.4	4.9	18.0	17.0
	I_2	33.5	22.2	27.9	11.3	77.0	45.7	62.1	0.0	0.0	8.8	6.1	4.7	18.1	17.2
	I_3	33.6	22.4	28.0	11.2	76.8	44.9	61.8	0.0	0.0	9.3	6.4	4.9	18.0	17.0
D3	I_1	34.3	22.3	28.3	11.9	75.3	41.5	58.6	0.0	0.0	9.2	5.7	5.0	21.9	16.0
	I_2	34.3	22.3	28.3	11.9	75.3	41.5	58.6	0.0	0.0	9.2	5.7	5.0	21.9	16.0
	I_3	34.2	22.4	28.3	11.8	75.3	41.7	59.1	0.0	0.0	9.3	5.9	5.1	21.7	16.0
D4	I_1	35.1	22.8	29.6	12.4	72.8	37.9	55.8	0.0	0.0	9.5	5.0	5.6	21.5	15.1
	I_2	35.0	22.7	28.8	12.4	73.1	38.1	55.9	0.0	0.0	9.5	4.9	5.5	21.6	15.2
	I_3	35.0	22.7	28.8	12.4	73.1	38.1	55.9	0.0	0.0	9.5	4.9	5.5	21.6	15.2

D1 – November 1st , D2 – November 15th, D3 – December 1 st, D4 – December 15th

I_1 - IW/CPE 0.6, I_2 - IW/CPE 0.8, l_3 - IW/CPE 1.0

Lowest mean temperature (29.3 ^0C) recorded in I_3 treatment during November 1st planting. Temperature range showed an increasing trend towards December 1st planting it ranges from 11.8 ^0C to 12.2 ^0C.

4.3.6.2. Relative humidity (RH I, RH II and RH mean) and vapour \pressure deficit (VPDI and VPD II)

Forenoon relative humidity experienced during pod formation to physiological maturity stage ranges from 76.6 % to 84.7 %. Highest forenoon relative humidity recorded in I_1 treatment during December 15th planting (84.7 %). Lowest forenoon relative humidity observed in I_3 treatment during November 1st planting (76.6 %). The highest (50.1 %) afternoon relative humidity observed in I_1 treatment during December 15th planting. Lowest afternoon relative humidity (41.5 %) in I_1 and I_2 treatments during first date of planting. Mean relative humidity ranges from 58.5 % to 66.4 %. Forenoon vapour pressure deficit showed an increasing trend towards delayed date of planting. Higher value of forenoon vapour pressure deficit was recorded for I_1 treatment during December 15th planting (23 mm Hg). Whereas, lowest value of 20.8 mm Hg was recorded I_1 and I_2 treatments during November 1st planting. Afternoon vapour pressure deficit ranges from 16.8 mm Hg to 21.0 mm Hg. Lowest value (16.8 mm Hg) noticed in November 1st planting in all the treatments and higher value (21.0 mm Hg) recorded for I_1 during December 15th planting.

4.3.6.3. Rainfall (RF) and Rainy days (RD)

During pod formation to physiological maturity the amount of rainfall showed an increasing trend toward delayed dates of planting. Highest (78.1 mm) amount of rainfall received in last date of planting (December 15th) lowest (33.4) amount of rainfall received during 1st dates of planting. Maximum number of rainy days (6 days) received during December 15th planting from pod formation to physiological maturity stage.

4.3.6.4. Bright sunshine hours (BSS)

Bright sunshine hours exhibited a decreasing trend towards delayed dates of planting. Higher value (9.2 hrs) recorded for November 1st planting in all treatments. Whereas, lower value (8.3 hrs) recorded during December 15th planting in all treatments.

4.3.6.5. *Pan evaporation* (Epan)

Pan evaporation showed an deceasing trend towards delayed dates of planting. Value ranges from 4.7 mm to 5.3 mm. Higher value (5.3 mm) noticed during November 1st planting in all the treatments and lower value (4.7 mm) observed for I_1 treatment during December 15th planting.

4.3.6.6. Wind speed (WS)

Higher wind speed of 4.8 km hr^{-1} noticed during November 1st planting in all treatments and lower value of 2.8 km hr^{-1} were observed in I_1 treatment during December 15thplanting.

Table 4.12. Weather condition experienced by the crop from pod formation to physiological maturity

Dates of planting	Irrigation treatment	Tmax °C	Tmin °C	Tmean °C	TR °C	RH1 %	RH2 %	RH mean %	Rainfall mm	RD Days	BSS hrs	WS km hr^{-1}	Epan mm	VPD1 mm Hg	VPD2 mm Hg
D1	I_1	35.4	23.3	29.4	12.1	76.9	41.5	58.5	33.4	2.0	9.2	4.8	5.3	20.8	16.8
	I_2	35.4	23.3	29.4	12.1	76.9	41.5	58.5	33.4	2.0	9.2	4.8	5.3	20.8	16.8
	I_3	35.3	23.3	29.3	12.0	76.6	41.6	58.5	33.4	2.0	9.2	4.8	5.3	20.6	16.8
D2	I_1	35.9	23.7	29.8	12.2	79.4	43.0	60.4	45.0	3.0	8.9	3.9	5.2	21.9	17.8
	I_2	35.9	23.7	29.8	12.2	79.2	42.9	60.2	45.0	3.0	8.9	4.1	5.3	21.8	17.8
	I_3	35.9	23.7	29.8	12.2	79.4	43.0	60.4	45.0	3.0	8.9	3.9	5.2	21.9	17.8
D3	I_1	36.3	24.3	30.3	12.0	81.1	46.2	59.7	66.1	5.0	8.7	3.5	5.1	21.5	19.3
	I_2	36.3	24.3	30.3	12.0	81.1	46.2	59.7	66.1	5.0	8.7	3.5	5.1	21.5	19.3
	I_3	36.2	24.2	30.2	12.1	81.0	46.0	62.7	66.1	5.0	8.7	3.5	5.1	21.4	19.2
D4	I_1	36.4	24.5	30.5	11.8	84.7	50.1	66.4	78.1	6.0	8.3	2.8	4.7	23.0	21.0
	I_2	36.4	24.6	30.5	11.8	84.3	49.7	66.1	78.1	6.0	8.3	3.0	4.8	22.9	20.8
	I_3	36.4	24.6	30.5	11.8	84.3	49.7	66.1	78.1	6.0	8.3	3.0	4.8	22.9	20.8

D1 – November 1^{st} , D2 – November 15^{th}, D3 – December 1 st, D4 – December 15^{th}

I_1 - IW/CPE 0.6, I_2 - IW/CPE 0.8, l_3 - IW/CPE 1.0

4.4. CROP WEATHER RELATIONSHIP OF GROUNDNUT

Correlation analysis was carried out between weather variables and duration of phenophases, yield and yield attributes using the data collected from the time of experimentation during 2019-2020. The results obtained are given below.

4.4.1. Yield of groundnut influenced by weather

The correlation between weather elements and yield of groundnut are presented in Table 4.13 respectively.

4.4.1.1. Sowing to germination (P1)

During sowing to germination minimum temperature, wind speed and evaporation showed significant negative correlation with yield Forenoon relative humidity, afternoon relative humidity, forenoon and afternoon vapour pressure deficit and rainy days showed significant positive correlation at one per cent level, whereas, for rainfall, significance was at five per cent level.

4.4.1.2. Germination to first flowering (P2)

The correlation between yield and weather experienced from germination to first flowering revealed that, there exist a significant positive correlation with forenoon vapour pressure deficit, afternoon relative humidity (one per cent level) and rainfall, in which significance was at five per cent level with yield.

4.4.1.3. First flowering to fifty percentage flowering (P3)

Minimum temperature, rainfall, rainy days, afternoon relative humidity, afternoon vapour pressure deficit and wind speed significant positive correlation with yield whereas significant negative correlation was observed with maximum temperature bright sunshine hours and evaporation

4.4.1.4. Fifty percentage flowering to pegging (P4)

The correlation between yield and afternoon relative humidity, afternoon vapour pressure deficit showed a significant positive correlation, while minimum temperature and evaporation showed a significant negative correlation during fifty percentage flowering to pegging stage.

4.4.1.5. Pegging to pod formation (P5)

Rainfall, forenoon relative humidity, afternoon relative humidity, afternoon vapour pressure deficit and wind speed showed a significant positive correlation with yield. Whereas, maximum temperature, minimum temperature, bright sunshine hours and evaporation exhibited a significant negative correlation during pegging to pod formation period.

4.4.1.6. Pod formation to physiological maturity (P6)

Wind speed, bright sunshine hours and evaporation showed significant positive correlation with yield. Whereas, minimum temperature, maximum temperature, forenoon relative humidity, afternoon relative humidity, forenoon vapour pressure deficit, afternoon vapour pressure deficit and rainy days exhibited significant negative correlation with yield.

Table 4.13 Yield of groundnut influenced by weather variables

Stage	Tmax °C	Tmin °C	RF mm	RD Days	RH I %	RH II %	VPDI mm Hg	VPDII mm Hg	WS km hr-1	BSS hrs	Epan mm
P1	0.041	-0.272*	0.294*	0.367**	0.387**	0.446**	0.369**	0.396**	-0.304*	0.047	-0.422**
P2	-0.202	-0.096	0.288*	0.201	-0.023	0.391**	0.212	0.327*	-0.009	-0.237	-0.235
P3	-0.413**	0.257*	0.469**	0.409**	-0.05	0.355**	0.217	0.313*	0.369**	-0.346**	-0.278*
P4	-0.203	-0.336**	0.0	0.0	0.173	0.300*	0.239	0.489**	-0.181	-0.095	-0.495**
P5	-0.455**	-0.511**	0.467**	0.0	0.325*	0.457**	-0.217	0.409**	0.460**	-0.476**	-0.472**
P6	-0.356**	-0.372**	-0.252	-0.348**	-0.432**	-0.396**	-0.482**	-0.400**	0.404**	0.400**	0.434**

*Significant at 5% level ** Significant at 1% level

P1 - Sowing to germination

P2 - Germination to first flowering

P3 - First flowering to fifty per cent flowering

P4 - Fifty per cent flowering to pegging

P5 - Pegging to pod formation

P6 - Pod formation to physiological maturity

4.4.2. Phenophases of groundnut as influenced by weather variables

The correlation between weather elements and phenophases of groundnut are presented in Table 4.14 respectively.

4.4.2.1. Sowing to germination (P1)

Minimum temperature, wind speed and evaporation showed significant positive correlation with phenophase duration from sowing to germination. Whereas, forenoon relative humidity, afternoon relative humidity, rainfall, forenoon vapour pressure deficit, afternoon vapour pressure deficit, bright sunshine hours and rainy days showed significant negative correlation.

4.4.2.2. Germination to first flowering (P2)

Maximum temperature, minimum temperature, forenoon relative humidity, forenoon vapour pressure deficit, bright sunshine hours, rainy days and evaporation exhibited positive significant correlation. While, afternoon relative humidity and wind speed showed negative significant correlation with phenophase duration from germination to first flowering.

4.4.2.3. First flowering to fifty percentage flowering (P3)

Minimum temperature, rainfall, rainy days, afternoon relative humidity, wind speed and afternoon vapour pressure deficit showed significant positive correlation with phenophase duration from first flowering to fifty per cent flowering. Whereas, maximum temperature, bright sunshine hours and forenoon relative humidity showed significant negative correlation with phenophase duration from first flowering to fifty per cent flowering.

4.4.2.4. Fifty percentage flowering to pegging (P4)

Minimum temperature, afternoon relative humidity, forenoon vapour pressure deficit and afternoon vapour pressure deficit showed significant positive correlation with phenophase duration from fifty per cent flowering to pegging while bright sunshine hours showed a negative significant correlation.

4.4.2.5. Pegging to pod formation (P5)

Rainfall, forenoon and afternoon relative humidity, afternoon vapour pressure deficit and wind speed exhibited positive significant correlation. Whereas, minimum temperature, maximum temperature, bright sunshine hours and evaporation showed a significant negative correlation with phenophase duration from Pegging to pod formation.

4.4.2.6. Pod formation to physiological maturity (P6)

Minimum temperature, maximum temperature, rainy days, rainfall, forenoon and afternoon relative humidity, forenoon and afternoon vapour pressure deficit showed a significant positive correlation with phenophase duration from pod formation to physiological maturity. Whereas, evaporation, wind speed and bright sunshine hours showed significant negative correlation with phenophase duration from pod formation to physiological maturity.

Table 4.14 Phenophases of groundnut as influenced by weather variables

Stage	Tmax °C	Tmin °C	RF mm	RD Days	RH I %	RH II %	VPDI mm Hg	VPDII mm Hg	WS km hr-1	BSS hrs	Epan mm
P1	-0.153	0.912**	-0.927**	-0.899**	-0.975**	-0.890**	-0.785**	-0.888**	0.832**	-0.343**	0.950**
P2	0.968**	0.930**	0.233	0.763**	0.536**	-0.619**	0.813**	0.013	-0.734**	0.678**	0.633**
P3	-0.558**	0.393**	0.332**	0.434**	-0.439**	0.474**	-0.158	0.266*	0.556**	-0.564**	-0.206
P4	-0.125	0.448**	0.0	0.0	0.249	0.353**	0.393**	0.263*	0.041	-0.703**	-0.075
P5	-0.591**	-0.571**	0.408**	0.0	0.566**	0.595**	-0.560**	0.622**	0.563**	-0.533**	-0.601**
P6	0.951**	0.895**	0.612**	0.872**	0.831**	0.783**	0.691**	0.823**	-0.892**	-0.837**	-0.702**

*Significant at 5% level ** Significant at 1% level

P1 - Sowing to germination
P2 - Germination to first flowering
P3 - First flowering to fifty per cent flowering
P4 - Fifty per cent flowering to pegging
P5 - Pegging to pod formation
P6 - Pod formation to physiological maturity

4.4.3. Yield attributes of groundnut influenced by weather variables

4.4.3.1. *Harvest index of groundnut as influenced by weather variables*

The correlation between weather elements and harvest index of groundnut are presented in Table 4.15 respectively.

Significant positive correlation was noticed for forenoon relative humidity and afternoon vapor pressure deficit with harvest index during sowing to germination, while wind speed showed significant negative correlation. Afternoon relative humidity and afternoon vapor pressure deficit showed significant positive correlation with harvest index during germination to flowering. Rainfall, rainy days, wind speed and afternoon relative humidity showed a significant positive correlation and maximum temperature and bright sunshine hours showed a significant negative correlation with harvest index during first flower to fifty percentage flowering. Afternoon vapour pressure deficit showed a significant positive correlation during fifty per cent flowering to pegging. Rainfall, afternoon relative humidity, afternoon vapor pressure deficit and wind speed showed a positive significant correlation with harvest index from pegging to pod formation stage. Wind speed and bright sunshine hours showed a significant positive correlation, while maximum temperature, minimum temperature, forenoon relative humidity, afternoon relative humidity, afternoon vapour pressure deficit and rainy days showed a significant negative correlation with harvest index during pod formation to physiological maturity.

4.4.3.2. Shelling percentage of groundnut as influenced by weather variables

The correlation between weather elements and shelling of groundnut are presented in Table 4.16 respectively.

Significant negative correlation was noticed for minimum temperature and evaporation with shelling percentage, whereas, rainfall, rainy days, forenoon relative humidity, afternoon relative humidity and afternoon vapour pressure deficit showed significant positive correlation with during sowing to germination. Afternoon relative humidity, afternoon vapour pressure deficit and rainfall exhibit a significant positive correlation shelling percentage during germination to first flowering. Minimum temperature, rainfall, rainy days, afternoon relative humidity, forenoon vapour pressure deficit, afternoon vapour pressure deficit and wind speed showed significant positive correlation, whereas, maximum temperature and bright sunshine hours showed a significant negative correlation with shelling percentage during first flowering to fifty per cent flowering. Shelling percentage showed a significant negative correlation with pan evaporation from fifty percentage flowering to pegging stage. Rainfall, after noon relative humidity, afternoon vapour pressure deficit and wind speed showed a significant positive correlation, whereas, maximum temperature, minimum temperature, bright sunshine hours and evaporation showed a significant negative correlation with shelling percentage during pegging to pod formation stage. Wind speed, bright sunshine hours and evaporation rate showed a significant positive correlation, while, maximum temperature, minimum temperature, forenoon relative humidity, afternoon relative humidity, forenoon vapour pressure deficit, afternoon vapour pressure deficit and rainy days showed significant negative correlation with shelling percentage from pod formation to physiological maturity.

4.15 Harvest index of groundnut as influenced by weather variables

Stages	Tmax °C	Tmin °C	RF mm	RD Days	RHI %	RHII %	VPDI mm Hg	VPDII mm Hg	WS km hr^{-1}	BSS hrs	Epan mm
P1	0.153	-0.239	0.222	0.171	0.266*	0.196	0.246	0.258*	-0.272*	0.196	-0.251
P2	-0.053	0.067	0.232	0.234	0.123	0.285*	0.251	0.281*	-0.09	-0.149	-0.241
P3	-0.366**	0.099	0.303*	0.271*	-0.232	0.274*	-0.019	0.161	0.334**	-0.283*	-0.138
P4	-0.216	-0.239	0.0	0.0	-0.069	0.234	-0.017	0.314*	0.049	-0.084	-0.164
P5	-0.312*	-0.282*	0.347**	0.0	0.173	0.322*	-0.246	0.294*	0.309*	-0.354**	-0.302*
P6	-0.288*	-0.284*	-0.193	-0.270*	-0.274*	-0.264*	-0.232	-0.272*	0.285*	0.264*	0.249

*Significant at 5% level ** Significant at 1% level

P1 - Sowing to germination

P2 - Germination to first flowering

P3 - First flowering to fifty per cent flowering

P4 - Fifty per cent flowering to pegging

P5 - Pegging to pod formation

P6 - Pod formation to physiological maturity

Table 4.16 Shelling percentage of groundnut as influenced by weather

Stages	**Tmax °C**	**Tmin °C**	**RF mm**	**RD Days**	**RHI %**	**RHII %**	**VPDI mm Hg**	**VPDII mm Hg**	**WS km hr^{-1}**	**BSS hrs**	**Epan mm**
P1	-0.094	-0.301*	0.338**	0.412**	0.341**	0.403**	0.254	0.306*	-0.225	-0.041	-0.358**
P2	-0.046	-0.219	0.319*	0.139	0.056	0.306*	0.200	0.285*	-0.138	-0.06	-0.252
P3	-0.345**	0.317*	0.427**	0.421**	0.073	0.304*	0.282*	0.367**	0.328*	-0.328*	-0.242
P4	-0.052	-0.245	0.0	0.0	0.148	0.087	0.180	0.232	-0.185	0.068	-0.346**
P5	-0.342**	-0.350**	0.434**	0.0	0.167	0.353**	-0.121	0.294*	0.376**	-0.407**	-0.334**
P6	-0.314*	-0.298*	-0.137	-0.264*	-0.345**	-0.289*	-0.429**	-0.304*	0.334**	0.314*	0.318*

*Significant at 5% level ** Significant at 1% level

P1 - Sowing to germination

P2 - Germination to first flowering

P3 - First flowering to fifty per cent flowering

P4 - Fifty per cent flowering to pegging

P5 - Pegging to pod formation

P6 - Pod formation to physiological maturity

4.5. EFFECTS OF DATES OF PLANTING AND IRRIGATION ON YIELD AND YIELD ATTRIBUTES

4.5.1. Total pod yield

Yield was found to be significantly influenced by dates of plating. Highest (935.62 kg ha^{-1}) yield was recorded during November 1st planting and a lowest (776.97 kg ha^{-1}) yield was recorded during December 15th planting. Effect of irrigation treatment on yield was found to be significant. Highest (1016.96 kg ha^{-1}) yield recorded under I_3 treatment and lowest yield recorded in I_1 treatment. Interaction between irrigation treatment and dates of planting with respect to yield was found to be non-significant.

4.5.2. Shelling percentage

From the ANOVA table (Table 4.17 (a)) effect of dates of planting on shelling percentage irrespective of irrigation treatment was found to be significant. Shelling percentage recorded during November 1st planting was on par with December 1st planting and shelling percentage recoded during November 15th planting was on par with December 15th planting. Effect of irrigation treatment on shelling percentage was found to be significant. Maximum value (73.09 %) of shelling percentage was recorded under I_3 treatment and I_1 and I_2 treatments were on par. Interaction between irrigation treatment and dates of planting with respect to shelling percentage was found to be no significant.

4.5.3. Harvest index

Effect of dates of planting on harvest index was found to be significant. The results showed that December 1st planting (0.36%) was on par with November 15th planting (0.37%) and November 1st planting. Harvest index recorded during November 15th planting was on par (0.36 %) with December 15th planting (0.34%) Effect of irrigation treatment on harvest index was also found to be significant. Harvest index recorded under I_3 treatment was found to be higher (0.38%) compared to other two treatments and harvest index recorded under I_1 (0.36%) and I_2 (0.34%) treatment were on par. Interaction of irrigation treatment and dates of planting was found to significant with respect to harvest index. During November 1st planting harvest index recorded under I_3 and I_2 treatments were found to be on par.

Table 4.17 (a) Effect of dates of planting on yield and yield attributes

Date of planting	Yield parameters		
	Yield (kg ha^{-1})	Shelling percentage (%)	Harvest Index
1st November	935.62^a	72.12^a	0.36^a
15th November	868.82^c	70.10^b	0.36^{ab}
1st December	897.65^b	71.53^a	0.37^a
15th December	776.97^d	69.51^b	0.34^b
CD	26.09	1.34	0.015

Table 4.17 (b) Effects on irrigation on yield parameters

Irrigation level	Yield parameters		
	Yield (kg ha^{-1})	Shelling percentage (%)	Harvest Index
I_1 (IW/CPE -0.6)	748.28^c	69.36^b	0.36^b
I_2 (IW/CPE -0.8)	844.05^b	69.99^b	0.34^b
I_3 (IW/CPE-1.0)	1016.96^a	73.09^a	0.38^a
CD	28.42	1.26	0.02

Table 4.17(c) Interaction effects between dates of planting and irrigation on total yield

Irrigation level	Dates of planting			
	1st November	15th November	1st December	15th December
I_1 (IW/CPE -0.6)	824.81	743.74	780.54	644.02
I_2 (IW/CPE -0.8	908.77	844.16	879.16	743.88
I_3 (IW/CPE-1.0)	1073.28	1018.55	1033.01	943.02
CD	NS			

4.17(d) Interaction effects between dates of planting and irrigation on shelling percentage

Irrigation level	Dates of planting			
	1st November	15th November	1st December	15th December
I_1 (IW/CPE -0.6)	70.46	68.08	69.66	68.70
I_2 (IW/CPE -0.8	71.94	69.29	70.99	67.91
I_3 (IW/CPE-1.0)	74.69	72.82	73.62	71.70
CD	NS			

Table 4.17(e) Interaction effects between dates of planting and irrigation on harvest index

Irrigation level	Dates of planting			
	1st November	15th November	1st December	15th December
I_1 (IW/CPE -0.6)	0.34[b]	0.37	0.36[b]	0.36
I_2 (IW/CPE -0.8	0.36[ab]	0.34	0.34[b]	0.32
I_3 (IW/CPE-1.0)	0.39[a]	0.37	0.40[a]	0.35
CD	0.04			

4.6. EFFECTS OF DATES OF PLANTING AND IRRIGATION ON PLANT CHARACTER

4.6.1. Weekly plant height (Results are shown in Table 4.18 a,b&c)

Analysis of variance were carried out for plant height recorded at weekly interval up to 120 days and are represented in Appendix II. The effect of dates of planting on plant height was found to be significant. Plant height recorded during November 1st planting was found to be higher compared to other dates of planting in every weekly interval. During fourth week plant height recorded during November 1st planting (13.98) was on par with November 15th planting (13.64). Plant height was found to be decreased with delaying planting. Maximum plant height was recorded during 16th week. The lowest plant height was recorded during December 15th planting in all the weeks.

Effect of irrigation treatment on plant height was found to be significant from 5th week to 16th week. Plant height recorded under I_3 and I_2 treatments were on par during 5th week. From 6th week to 16th week, plant height recorded under I_3 treatment was higher and plant height recorded during I_1 treatment was lower in all weekly intervals. Interaction between dates of planting and irrigation treatment with respect to plant height was found to be significant in 1st week only. During November 1st planting, plant height recorded in 1st week in I_1 treatment (7.01) was on par with I_2 treatment. During November 15th planting plant height (5.58) recorded in I_3 treatment was on par with I_2 treatment in 1st week. During December 1st planting, plant height recorded during I_1 treatment was on par with I_3 treatment.

Table 18 (a) Effect of dates of planting on plant height at weekly intervals

Dates of planting	**Plant height (cm)**															
	Week number															
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
D1	6.55^{a}	9.31^{a}	13.44^{a}	13.98^{a}	15.37^{a}	16.56^{a}	17.45^{a}	18.28^{a}	18.72^{a}	19.19^{a}	19.53^{a}	19.82^{a}	20.11^{a}	20.33^{a}	20.44^{a}	20.45^{a}
D2	5.56^{b}	8.67^{b}	11.32^{b}	13.64^{a}	13.39^{b}	14.43^{b}	15.12^{b}	15.64^{b}	16.10^{b}	16.52^{b}	16.86^{b}	17.18^{b}	17.48^{b}	17.73^{b}	17.91^{b}	17.96^{b}
D3	5.40^{bc}	7.43^{c}	9.01^{c}	10.95^{b}	12.53^{b}	13.29^{b}	14.13^{b}	14.82^{b}	15.46^{b}	16.07^{b}	16.58^{b}	17.08^{b}	17.53^{b}	17.87^{b}	18.08^{b}	18.11^{b}
D4	4.82^{c}	6.88^{c}	8.39^{c}	9.59^{b}	10.64^{c}	11.44^{c}	12.23^{c}	12.87^{c}	13.53^{c}	14.09^{c}	14.63^{c}	15.10^{c}	15.56^{c}	15.81^{c}	15.93^{c}	15.94^{c}
CD	**0.60**	**0.61**	**2.03**	**2.27**	**1.38**	**1.49**	**1.51**	**1.60**	**1.55**	**1.54**	**1.54**	**1.54**	**1.59**	**1.59**	**1.60**	**1.60**

D1 – November 1st, D2 – November 15th, D3 – December 1st, D4 – December 15th

Table 4.18 (b) Effect of irrigation treatment on plant height at weekly intervals

Dates of planting	**Plant height (cm)**															
	Week number															
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
I_1	5.61	8.04	10.01	12.22	12.51^{b}	13.41^{c}	14.13^{c}	14.76^{c}	15.28^{c}	15.79^{c}	17.62^{c}	16.60^{c}	17.02^{c}	17.28^{c}	19.65^{c}	17.47^{c}
I_2	5.55	8.06	11.19	11.80	13.00^{a}	13.91^{b}	14.70^{b}	15.37^{b}	15.89^{b}	16.43^{b}	16.86^{b}	17.26^{b}	17.61^{b}	17.84^{b}	20.49^{b}	18.03^{b}
I_3	5.58	8.12	10.42	12.10	13.43^{a}	14.47^{a}	15.36^{a}	16.08^{a}	16.69^{a}	17.18^{a}	16.22^{a}	18.03^{a}	18.38^{a}	18.69^{a}	21.19^{a}	18.84^{a}
CD	**NS**	**NS**	**NS**	**NS**	**0.44**	**0.44**	**0.42**	**0.39**	**0.35**	**0.33**	**0.32**	**0.30**	**0.31**	**0.30**	**0.60**	**0.30**

I_1 - IW/CPE 0.6, I_2 - IW/CPE 0.8, I_3 - IW/CPE 1.0

Table 4.18 (c) Interaction between dates of planting and irrigation treatment with respect to plant height

Date of planting	Plant height (cm)																			
	Week 1				Week 2				Week 3				Week 4				Week 5			
	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4
I_1	7.01^{a}	5.20^{b}	5.65^{a}	4.60	9.63	8.20	7.57	6.75	12.40	10.55	8.88	8.20	13.89	15.08	10.70	9.21	15.12	12.46	12.28	10.19
I_2	6.51^{ab}	5.58^{ab}	4.97^{b}	5.14	9.36	8.82	7.00	7.04	16.10	11.15	9.23	8.28	14.10	12.46	11.05	9.58	15.40	13.37	12.67	10.57
I_3	6.13^{b}	5.91^{a}	5.59^{a}	4.70	8.96	8.98	7.72	6.84	11.81	12.26	8.94	8.68	13.95	13.38	11.10	9.98	15.59	14.34	12.64	11.17
CD	0.60				NS															

Date of planting	Plant height (cm)																			
	Week 6				Week 7				Week 8				Week 9				Week 10			
	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4
I_1	16.34	13.54	12.74	11.02	17.03	14.17	13.46	11.84	17.80	14.63	14.13	12.50	18.16	15.16	14.70	13.11	18.59	15.58	15.36	13.64
I_2	16.24	14.52	13.46	11.42	17.26	15.16	14.17	12.22	18.10	15.69	14.82	12.86	18.58	16.09	15.44	13.47	19.12	16.55	16.01	14.03
I_3	17.12	15.24	13.66	11.89	18.05	16.02	14.76	12.63	18.92	16.60	15.52	13.25	19.44	17.05	16.23	14.02	19.86	17.44	16.84	14.60
CD	NS																			

D1 – November 1st , D2 – November 15th, D3 – December 1 st, D4 – December 15th

I_1 - IW/CPE 0.6, I_2 - IW/CPE 0.8, I_3 - IW/CPE 1.0

Table 4.18 (c) Interaction between dates of planting and irrigation treatment with respect to plant height

Dates of planting	**Plant height (cm)**															
	Week 11				**Week 12**				**Week 13**				**Week 14**			
	D1	**D2**	**D3**	**D4**	**D1**	**D2**	**D3**	**D4**	**D1**	**D2**	**D3**	**D4**	**D1**	**D2**	**D3**	**D4**
I_1	18.87	15.96	15.83	14.21	19.09	16.36	16.24	14.70	19.36	16.79	16.70	15.23	19.56	17.00	17.05	15.50
I_2	19.54	16.87	16.49	14.53	19.87	17.20	17.03	14.96	20.15	17.41	17.50	15.39	20.36	17.66	17.76	15.58
I_3	20.18	17.74	17.43	15.14	20.50	17.99	17.97	15.65	20.84	18.24	18.38	16.07	21.08	18.53	18.80	16.36
CD	NS															

Dates of planting	**Plant height (cm)**							
	Week 15				**Week16**			
	D1	**D2**	**D3**	**D4**	**D1**	**D2**	**D3**	**D4**
I_1	19.65	17.23	17.28	15.59	19.64	17.32	17.30	15.59
I_2	20.49	17.82	18.00	15.70	20.51	17.85	18.05	15.71
I_3	21.19	18.70	18.96	16.50	21.20	18.70	18.98	16.51
CD	NS							

D1 – November 1st , D2 – November 15th, D3 – December 1 st, D4 – December 15th

I_1 - IW/CPE 0.6, I_2 - IW/CPE 0.8, I_3 - IW/CPE 1.0

4.6.2. **Weekly number of leaves**

Effect of dates of planting on number of leaves irrespective of irrigation treatment was found to be significant in all weeks. Effect of dates of planting on number of leaves at weekly interval is given in Table 4.19 (a). In first week, number of leaves recorded during November 15^{th} planting was higher (15.1) and number of leaves recorded during December 15^{th} planting was lower (9.29). In 2^{nd} week, number of leaves recorded during November 1^{st} and November 15^{th} planting were on par. For third week, Maximum (42.24) number of leaves were recorded during November 1^{st} planting and minimum number of leaves recorded during December 15^{th} planting (25.69). November 15^{th} planting was on par with December 1^{st} planting during 4^{th} week. Number of leaves recorded during December 1^{st} planting was on par with November 1^{st} planting in all the weeks expect 1^{st}, 2^{nd}, 3^{rd}, 15^{th} and 16^{th} week. Number of leaves recorded during December 15^{th} planting was found to be lower in all the weeks.

Effect of irrigation treatment on number of leaves at weekly interval was found to be non- significant up to 10^{th} week. From 11^{th} week to 16^{th} week effect of irrigation treatment on number of leaves was found to be significant. Number of leaves recorded from 11^{th} week to 16^{th} week was found to be higher in I_3 treatment. During 11^{th} week and 12^{th} week, number of leaves recorded in I_2 treatment was on par with I_1 treatment. From 13^{th} to 16^{th} week lower number of leaves were recorded during I_1 treatment. Effect of irrigation treatment on dry matter accumulation at fortnightly interval is given in Table 4.19 (b). Interaction between dates of planting and irrigation treatment with respect to number of leaves presented in table 4.19 (c). Interaction between dates of planting and irrigation treatment with respect to number of leaves were found to be non-significant.

Table 4.19 (a) Effect of dates of planting on number of leaves at weekly intervals

Dates of planting	Number of leaves															
	Week number															
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
D1	12.48^{b}	24.58^{a}	42.24^{a}	53.76^{a}	65.86^{a}	75.76^{a}	83.84^{a}	88.37^{a}	93.34^{a}	95.67^{a}	98.06^{a}	99.62^{a}	105.64^{a}	109.06^{a}	112.94^{a}	115.76^{a}
D2	15.1^{a}	25.28^{a}	36.32^{b}	45.86^{b}	56.00^{b}	64.17^{b}	73.13^{b}	80.50^{b}	87.03^{a}	93.83^{a}	99.13^{a}	102.83^{a}	105.31^{a}	104.74^{a}	103.10^{ab}	100.65^{ab}
D3	10.82^{bc}	20.85^{b}	35.25^{b}	52.21^{ab}	64.96^{a}	75.28^{a}	81.36^{a}	87.62^{a}	92.90^{a}	95.68^{a}	98.13^{a}	98.18^{a}	99.36^{a}	98.40^{a}	94.93^{b}	92.37^{b}
D4	9.29^{c}	17.45^{c}	25.69^{c}	35.60^{c}	42.61^{c}	48.10^{c}	52.42^{c}	56.93^{c}	61.04^{b}	65.88^{b}	68.62^{b}	70.70^{b}	71.18^{b}	70.84^{b}	70.13^{c}	68.66^{c}
CD	**1.96**	**1.90**	**5.64**	**6.99**	**8.10**	**8.91**	**7.58**	**6.95**	**7.53**	**7.95**	**9.96**	**12.40**	**11.99**	**14.17**	**16.72**	**18.32**

D1 – November 1st , D2 – November 15th, D3 – December 1 st, D4 – December 15th

Table.4.19 (b) Comparison between irrigation levels with respect to number of leaves

Dates of planting	Number of leaves															
	Week number															
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
I_1	11.69	21.77	34.35	46.20	56.70	64.73	71.52	77.82	83.16	87.27	89.28^{b}	90.14^{b}	91.45^{c}	91.05^{c}	90.39^{c}	88.83^{c}
I_2	12.24	22.36	34.70	47.42	57.82	65.92	72.44	77.65	83.12	87.43	90.32^{b}	91.65^{b}	94.45^{b}	94.75^{b}	93.85^{b}	92.85^{b}
I_3	11.88	22.00	35.58	46.96	57.56	66.84	74.10	79.60	84.45	88.60	93.35^{a}	96.71^{a}	100.21^{a}	101.47^{a}	101.59^{a}	101.41^{a}
CD	**NS**										**2.55**	**1.74**	**1.87**	**2.49**	**2.30**	**2.35**

I_1 - IW/CPE 0.6, I_2 - IW/CPE 0.8, I_3 - IW/CPE 1.0

Table.4.19 (c) Interaction between dates of planting and irrigation treatment with respect to number of leaves

Dates of planting	Number of leaves																			
	Week 1				**Week 2**				**Week 3**				**Week 4**				**Week 5**			
	D1	**D2**	**D3**	**D4**	**D1**	**D2**	**D3**	**D4**	**D1**	**D2**	**D3**	**D4**	**D1**	**D2**	**D3**	**D4**	**D1**	**D2**	**D3**	**D4**
I_1	12.0	14.5	10.5	9.6	24.9	24.4	20.0	17.6	41.1	35.6	34.5	26.0	52.8	46.4	51.6	33.8	63.7	57.6	65.1	40.3
I_2	13.9	15.5	10.8	8.6	25.9	25.9	20.6	16.9	42.8	36.7	34.2	24.9	54.4	46.3	51.3	37.6	67.5	55.1	63.6	44.9
I_3	11.5	15.3	11.0	9.6	22.8	25.4	21.9	17.7	42.7	36.5	36.9	26.0	54.0	44.8	53.6	35.3	66.3	55.2	66.0	42.5
CD	NS																			

Dates of planting	Number of leaves																			
	Week 6				**Week 7**				**Week 8**				**Week 9**				**Week 10**			
	D1	**D2**	**D3**	**D4**	**D1**	**D2**	**D3**	**D4**	**D1**	**D2**	**D3**	**D4**	**D1**	**D2**	**D3**	**D4**	**D1**	**D2**	**D3**	**D4**
I_1	73.9	64.6	76.4	43.8	82.2	73.6	82.0	48.1	86.0	81.3	90.2	53.6	93.1	87.2	94.0	58.1	95.0	94.4	97.2	62.2
I_2	75.5	64.4	73.2	50.4	84.0	73.1	78.2	54.4	88.9	80.5	84.0	57.1	92.8	87.6	91.3	60.6	95.0	94.2	93.9	66.5
I_3	77.8	63.3	76.0	50.0	85.2	72.6	83.7	54.7	90.0	79.6	88.6	60.0	94.0	86.2	93.2	64.3	96.9	92.8	95.8	68.8
CD	NS																			

D1 – November 1st, D2 – November 15th, D3 – December 1 st, D4 – December 15th

I_1 - IW/CPE 0.6, I_2 - IW/CPE 0.8, I_3 - IW/CPE 1.0

Table.4.19 (c) Interaction between dates of planting and irrigation treatment with respect to number of leaves

Dates of planting	Number of leaves															
	Week 11				Week12				Week 13				Week 14			
	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4
I_1	97.2	96.4	97.7	65.7	97.9	99.1	96.1	67.3	102.1	100.5	96.1	67.0	104.3	99.5	93.4	66.9
I_2	96.6	99.7	96.0	68.9	98.4	101.5	95.8	70.8	104.7	104.4	96.3	72.3	108.1	102.5	96.8	71.5
I_3	100.3	101.2	100.6	71.2	102.5	107.8	102.5	73.9	110.1	110.9	105.6	74.2	114.7	112.0	104.9	74.0
CD	NS															

Number of leaves							
Week 15				Week16			
D1	D2	D3	D4	D1	D2	D3	D4
108.2	96.8	90.8	65.6	110.3	93.7	87.3	63.9
111.4	101.1	92.3	70.5	114.1	98.7	89.9	68.6
119.1	111.4	101.6	74.2	122.8	109.5	99.8	73.4
NS							

D1 – November 1st , D2 – November 15th, D3 – December 1 st, D4 – December 15th

I_1 - IW/CPE 0.6, I_2 - IW/CPE 0.8, I_3 - IW/CPE 1.0

4.6.3. Dry matter accumulation

Analysis of variance was performed for dry matter accumulation at fortnightly interval for four different dates of planting and irrigation treatment were given in appendix II. Effect of dates of planting on dry matter accumulation at fortnightly interval is given in Table 4.20 (a). Dry matter accumulation at fortnightly interval was found to be significantly influenced by dates of planting. The result indicate that dry matter accumulation during November 1st was higher during 30, 45, 60, 90 and 120 DAP. Dry matter accumulation recorded during November 1st planting (2675.55 kg ha^{-1}) was on par with November 15th (2497.47 kg ha^{-1}) 105 DAP. Dry matter accumulation was found to be decreased with the delayed planting.

Effect of irrigation treatment on dry matter accumulation was found to be significant only during 90 days after planting. During 90 days after planting (2159.10 kg ha^{-1}) dry matter accumulation recorded in I_3 treatment was on par with I_1 treatment (2043.10 kg ha^{-1}). Effect of irrigation treatment on dry matter accumulation at fortnightly interval is given in Table 4.20 (b).

Interaction between dates of planting and irrigation treatment with respect to dry matter accumulation was found to be significant during 45, 60, 75 and 105 DAP. Dry matter accumulation recording during November 1st planting was found to be higher (3264.8 kg ha^{-1}) in I_1 treatment at 60 days after planting. Dry matter accumulation recorded in I_2 and I_3 treatment were on par at 75 days after planting. Dry matter accumulation recorded during December 1st planting was found to be higher in I_2 (2307.5 kg ha^{-1}) and I_1 (2250.6 kg ha^{-1}) treatment at 105 days after planting. The result also showed that dry matter accumulation during December 15th planting in I_3 treatment was found to be higher (2372.4 kg ha^{-1}) at 105 days after planting,. Interaction between dates of planting at irrigation treatments with respect to dry matter accumulation presented in Table 20(c).

Table 4.20 (a) Effect of dates of planting on dry matter accumulation at fortnightly intervals

Dates of planting	**Dry matter accumulation (kg ha^{-1})**							
	15DAP	**30DAP**	**45DAP**	**60DAP**	**75DAP**	**90DAP**	**105DAP**	**120DAP**
D1	250.66	626.07^{a}	1995.84^{a}	2746.07^{a}	2170.66^{a}	2629.03^{a}	2675.55^{a}	3326.51^{a}
D2	207.99	375.40^{b}	1002.07^{b}	2088.59^{b}	1980.73^{a}	2263.70^{b}	2497.47^{a}	2712.88^{b}
D3	212.44	436.44^{b}	746.66^{b}	1300.44^{c}	1904.29^{a}	2028.14^{b}	2076.14^{b}	2705.47^{b}
D4	221.62	417.18^{b}	641.48^{b}	832.88^{c}	1418.66^{b}	1209.48^{c}	1934.51^{b}	1873.18^{c}
CD	**NS**	**153.53**	**396.97**	**522.41**	**353.91**	**355.89**	**290.29**	**537.90**

D1 – November 1st , D2 – November 15th, D3 – December 1 st, D4 – December 15th

Table 4.20 (b) Effect of irrigation treatment on dry matter accumulation at fortnightly intervals

Dates of planting	**Dry matter accumulation (kg ha^{-1})**							
	15DAP	**30DAP**	**45DAP**	**60DAP**	**75DAP**	**90DAP**	**105DAP**	**120DAP**
I_1	208.22	467.55	1035.77	1896.66	2165.55	2043.10^{ab}	2314.44	3019.99
I_2	232.22	466.66	1143.33	1619.99	2189.99	1895.55^{b}	2393.10	2995.55
I_3	229.11	457.11	1110.44	1709.33	2236.66	2159.10^{a}	2180.22	3128.88
CD	**NS**					**0.52**	**NS**	**NS**

I_1 - IW/CPE 0.6, I_2 - IW/CPE 0.8, I_3 - IW/CPE 1.0

Table.4.20 (c) Interaction effects between dates of planting and irrigation treatment with respect to dry matter accumulation

Dates of planting	Dry matter accumulation (kg ha^{-1})															
	15DAP				**30DAP**				**45DAP**				**60DAP**			
	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4
I_1	267.5	197.3	215.9	151.9	653.3	352.8	469.3	394.6	1552.8[b]	1154.6	732.4	703.1	3264.8[a]	2111.9	1394.6	815.1
I_2	272.8	219.5	184.8	251.5	636.4	362.6	416.8	450.6	2323.5[a]	915.5	719.9	614.2	2696.8[b]	2007.9	1076.4	698.6
I_3	211.5	207.1	236.4	261.3	588.4	410.6	423.1	406.2	2111.1[a]	935.9	787.5	607.1	2276.4[b]	2145.7	1430.2	984.8
CD	**NS**								**409.27**				**509.67**			

Dates of planting	Dry matter accumulation (kg ha^{-1})															
	75DAP				**90DAP**				**105DAP**				**120DAP**			
	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4	D1	D2	D3	D4
I_1	2167.9	1903.9	2167.1[a]	1424.8	2528.8	2276.4	2177.7	1189.3	2595.5	2835.5	2250.6[a]	1575.9[b]	3478.2	2799.1	2614.2	1888.8
I_2	2103.1	2213.3	1502.2[b]	1403.5	2547.5	2134.2	1750.2	1150.2	2560.8	2848.8	2307.5[a]	1855.1[b]	3060.4	2615.1	2925.3	1844.4
I_3	2240.8	1824.8	2043.5[ab]	1427.5	2810.6	2380.4	2156.4	1288.8	2870.2	1807.9	1670.2[b]	2372.4[a]	3440.8	2724.4	2576.8	1886.2
CD	**573.08**				**NS**				**418.57**				**NS**			

D1 – November 1st , D2 – November 15th, D3 – December 1 st, D4 – December 15th

I_1 - IW/CPE 0.6, I_2 - IW/CPE 0.8, l_3 - IW/CPE 1.0

4.6.4. Leaf area index

Effect of dates of planting on leaf area index at fortnightly interval was found to be statistically significant during 15, 30, 45 and 60 days after planting. Table 4.21 (a) represent the effect of dates of planting on leaf area index at fortnightly interval. The result showed that the highest value of leaf area index at 15 days after planting was observed during November 1^{st} planting. Leaf area index recorded during November 1^{st} planting (0.22) was on par with November 15^{th} planting (0.18) and leaf area index recorded during December 1^{st} planting (0.14) was on par with December 15^{th} planting (0.12) at 15 days after planting. At 30 days after planting, leaf area index recorded at fortnightly interval during November 1^{st} planting (0.61) was on par with November 15^{th} planting (0.50) and that recorded during November 15^{th} planting was on par with December 1^{st} (0.48) and December 15^{th} (0.42) planting. At 45 days after planting, leaf area index recorded fortnightly interval during November 1^{st} planting (0.87) was on par with November 15^{th} planting (0.82) and December 1^{st} planting (0.88).

The effect of irrigation treatment on leaf area index recorded at fortnightly interval was found to be significant at 75, 90, 105 and 120 DAP. At 75 days after planting and 90 days after planting leaf area index recorded during I_3 treatment was on par (1.45) with I_2 (1.44) and that recorded during I_2 was on par with I_1. Whereas, 105 day after planting and 120 days after planting maximum leaf area index was recorded under I_3 treatment and that recorded under I_2 and I_1 treatments were on par. Interaction between dates of planting and irrigation treatments with respect to leaf area index was found to be non-significant during all fortnightly interval. Interaction between dates of planting at irrigation treatments with respect to leaf area index presented in Table21 (c).

Table 4.21 (a) Effect of dates of planting on Leaf area index at fortnightly intervals

Dates of planting	Leaf area index							
	15DAP	**30DAP**	**45DAP**	**60DAP**	**75DAP**	**90DAP**	**105DAP**	**120DAP**
D1	0.22[a]	0.61[a]	0.87[a]	1.13[ab]	1.34	1.57	1.75	1.81
D2	0.18[a]	0.50[ab]	0.82[a]	1.22[a]	1.34	1.59	1.70	1.71
D3	0.14[b]	0.48[b]	0.88[a]	1.30[a]	1.51	1.63	1.77	1.71
D4	0.12[b]	0.42[b]	0.62[b]	0.92[b]	1.33	1.66	1.83	1.80
CD	**0.04**	**0.011**	**0.019**	**0.24**	**NS**			

D1 – November 1st , D2 – November 15th, D3 – December 1 st, D4 – December 15th

Table 4.21 (b) Effect of irrigation treatment on leaf area index at fortnightly intervals

	Leaf area index							
Irrigation level	**15 DAP**	**30 DAP**	**45 DAP**	**60 DAP**	**75 DAP**	**90 DAP**	**105DAP**	**120DAP**
I_1	0.16	0.49	0.80	1.07	1.26[b]	1.45[b]	1.58[b]	1.57[b]
I_2	0.16	0.53	0.79	1.23	1.44[ab]	1.61[ab]	1.67[b]	1.70[b]
I_3	0.18	0.48	0.81	1.12	1.45[a]	1.77[a]	2.05[a]	2.02[a]
CD	**NS**				**0.18**	**0.16**	**0.38**	**0.36**

I_1 - IW/CPE 0.6, I_2 - IW/CPE 0.8, l_3 - IW/CPE 1.0

Table.4.21 (c) Interaction between dates of planting and irrigation treatment with respect to leaf area index

Date of planting	Number of leaves																			
	15 DAP				30 DAP				45 DAP				60 DAP				75 DAP			
	D1	**D2**	**D3**	**D4**	**D1**	**D2**	**D3**	**D4**	**D1**	**D2**	**D3**	**D4**	**D1**	**D2**	**D3**	**D4**	**D1**	**D2**	**D3**	**D4**
I_1	0.19	0.19	0.14	0.12	0.59	0.48	0.48	0.41	0.92	0.84	0.89	0.54	1.06	1.13	1.24	0.85	1.16	1.28	1.42	1.18
I_2	0.22	0.18	0.13	0.12	0.66	0.55	0.47	0.45	0.87	0.77	0.82	0.68	1.32	1.27	1.37	0.97	1.55	1.34	1.51	1.35
I_3	0.24	0.19	0.15	0.13	0.57	0.47	0.49	0.40	0.83	0.85	0.92	0.64	1.00	1.25	1.30	0.94	1.31	1.39	1.61	1.48
CD	NS																			

Date of planting	Number of leaves											
	90 DAP				105 DAP				120 DAP			
	D1	**D2**	**D3**	**D4**	**D1**	**D2**	**D3**	**D4**	**D1**	**D2**	**D3**	**D4**
I_1	1.40	1.45	1.53	1.42	1.62	1.49	1.58	1.61	1.65	1.55	1.50	1.57
I_2	1.74	1.52	1.49	1.72	1.67	1.54	1.61	1.85	1.76	1.59	1.57	1.86
I_3	1.58	1.78	1.87	1.85	1.96	2.06	2.11	2.07	2.01	1.99	2.06	2.00
CD	NS											

D1 – November 1^{st} , D2 – November 15^{th}, D3 – December 1 st, D4 – December 15^{th}

I_1 - IW/CPE 0.6, I_2 - IW/CPE 0.8, l_3 - IW/CPE 1.0

Table 4.22 Genetic coefficients calibrated for the variety TNAU CO-6

Growth and development aspects of the groundnut crop	Description of parameter coefficients controlling development aspects	Genetic coefficients
CSDL	Critical Short Day Length below which reproductive development progresses with no day length effect (for short day plants) (hours)	**11.84**
PPSEN	Slope of the relative response of development to photoperiod with time (negative for long day plants) (1/ hour)	**0.00**
EM-FL	Time between plant emergence and flower appearance (R1) (photothermal days)	**27.0**
FL-SH	Time between first flower and first pod (R3) (photothermal days)	**11.2**
FL-SD	Time between first flower and first seed (R5) (photothermal days)	**15.4**
SD-PM	Time between first seed (R5) and physiological maturity (R7) (photothermal days)	**84.69**
FL-LF	Time between first flower (R1) and end of leaf expansion (photothermal days)	**80.00**
LFMAX	Maximum leaf photosynthesis rate at 30 °C, 350 vpm CO_2 and high light (mg CO_2 / m^2 / s)	**1.54**
SLAVR	Specific leaf area of cultivar under standard growth conditions (cm^2 /g)	**275**
SIZLF	Maximum size of full leaf (three leaflets) (cm^2)	**13.5**
XFRT	Maximum fraction of daily growth that is partitioned to seed + shell	**0.80**
WTPSD	Maximum weight per seed (g)	**0.950**
SFDUR	Seed filling duration for pod cohort at standard growth conditions (photothermal days)	**35.3**
SDPDV	Average seed per pod under standard growing conditions	**1.72**
PODUR	Time required for cultivar to reach final pod load under optimal conditions (photothermal days)	**15.4**
TRESH	Threshing percentage. The maximum ratio of (seed/ (seed + shell)) at maturity. Causes seeds to stop growing as their dry weight increases until shells are filled in a cohort.	**68.3**
SDPRO	Fraction protein in seeds (g (protein)/g(seed))	**270**
SDLIP	Fraction oil in seeds (g (oil) /g (seed)	**510**

4.6. CALIBRATION OF GENETIC COEFFICIENTS

The peanut crop with four dates of sowing (November 1st, November 15th, December 1st and December 15th) has been raised at Instructional Farm, KAU, Vellanikkara. Data collected from the experiment was used for calibrating genetic coeffient for TNAU CO-6 variety. DSSAT CROPGO- peanut model was used in simulation studies. The Genetic coefficients for the variety TNAU CO-6 are developed and presented in the Table 4.22.

Model performance was evaluated using three statistics *i.e* Root Mean Square Error (RMSE), Mean Absolute Percentage Error (MAPE) and d-stat index for yield and phenophases and given in Table 4.23.

Table 4.23. RMSE, MAPE and D-stat index for yield and phenophases

Variable name	**RMSE**	**MAPE**	**d-stat**
Days to germination	1.32	1	0.42
Days to anthesis	2.21	2	0.41
Days to physiological maturity	5.01	4	0.41
Total yield	185.23	143	0.73
Threshing percentage	4.07	3.56	0.42
Harvest index	0.108	0.099	0.23

4.6.1. Days to germination

Model performance to predict number of days taken for germination was evaluated by calculating error percentage. Error percentage was calculated for each treatments using observed and simulated values and were represented in Table 4.24. Results showed that the observed duration of days to germination varied between 5 to 8 days among treatments, while simulated value of days to germination was 6 days in all dates of sowing. It was found that the model underestimated the days to germination in all dates of sowing exept for D1 planting.

Table 4.24. Predicted and observed values of number of days taken for germination

Treatment	Germination		Error (%)
	Simulated	Observed	
D1 I_1	6	5	20.00
D2 I_1	6	7	-14.29
D3 I_1	6	7	-14.29
D4 I_1	6	8	-25.00
D1 I_2	6	5	20.00
D2 I_2	6	7	-14.29
D3 I_2	6	7	-14.29
D4 I_2	6	8	-25.00
D1 I_3	6	5	20.00
D2 I_3	6	7	-14.29
D3 I_3	6	7	-14.29
D4 I_3	6	8	-25.00
Average	6	6.75	-8.4

Error percentage = [simulated value- Observed value]/Observed value*100

4.6.2. Days to anthesis

The model simulated values of days to anthesis was 35 days under all treatments. The observed anthesis day varied between 31-37 days. The model underestimated days to anthesis for all dates of sowing exept D1 planting. The comparison between observed and simulated days to anthesis and error percentage were presented in Table 4.25.

4.25 Predicted and observed values of anthesis days

Treatment	**Anthesis days**		**Error (%)**
	Simulated	**Observed**	
D1 I_1	35	37	-5.41
D2 I_1	35	33	6.06
D3 I_1	35	34	2.94
D4 I_1	35	35	0.00
D1 I_2	35	37	-5.41
D2 I_2	35	31	12.90
D3 I_2	35	34	2.94
D4 I_2	35	33	6.06
D1 I_3	35	36	-2.78
D2 I_3	35	33	6.06
D3 I_3	35	31	12.90
D4 I_3	35	33	6.06
Average	35	33.92	3.53

Error percentage = [simulated value- Observed value]/Observed value*100

4.6.3. Days to physiological maturity

A comparison between the model simulated values and the observed values for duration of physiological maturity is presented in Table 4.26. The results showed that, the observed duration of physiological maturity varied from 142 to 149 days for all the treatments. Whereas, simulated values by model ranged between 138-142. Model underestimated the duration of physiological maturity in all treatments.

Table 4.26 Predicted and observed values for days to physiological maturity

Treatment	**Physiological maturity**		**Error (%)**
	Simulated	**Observed**	
D1 I_1	138	142	-2.82
D2 I_1	139	146	-4.79
D3 I_1	140	149	-6.04
D4 I_1	140	148	-5.41
D1 I_2	140	142	-1.41
D2 I_2	145	146	-0.68
D3 I_2	140	149	-6.04
D4 I_2	141	148	-4.73
D1 I_3	141	142	-0.70
D2 I_3	143	146	-2.05
D3 I_3	142	149	-4.70
D4 I_3	142	148	-4.05
Average	140.92	146.25	-3.62

Error percentage = [simulated value- Observed value]/Observed value*100

4.6.4. Total yield

The comparison between observed and simulated pod yield were presented in Table 4.27. The highest observed mean pod yield was recorded during November 1st planting in I_3 treatment (1073 kg ha^{-1}). Whereas, highest simulated pod yield observed during December 1st plating in I_3 treatment (1033 kg ha^{-1}). Model underestimated the pod yield among all treatments.

Table 4.27. Predicted and observed values for total yield

Treatment	Total yield		Error (%)
	Simulated (kg ha^{-1})	Observed (kg ha^{-1})	
D1 I_1	877	824.8	6.33
D2 I_1	476	743.7	-36.00
D3 I_1	432	780.5	-44.65
D4 I_1	393	644	-38.98
D1 I_2	596	908.7	-34.41
D2 I_2	736	844.1	-12.81
D3 I_2	781	879.3	-11.18
D4 I_2	653	743.8	-12.21
D1 I_3	914	1073	-14.82
D2 I_3	1014	1018	-0.39
D3 I_3	1018	1033	-1.45
D4 I_3	947	943.0	0.42
Average	736.42	869.66	-16.68

Error percentage = [simulated value- Observed value]/Observed value*100

4.6.5. Shelling percentage

The comparison between observed and simulated shelling percentage and calculated error percentage were presented in Table 4.29. The mean value of observed shelling per cent was 67.35 % and the model simulated value was 70.91 %. The evaluation of the model on an overall basis revealed that the model performance in simulation of shelling percentage was found to be good with an acceptable level.

Table 4.29 Predicted and observed values of shelling percentage

Treatment	Shelling percentage		Error (%)
	Simulated	Observed	
D1 I_1	66.62	70.4	-5.37
D2 I_1	67.56	68.0	-0.65
D3 I_1	66.87	69.6	-3.92
D4 I_1	66.89	68.7	-2.63
D1 I_2	65.66	71.9	-8.68
D2 I_2	68.26	69.2	-1.36
D3 I_2	67.20	70.9	-5.22
D4 I_2	67.00	69.5	-3.60
D1 I_3	67.32	74.6	-9.76
D2 I_3	68.51	72.8	-5.89
D3 I_3	67.99	73.6	-7.62
D4 I_3	68.29	71.7	-4.76
Average	67.35	70.91	-4.95

Error percentage = [simulated value- Observed value]/Observed value*100

4.6.6. Harvest index

Data pertaining to harvest Index is given in Table 4.30. The observed mean harvest index value was 0.36 and the mean model simulated value was 0.27. Looking to the overall performance of the model it was found out that model underestimated harvest index among all treatments.

Table 4.30 Predicted and observed values of harvest index

Treatment	**Harvest index**		**Error (%)**
	Simulated	**Observed**	
D1 I_1	0.22	0.35	-37.14
D2 I_1	0.24	0.38	-36.84
D3 I_1	0.2	0.36	-44.44
D4 I_1	0.22	0.37	-40.54
D1 I_2	0.27	0.35	-22.86
D2 I_2	0.35	0.38	-7.89
D3 I_2	0.3	0.36	-16.67
D4 I_2	0.22	0.37	-40.54
D1 I_3	0.3	0.35	-14.29
D2 I_3	0.33	0.38	-13.16
D3 I_3	0.3	0.34	-11.76
D4 I_3	0.28	0.36	-22.22
Average	0.27	0.36	-25.70

Error percentage = [simulated value- Observed value]/Observed value*100

Discussion

5. DISCUSSION

This experiment was aimed at studying the crop weather relationship of groundnut under different dates of sowing and varying irrigation levels and to calibrate the genetic coefficient of groundnut variety TNAU CO-6 using DSSAT-CROPGRO model. The results obtained from the experiments are discussed objective wise in this chapter and are presented here.

Two objectives framed under this study were, to investigate crop weather relationship in groundnut at varying irrigation level and to calibrate genetic coefficient for TNAU CO-6 groundnut variety.

Discussion begins with the first objective was meant to understand the crop weather relationship in groundnut under varying irrigation levels.

The important factor influencing crop growth and yield is moisture stress during the crop growth period. Proper irrigation scheduling will assure adequate soil moisture conditions, proper absorption of plant nutrients, growth of soil microbes and avoid moisture stress related yield losses. In this study, effect of weather parameters on growth and development of groundnut was studied under different IW/CPE ratios. Performance of the crop under different weather conditions were studied by adopting different dates of planting.

The growth parameters like plant height, number of leaves and leaf area index were found to be significantly higher under D1 (November 1st) planting and it was found to be decreasing towards delay in planting. According to Padmalatha *et al.* (2002), high relative humidity during morning and evening would significantly reduce the plant height. Compared to other three plantings, D1 planting experienced a lower value of both forenoon and after noon relative humidity and relative humidity increased with delay in planting (Fig 5.1). This trend of relative humidity resulted in a higher value of plant height during D1 and reduced plant height with delay in planting.

The maximum number of leaves was observed for November 1st (D1) planting which was superior over D3 (December 1st), D2 (November 15th) and D4 (December 15th) planting, *i.e* with delay in planting number of leaves decreases (Fig. 5.2). Similar results was given by Giridhar (2019) and Desai (1989). According to them, the maximum number of functional leaves was recorded in D1 *i.e*. 87.6 was significantly superior over D2 (85.8), D3 (82.9) and D4 (82) planting. Increased number of leaves were associated with increased shoot length.

Maximum leaf area index was observed for November 1st planting and the value of LAI reduced with delay in planting. This result shows similarity with the findings of Banik *et al*. (2009). According to Banik *et al*. (2009) each dates of planting, maximum value of LAI was recorded at 60 DAS after that LAI decreases because of the advancement of growth, senescence and leaf fall. Hardwick *et al.* (2014) found that maximum air temperature showed a significant negative correlation with LAI. The maximum temperature experienced during vegetative stage was less under early planting *i.e* D1 and D2 and increased with delay in planting. The effect of this maximum air temperature might have reduced the leaf area index with delay in planting (Fig. 5.3).

Yield and yield attributes were significantly influenced by dates of planting .The higher yield were observed for November 1st (D1) planting, with delay in planting yield decreased. This result was in accordance with Giridhar (2019) and Patil *et al*. (2007). According to them the maximum pod yield was noticed in D1 (2085 kg ha^{-1}) which was superior in yield, followed by D2 (2035 kg ha^{-1}), D3 (1956.5 kg ha^{-1}) and D4 (1895.8 kg ha^{-1}). The different weather conditions experienced under different dates of planting lead to difference in yield under each dates of planting.

A larger portion of irrigation water applied is consumed for vegetative growth. The growth characters like plant height, number of leaves and dry matter production was affected by quantity and frequency of irrigation (Behra *et al*., 2015). Chandoba (2012) observed that yield showed a significant negative correlation with bright sunshine hours during pod maturity stage and significant positive correlation was shown during physiological maturity stage. A low value of bright sunshine hours experienced in pod maturity stage during first dates of planting might be reason for highest yield during this period (Fig. 5.4). Afternoon and forenoon relative humidity experienced during P6 stage showed a negative influence on yield (Fig. 5.5 and Fig. 5.6). The results was in accordance with Chandoba (2012). The increase in relative humidity would reduce the transpiration rate. A reduction in transpiration rate resulted in reduced rate of transfer of water, nutrients and photosynthetic assimilate, which would have affected the yield. The yield of groundnut directly depends on shelling percentage. Higher yield recorded under November 1st planting was attributed to higher shelling percentage and harvest index recorded during this period.

The early planting of ground nut *i.e* during November 1st planting coincided with north east monsoon. Under this condition, crop rarely experiences moisture stress during crop growth stage especially during critical crop growth stages. Unfavorable conditions like lack of rainfall and resulting moisture stress reduced yield under delayed planting. Similar findings were reported by Patel *et al*. (2013). In this experiment, rain fall received during pegging stage would have influenced the yield. Rainfall received during pegging stage was higher under November 1st planting and was less under December 15th planting (Fig. 5.9). The sufficient rainfall received during pegging stage results in enriched soil moisture and the soils get loosened under high soil moisture conditions which favored pegging and resulted in higher yield.

Lenka (1998) reported that, if the crop is subjected to a higher mean temperature particularly at the critical phenophases such as pegging, pod formation and pod development, the yield would adversely affected. The mean temperature experienced during early planting was less and it was found to be increasing with delay in planting. The negative influence of temperature also would have contributed to yield reduction in delayed planting (Fig. 5.10).

The combined effect of above mentioned weather parameters was responsible for variation in growth and yield parameters under different dates of planting.

Three different irrigation scheduling treatments *i.e* IW/CPE ratio 0.6 (I_1), 0.8 (I_2) and 1.0 (I_3) were compared. Amount of water supplied in one irrigation was 50 mm. The irrigation frequency and total amount of irrigation water was different under different dates of planting and irrigation treatments, which is represented in Fig. 5.7 and 5.8. Among the three irrigation treatments, maximum irrigation frequency was observed under I_3 treatment. Hence more amount of water was supplied under I_3 treatment. Hence soil moisture was enriched more under I_3 treatment.

Plant growth is the funcion of cell divsion and its enlargement (Kramer, 1969). Irrigation enhances the growth of plant by increasing cell water potential and there by cell division and enlargement leading to more plant height. Plant height was reduced due to moisture stress that inhibited cell enlargement more than cell division (Shao *et al*., 2008). In this study, maximum water availability was there under I_3 treatment hence a maximum plant height was recorded under this treatment in all dates of plantings. The desirable influence of irrigation on plant height of groundnut was observed by Lourderaj (2000) which confirms the findings of this study.

Maintanance of optimum soil moisture condition enhances growth process and resulting in increased number of leaves, dry matter accumulation and leaf area index. Leaf area index is a better determining factor of crop growth, which determines the photosynthetic capacity of the crop (Watson, 1952). Increased LAI under I_3 treatment would have complemented to yield by increased photosynthetic capacity. Similar results were observed by Mane (2002). He suggested that among the five IW/CPE ratios (0.6, 0.75, 0.9, 1.05 and 1.20), a minimum plant height was recorded under 0.6 ratio, highest value of plant height was recorded under the treatment 1.20 IW/CPE ratio and next best treatment was 1.05 IW/CPE ratio.

According to Dutta and Mandal (2006), application of irrigation water guarantees steady availability of soil moisture to crop, which therefore increases uptake of nutrient, fertilizer use efficiency, growth and development. It ultimately reflects on accumulation of higher dry matter in aerial parts. Increased irrigation frequency and moisture supply under I_3 treatment was responsible for higher growth rate and dry matter accumulation.

The increase in soil moisture levels reduces the soil strength (Gill, 1959) and facilitates the ease with which the soil can be deformed to accommodate the enlarging underground plant organs. Good growth and development of pods were observed in crops subjected to adequate moisture supply (Behra *et al*., 2015). Hence high moisture availability under I_3 treatment resulted in high yield and moisture stress under I_1 treatment resulted in low yield.

Pods are formed on the axis of stems, longer the branches possibility of formation of more number of pods are high (Behra *et al*., 2015). As mentioned earlier, higher soil moisture supply leads to the taller plants under I_3 treatment. This might have lead to increased number of pod and contributed to yield. Moisture stress experienced during pod development stage might be the reason for reduced shelling percentage with delay in planting. Similar result was observed by Patel (1995) and Parihar *et al*. (1999).

The favourable weather parameters along with adequate soil moisture conditions under I_3 irrigation treatment of November 1st planting was responsible for the higher yield and growth parametrs recorded during this period. The moisture stress coupled with unfavourable weather conditions resulted in yield reduction and reduced growth under delayed planting.

The second objective of the study was to calibrate genetic coefficient for TNAU CO-6 groundnut variety. Using the data collected from the field experiment the genetic coefficients for the particular variety was calibrated.

Model helps farmers to make decisions in agricultural planning by prediction of groundnut yields at various stages of crop growth based on weather variables. Genetic coefficients for TNAU CO-6 varieties were calibrated. Goodness of fitness between simulated and observed variable was examined.

Two statistics were used to evaluate the model performances. Root Mean Square Error (RMSE) and d-stat index. Willmott (1982) stated that the d-stat index value should approach unity and the RMSE should approach zero for good performance of the model.

The simulated yield and observed yield were analyzed. Simulated values of number of days taken for germination, anthesis, physiological maturity, pod yield and threshing percentage were also simulated and were in good agreement with the observed duration (Fig. 5.11 to 5.16).

According to Vysakh *et al*. (2016), the percentage deviation between observed and predicted values within 10 per cent indicates good performance of the model. The average error percentage calculated for days to germination, anthesis, physiological maturity and shelling percentage was less than 10 per cent. Hence the model performance in predicting the above variables was good. Among the different phenophases model could able to predict days to germination more accurately.

Model predicted pod yield more accurately than the phenophases with a d-stat value of 0.73 and RMSE value 185.23. The d-stat value indicates that the model performance in predicting pod yield was excellent. Similar result was reported by Giridhar (2019).

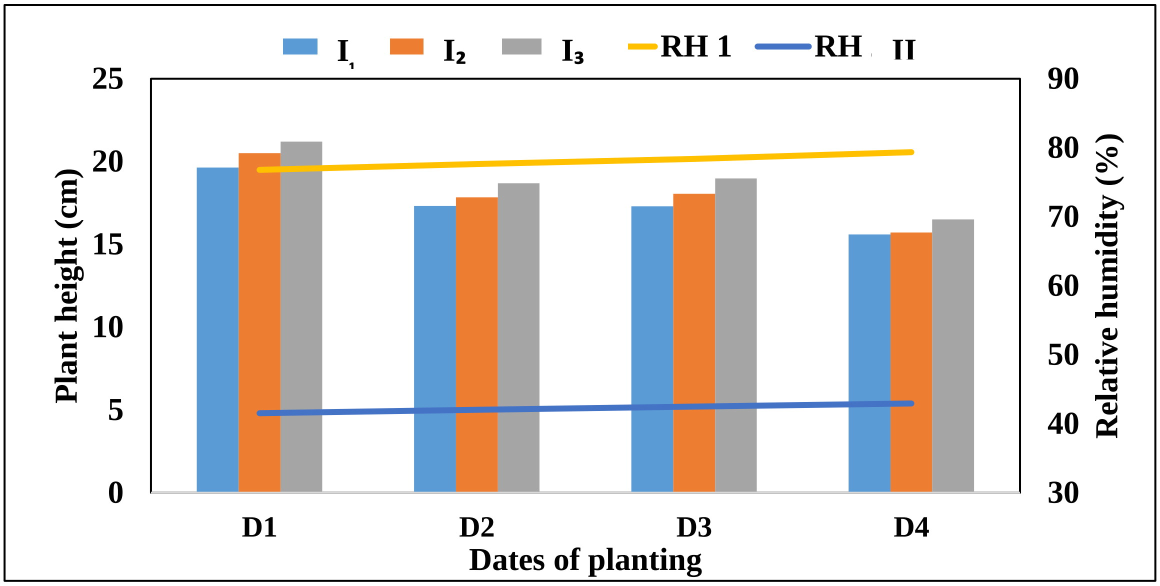

Fig 5.1. Influence of forenoon and after noon relative humidity on plant height

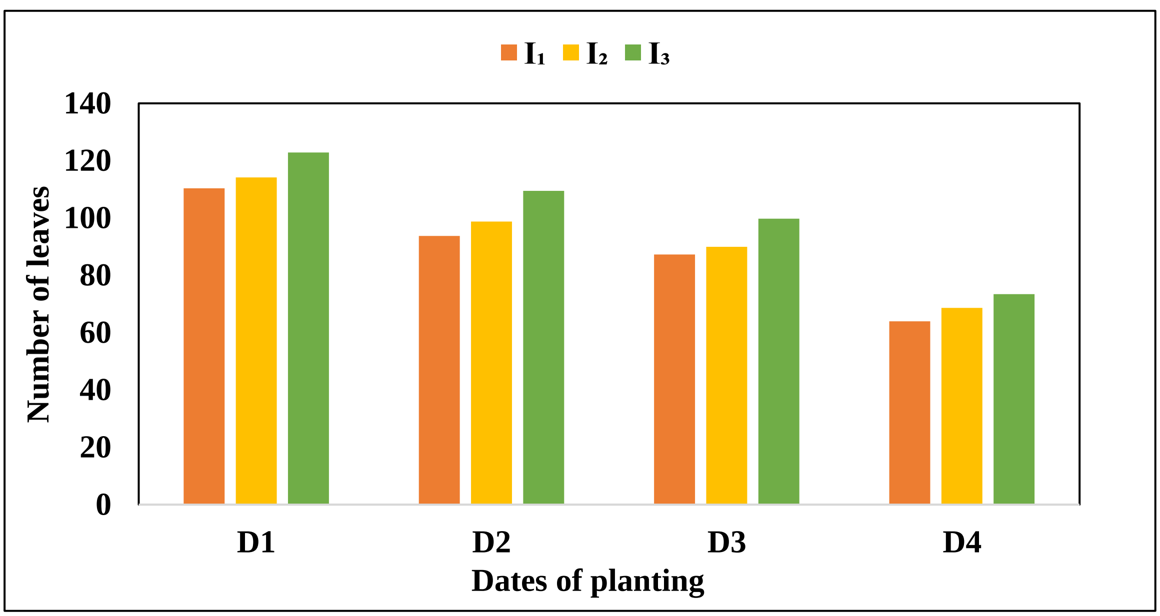

Fig. 5.2. Number of leaves per plant recorded under different dates of planting and irrigation

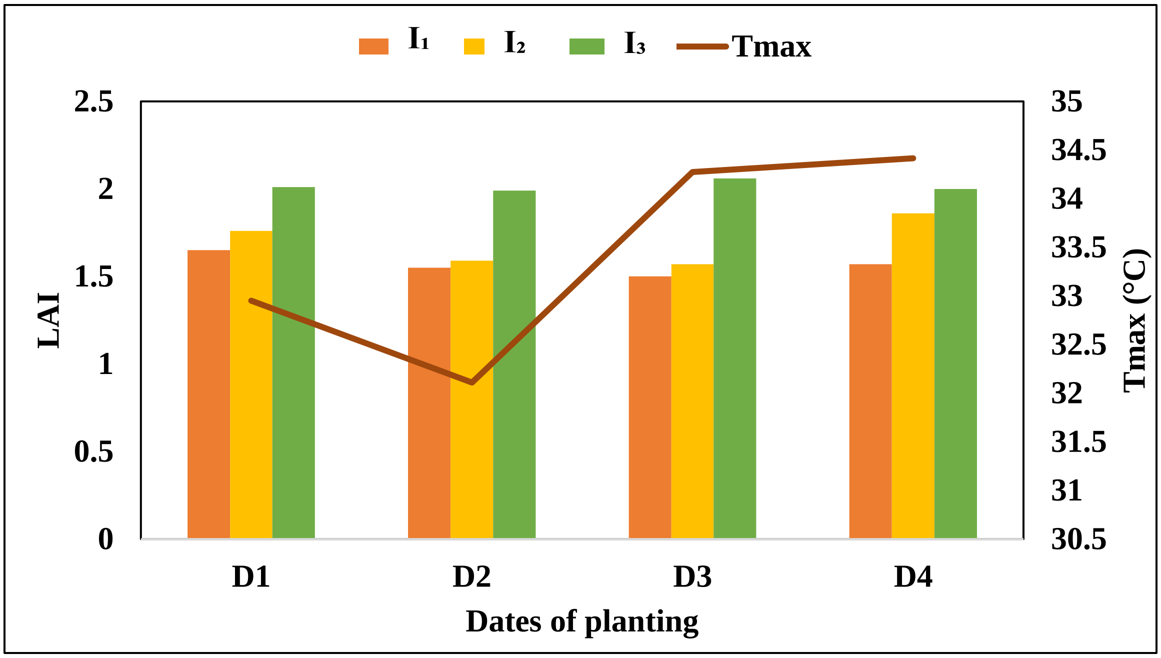

Fig. 5.3. Effect of maximum temperature on leaf area index

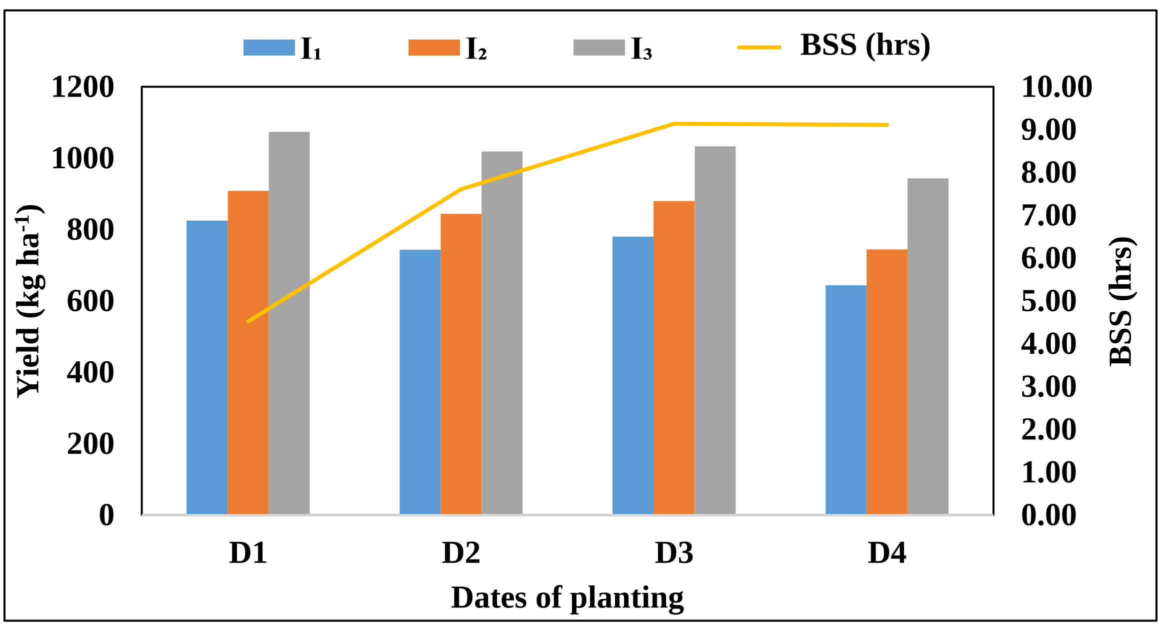

Fig. 5.4. Effect of bright sunshine hours on yield

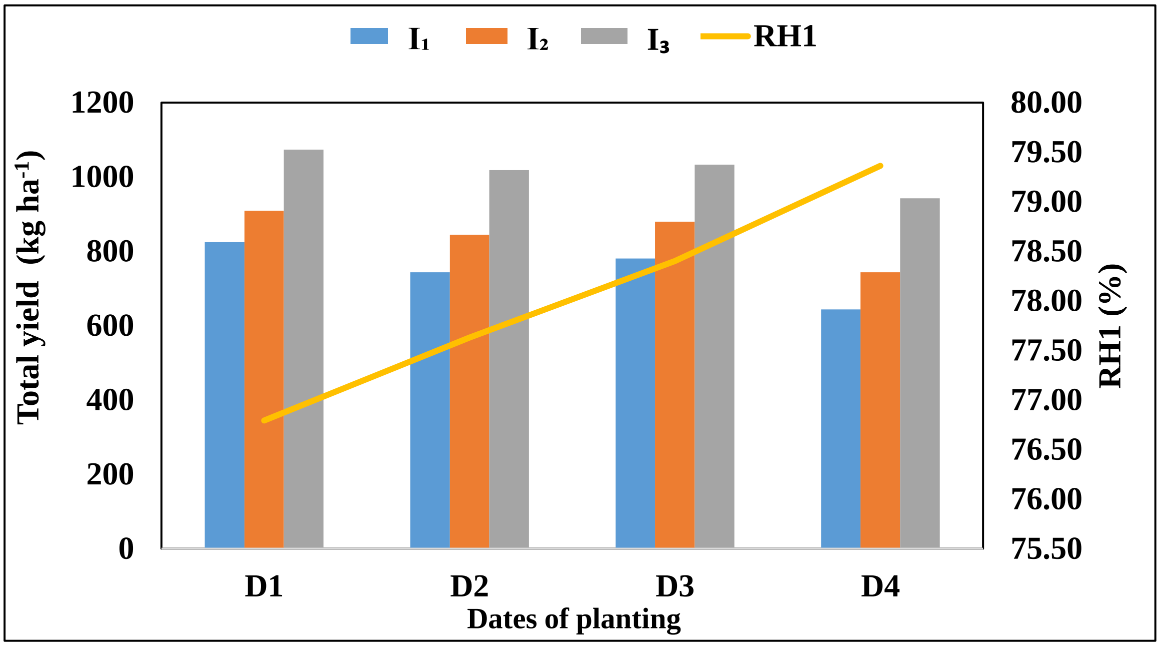

Fig. 5.5. Effect of Forenoon relative humidity on yield

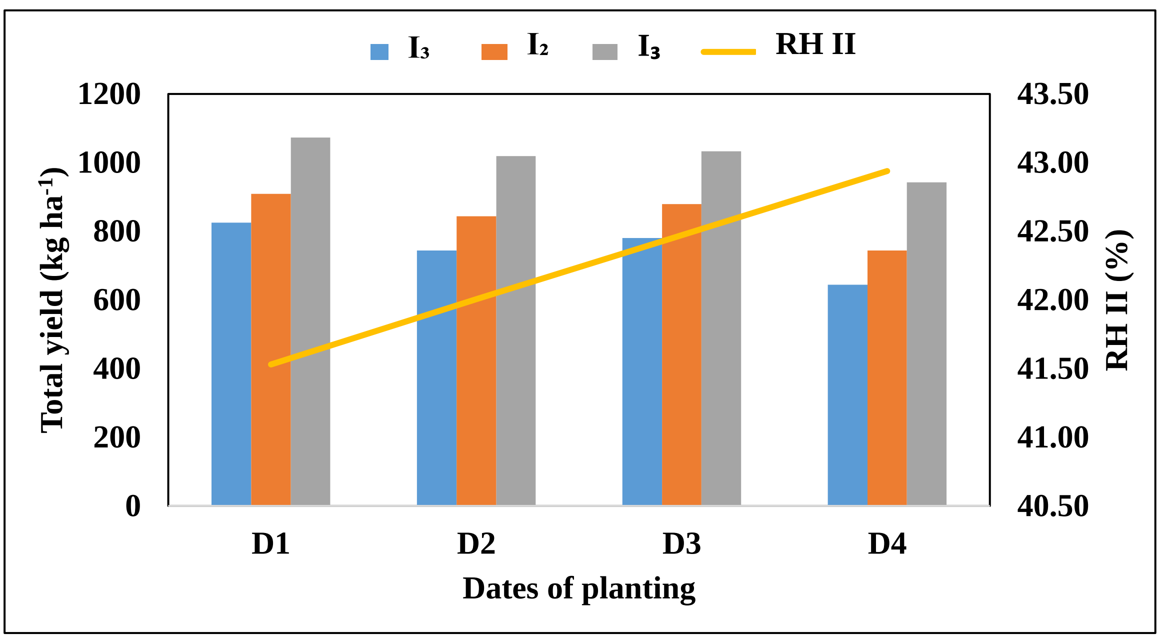

Fig. 5.6. Effect of afternoon relative humidity on yield

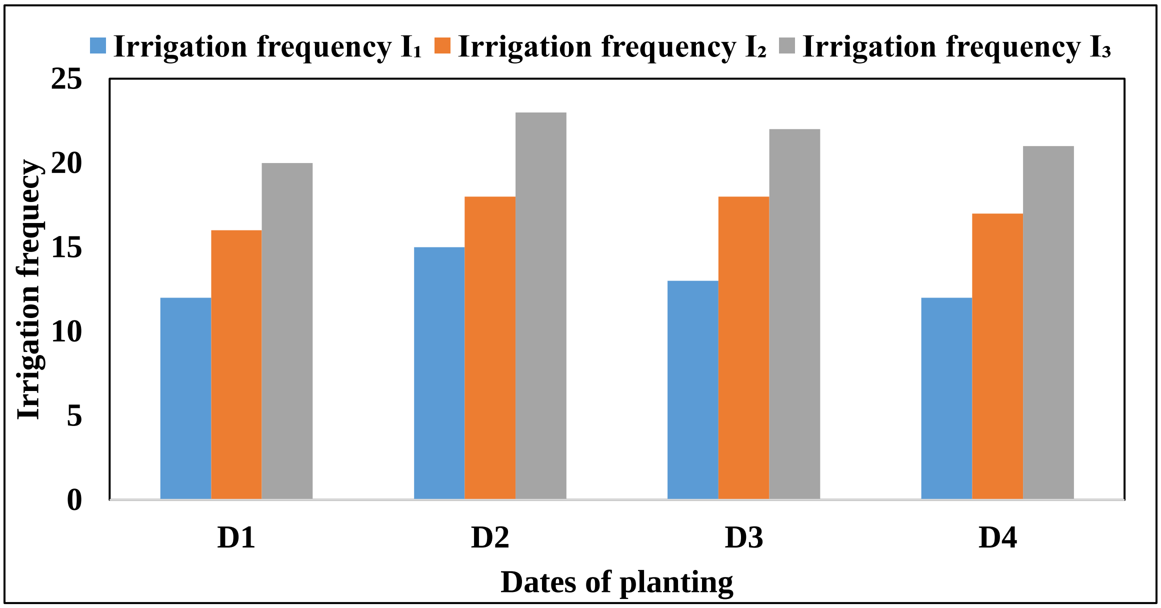

Fig 5.7. Irrigation frequency under different planting

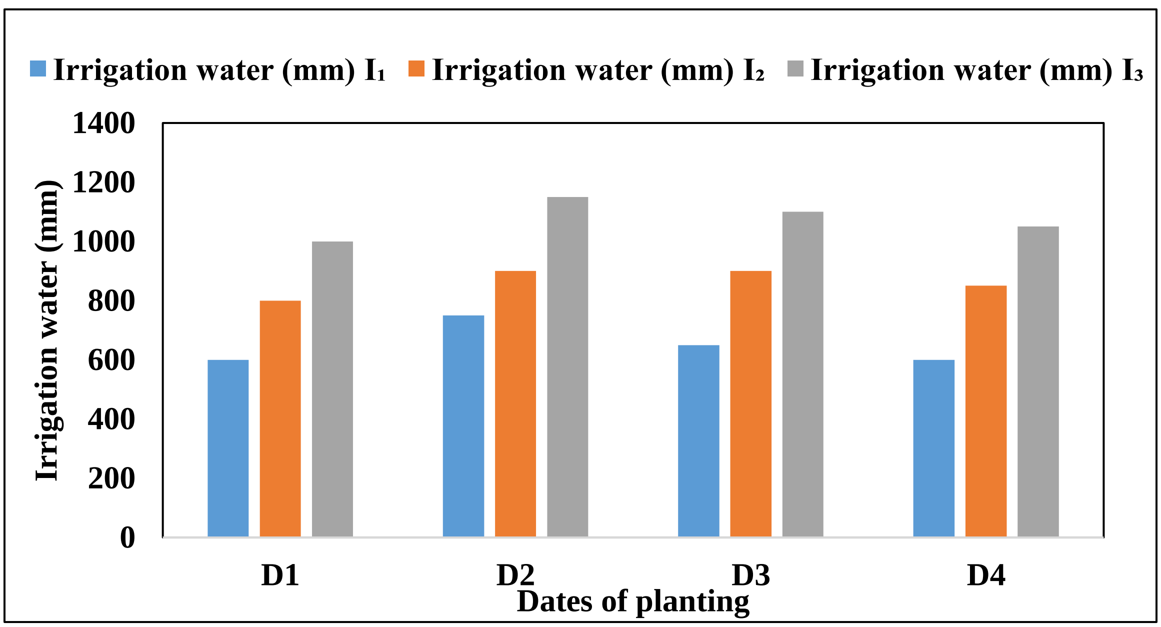

Fig 5.8. Total amount of irrigation water

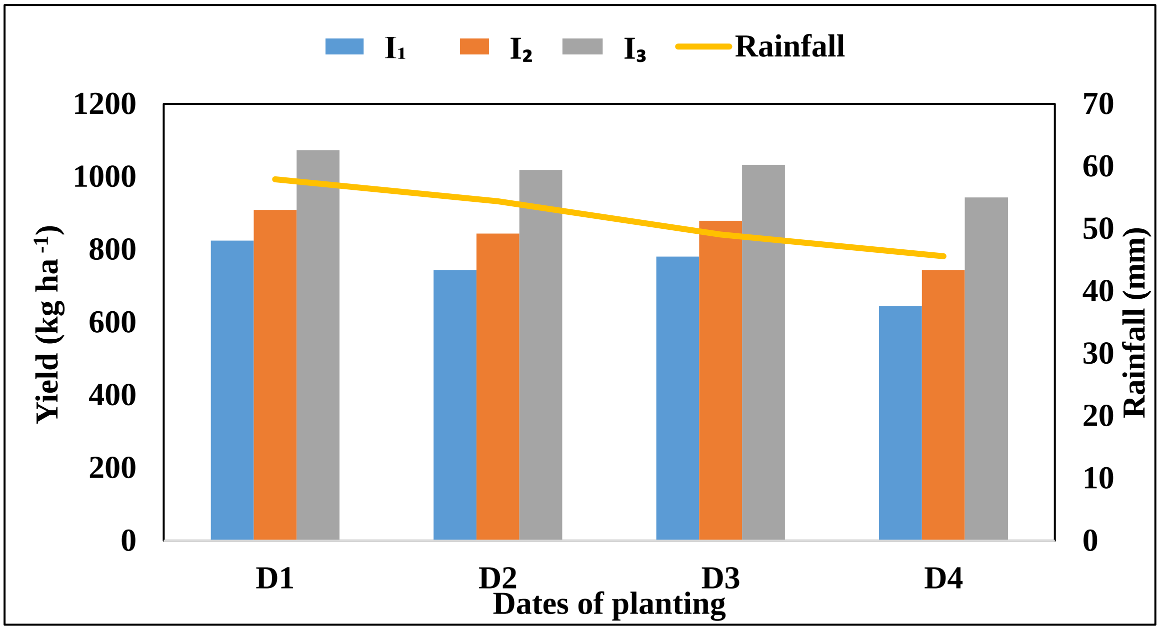

Fig 5.9. Effect of rainfall received during pegging stage on yield

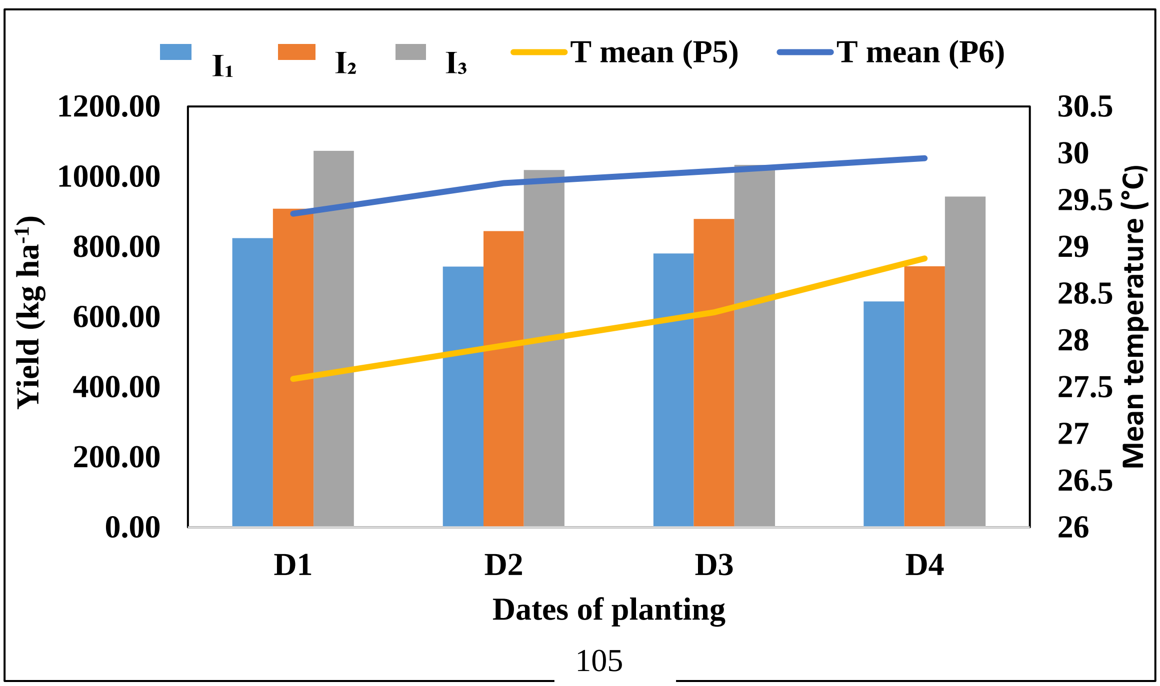

Fig. 5.10. Effect of mean temperature experienced during P5 and P6 stage on yield

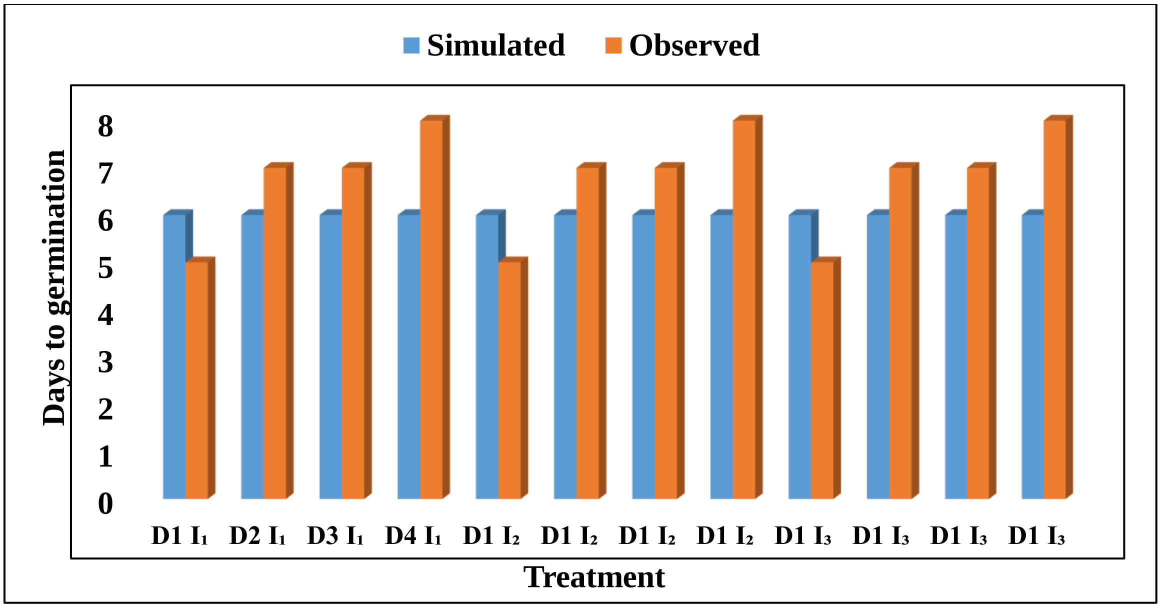

Fig 5.11. Predicted and observed days to germination days

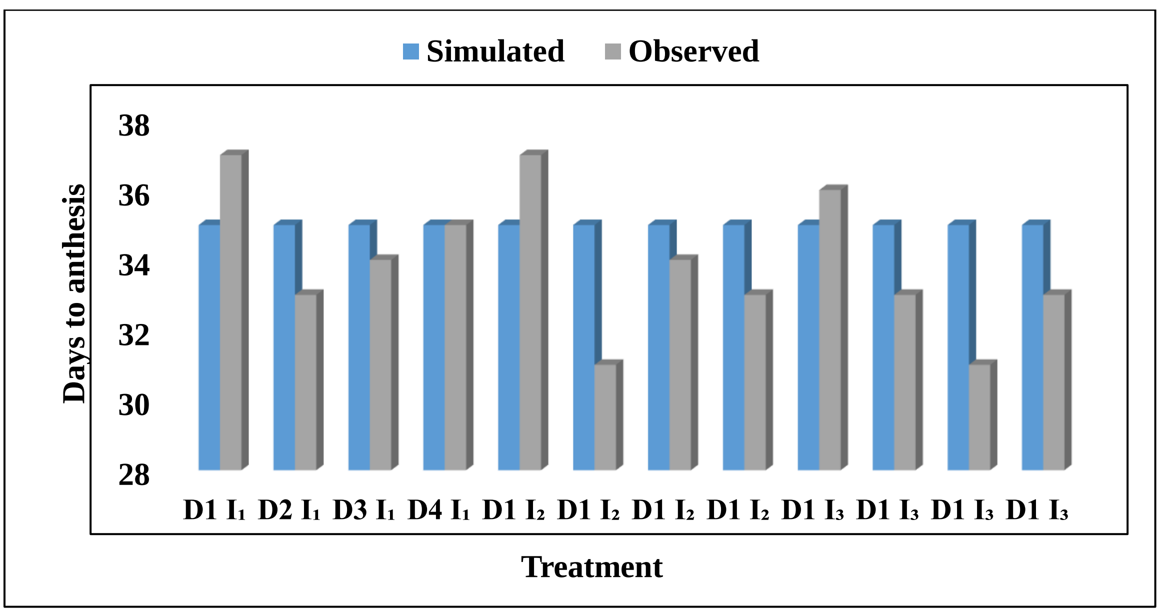

Fig 5.12. Predicted and observed days to anthesis

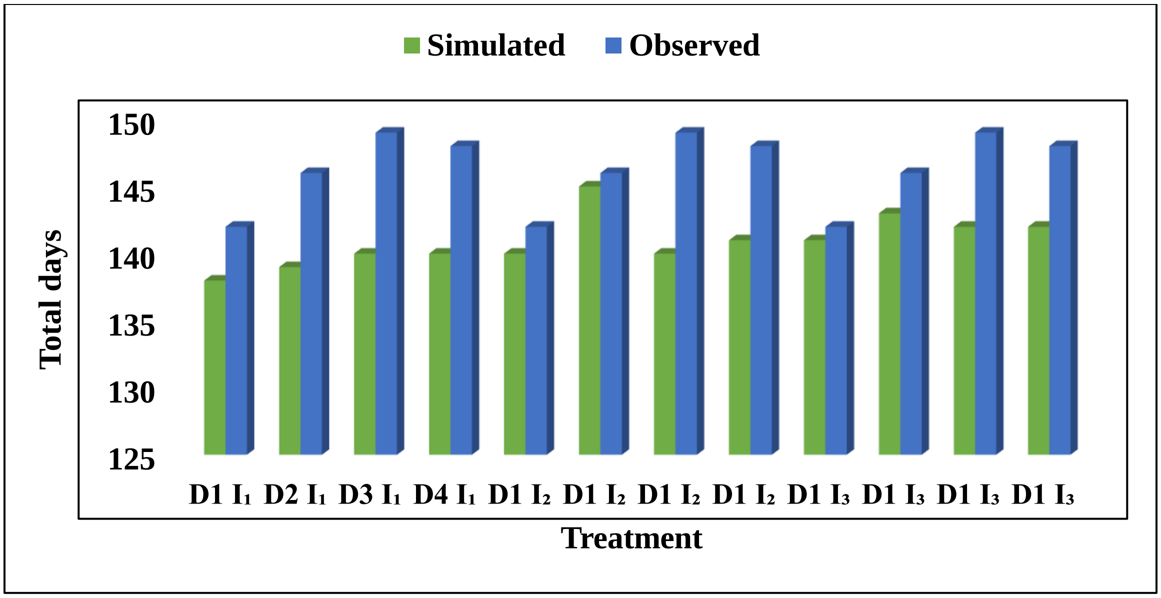

Fig 5.13. Predicted and observed days to physiological maturity

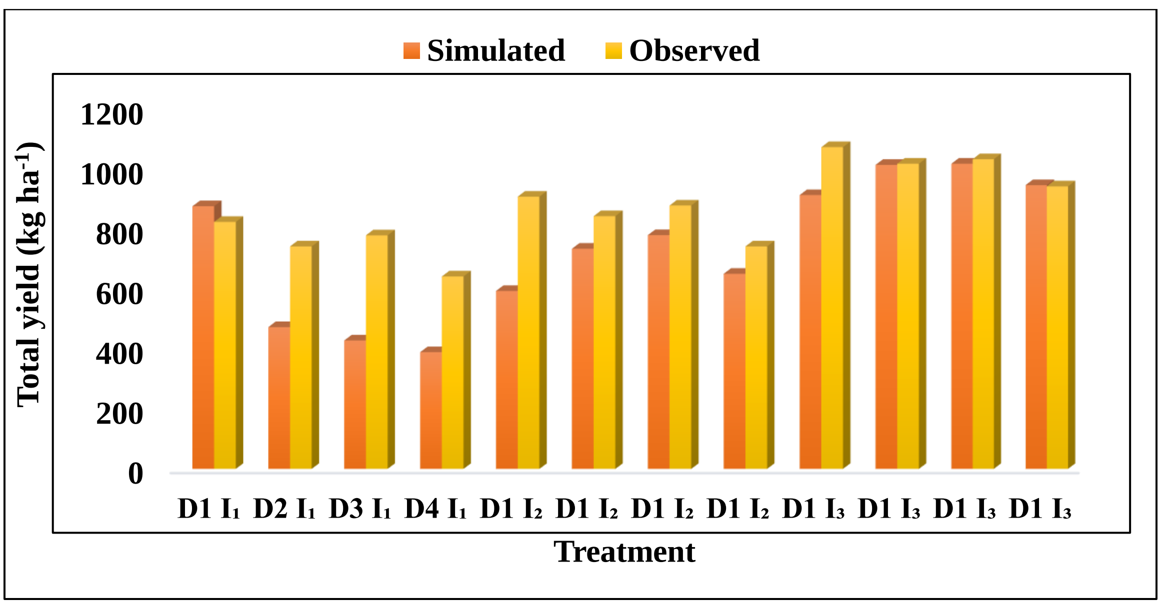

Fig 5.14. Predicted and observed yield

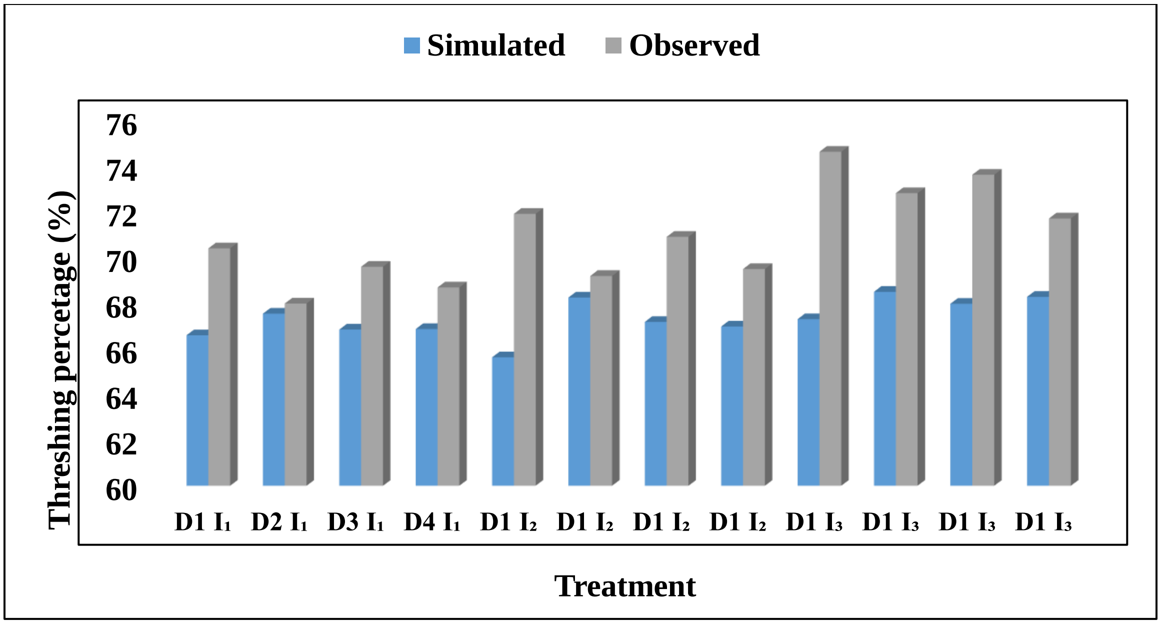

Fig 5.15. Predicted and observed shelling percentage

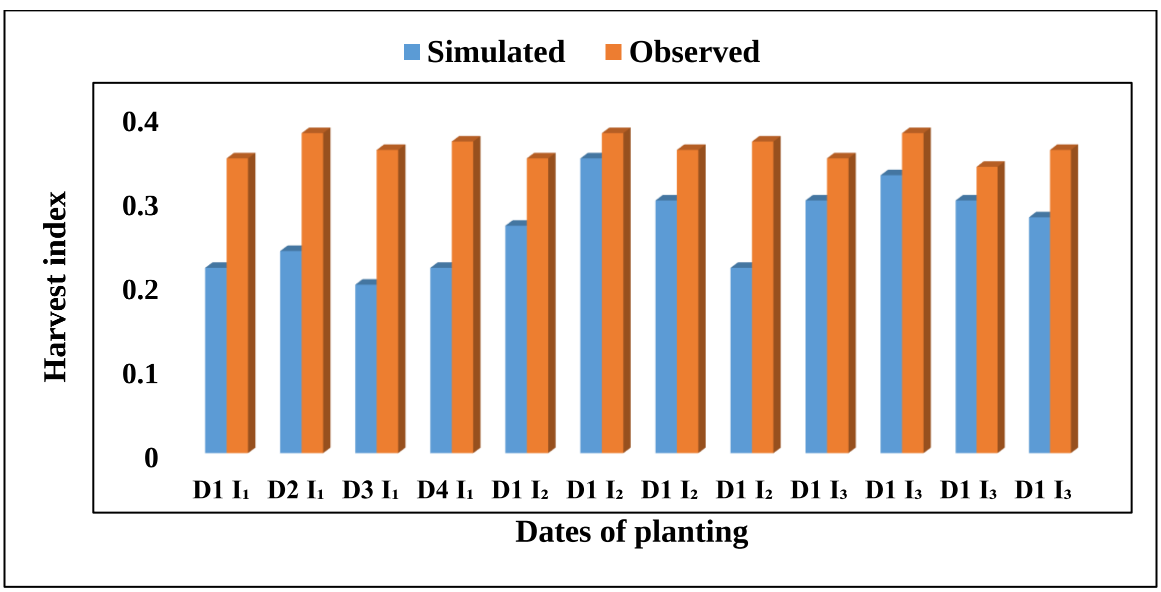

Fig 5.16. Predicted and observed harvest index

Summary

6. SUMMARY

The research on "Crop simulation of groundnut (*Arachis hypogaea* L.) using DSSAT-CROPGRO model" was conducted at Department of Agricultural Meteorology, College of Horticulture, Vellanikkara during 2019-2020. The crop weather relationships were studied under different dates of planting and irrigation level and calibration of genetic coefficient for DSSAT-CROPGRO model of groundnut variety TNAU CO-6 was done using the data collected from the experiment.

Different observations like weather, growth parameters, phenology, yield and yield attributes were noted during different plantings. The study was carried out for the purpose of simulation of phenology, growth and yield of groundnut, to calibrate genetic coefficient of groundnut (var. TNAU CO-6) using DSSAT CROPGRO-Peanut model, to study the crop weather relationship of groundnut in Kerala condition and to find out the best irrigation scheduling based on climatological approach (IW/CPE ratio 0.6, 0.8 and 1). The summarized results of this experiments were given below:

- The plant height and number of leaves showed significant differences in different dates of sowing and irrigation treatments. The groundnut sown in November 1st planting was produced a significantly higher value of all the growth characters as compared to November 15th, December 1st and December 15th planting and irrigation scheduling at IW/CPE ratio of 1 recorded significantly highest height and number of leaves than IW/CPE of 0.6 and 0.8.
- Effect of dates of sowing and irrigation on yield and yield attributes were found to be significant. The first date of sowing (November 1st) was produced significantly higher yield over the November 15th, December 1st andDecember 15th planting and irrigation scheduling of IW/CPE ratio 1.0 recorded significantly higher pod yield.
- Effect of dates of sowing on dry matter accumulation was found to be significant. The groundnut sown in November 1st planting showed significantly higher dry matter accumulation as compared to November 15th, December 1st and December 15th planting and irrigation scheduling at IW/CPE ratio 1.0 was found to be significant only during 90 days after planting.

- Rainfall received during pegging stage positively influenced the yield, the negative influence of temperature have contributed to yield reduction in delayed planting.
- The genetic coefficients for DSSAT-CROPGRO Peanut model were calibrated using the data sets generated during the field experiment.
- The simulated value of phenological observations and yield of groundnut crop using DSSAT-CROPGRO Peanut model was in good agreement with observed value.
- Simulated germination day, anthesis day and physiological maturity day showed satisfactory agreement with observed values with an RMSE (Root Mean Square Error) value of 1.32, 2.21 and 5.01 and d-stat index of 0.42, 0.41 and 0.41 respectively indicating good performance of the model.
- Model underestimated the yield with an RMSE (root mean square error) of 185.23 and d-stat index of 0.73. Compared to phenology model could able to predict crop yield more accurately.
- Simulated yield attributes like shelling percentage and harvest index showed satisfactory agreement with observed values with an RMSE (Root Mean Square Error) of 4.07 and 0.10 and d-stat index of 0.42 and 0.23 respectively indicating good performance of the model.

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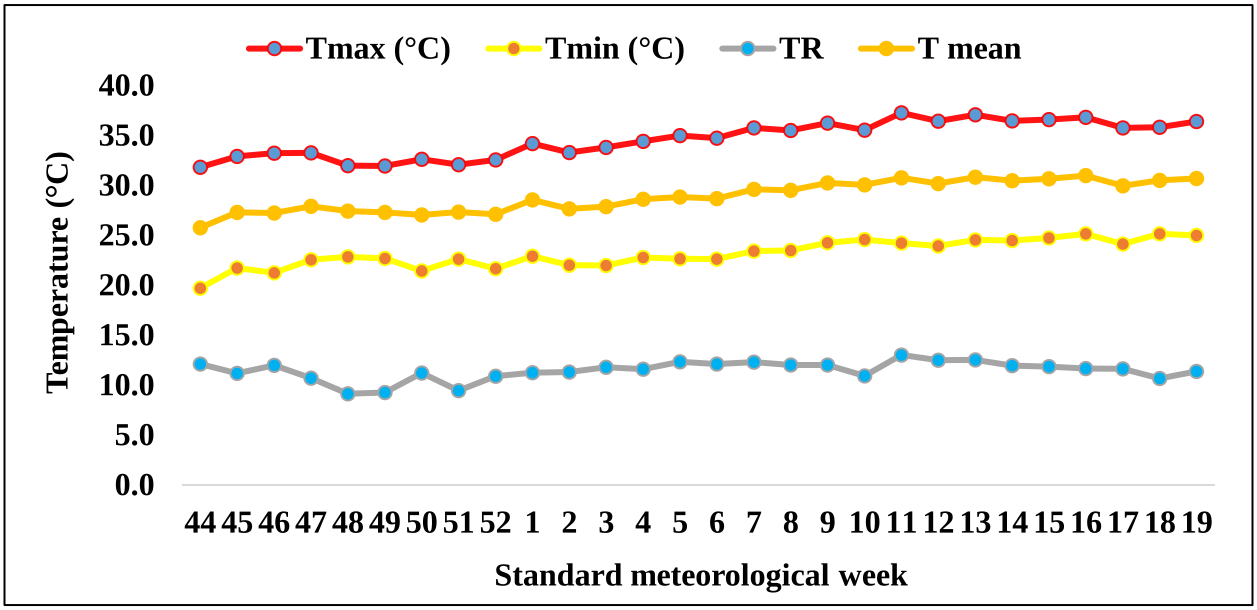
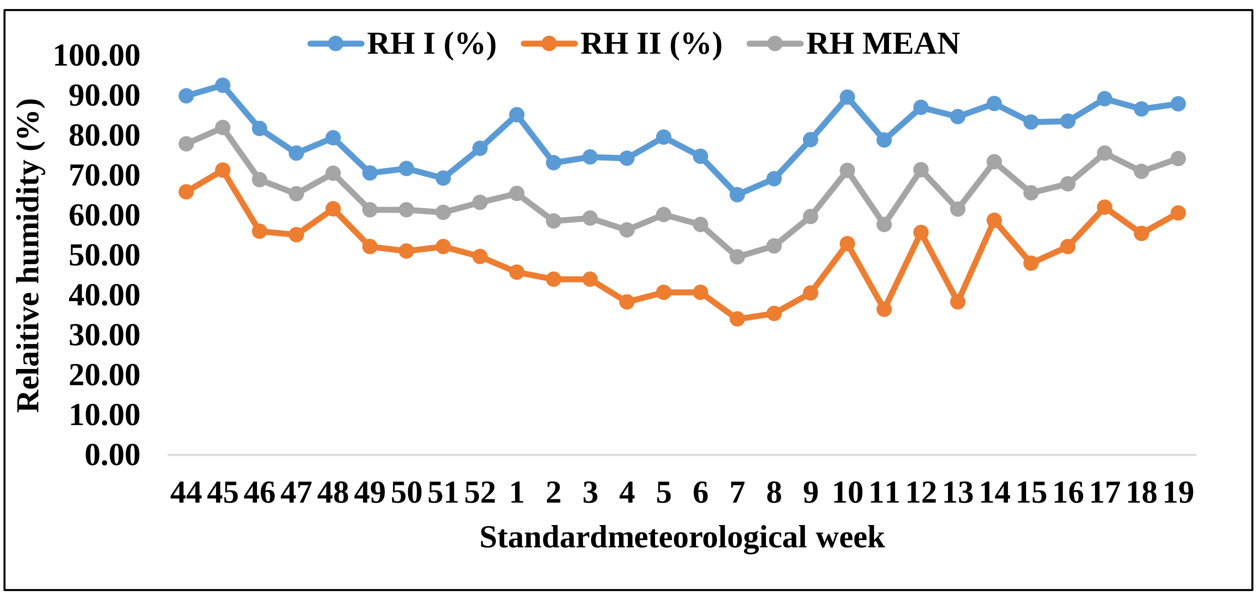
Annexure

(i)

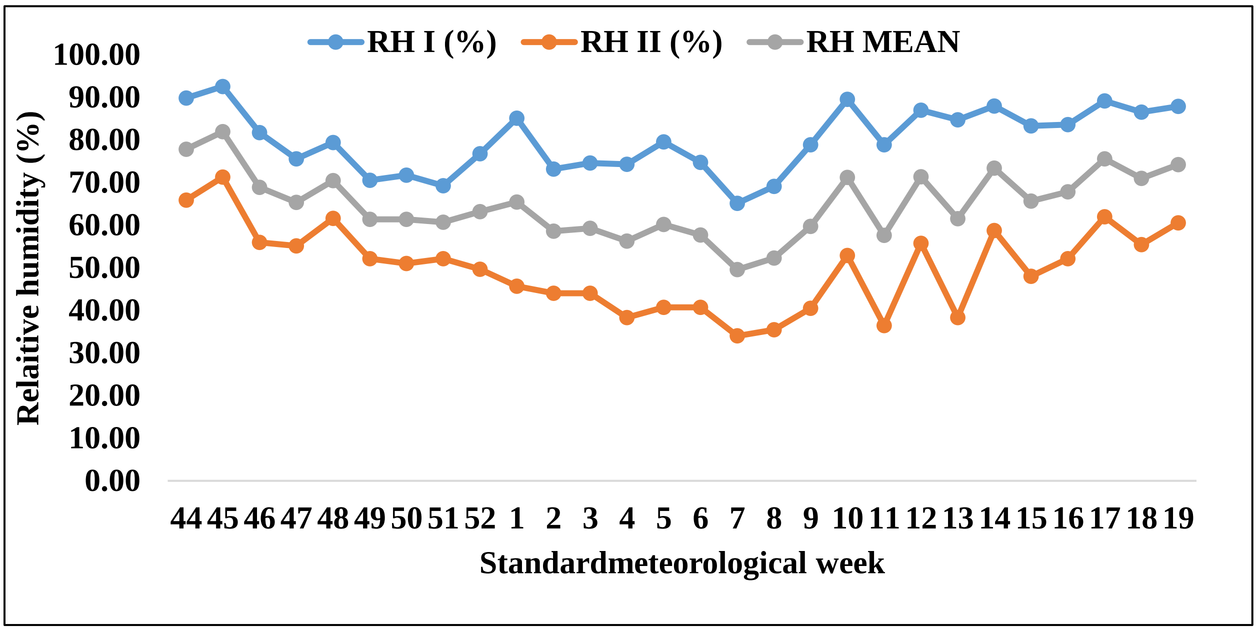
Annexure I



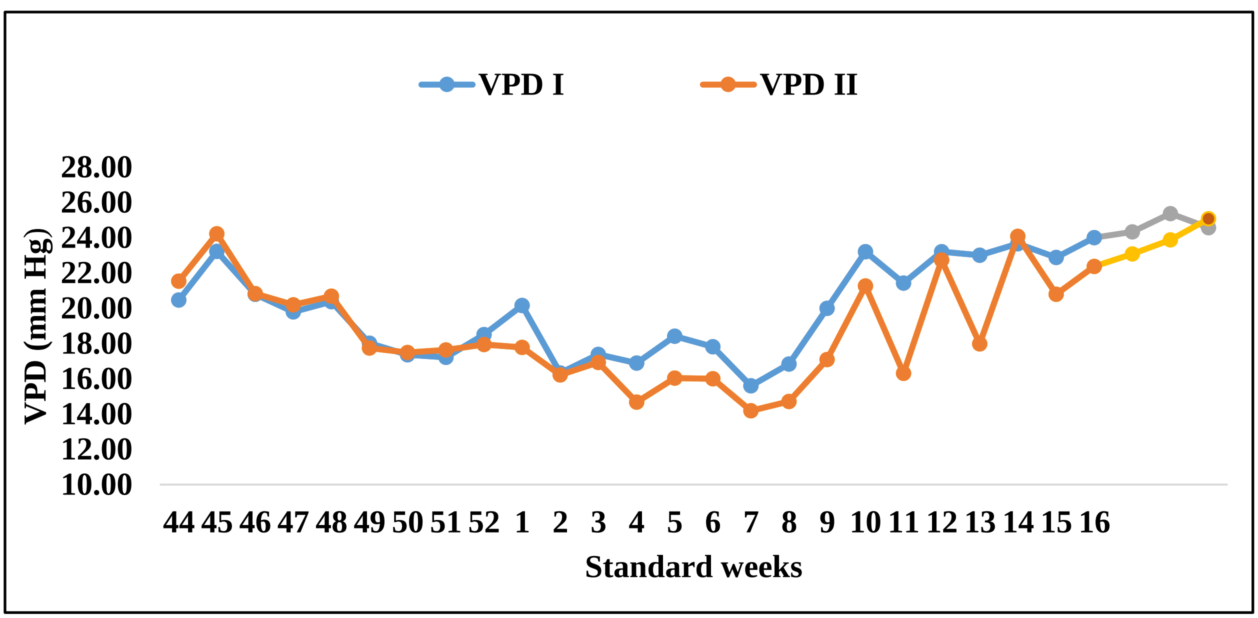
Weekly air temperature during crop period



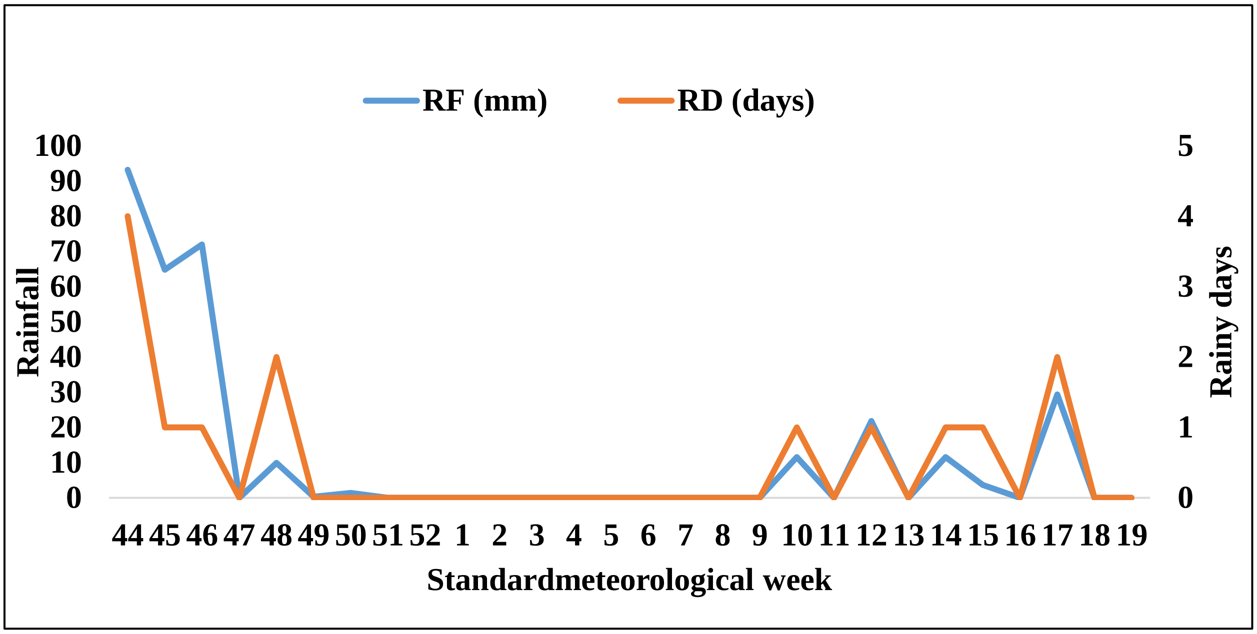
Weekly relative humidity (RH) during crop



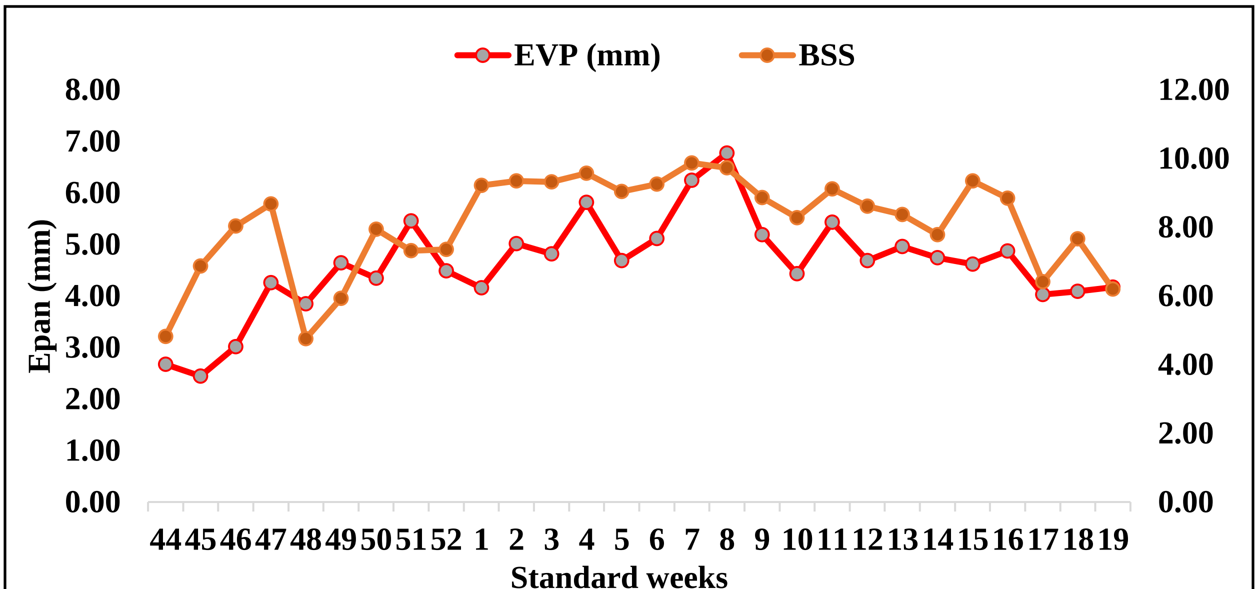
Weekly relative humidity (RH) during crop



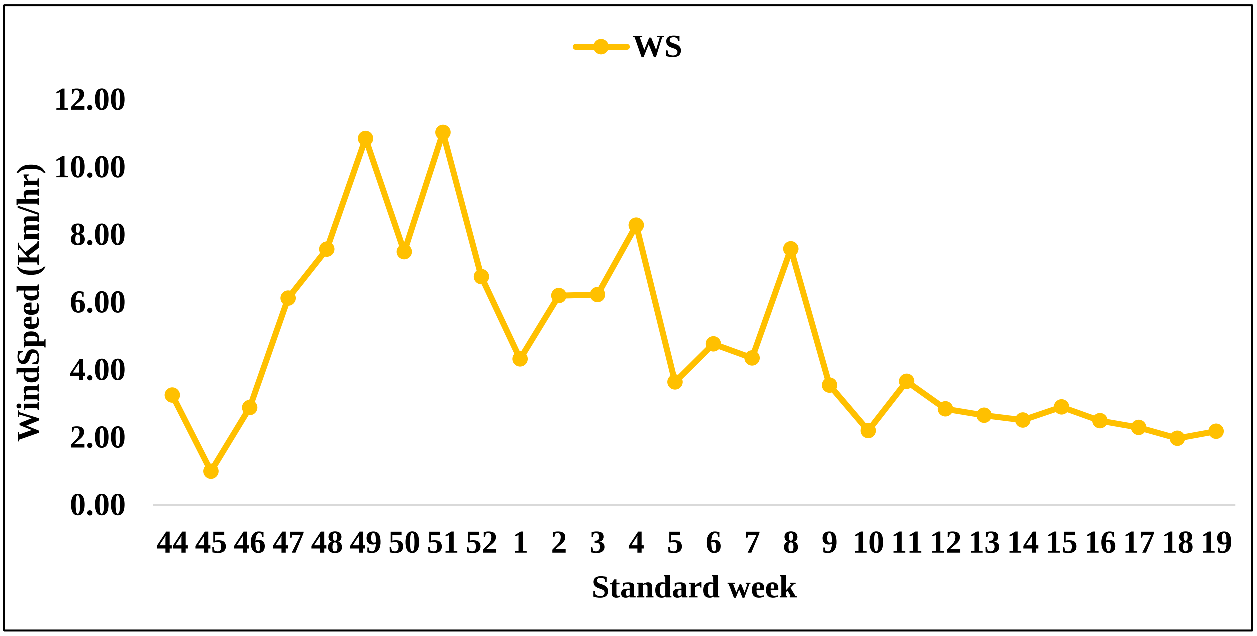
Weekly vapour pressure deficit (VPD) during crop period



Weekly rainfall (RF) and rainy days (RD) during crop period



Weekly bright sunshine hours (BSS) and evaporation (Epan) during crop



Weekly wind speed during crop period

Appendix

Appendix I

Abbreviations and units used

Weather parameters

Tmax : Maximum temperature

Tmin : Minimum temperature

Trange : Temperature range

RH I : Forenoon relative humidity

RH II : Afternoon relative humidity

VPD I : Forenoon vapour pressure deficit

VPD II: Afternoon vapour pressure deficit

RF : Rainfall

RD : Rainy days

WS : Wind speed

Epan : Pan evaporation

BSS : Bright sunshine hours

Phenophases

P1- Sowing to germination

P2- Germination to first flowering

P3- First flowering to fifty percent flowering

P4- Fifty percent flowering to pegging

P5- Pegging to pod formation

P6-Pod formation to physiological maturity

Irrigation Treatment

IW/CPE Ratio –Irrigation water and cumulative pan evaporation

Units

g : gram

kg : kilogram

km hr^{-1}: kilometre per hour

kg ha^{-1} : kilogram per hectare

% : per cent

^{0}C : degree Celsius

Appendix II

ANOVA of different plant growth characters of 2019-2020 experiment

Plant height at different weeks after planting

Source of variation	DF	Mean sum of squares							
		Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
Date of planting	3	7.760***	18.705***	79.847***	67.612 **	57.744***	68.911***	70.680***	75.296***
Error(a)	12	0.577	0.5967	6.574	8.151	3.045	3.547	3.624	4.088
Irrigation levels	2	0.019	0.0436	7.175	0.962	4.248 ***	5.671	7.682***	8.615***
DOP x Irrigation levels	6	0.900**	0.7377	8.032	2.977	0.642	0.405	0.300	0.362
Error(b)	32	0.218	0.4757	5.982	6.487	0.486	0.477	0.437	0.376

Source of variation	DF	Mean sum of squares							
		Week 9	Week 10	Week 11	Week 12	Week 13	Week 14	Week 15	Week 16
Date of planting	3	69.004***	66.138***	60.923***	56.104***	52.336***	51.497***	51.143***	51.081***
Error(a)	12	3.844	3.774	3.784	3.756	4.026	4.034	4.056	4.084
Variety	2	9.894***	9.647***	9.886***	10.237***	9.387***	10.166***	9.882***	9.624***
DOP x Variety	6	0.229	0.187	0.188	0.182	0.193	0.225	0.191	0.191
Error(b)	32	0.300	0.269	0.256	0.231	0.236	0.222	0.224	0.222

DF – degrees of freedom -** Significant at 1% level -* Significance at 5% level

Appendix II (contd.)

Number of leaves at different weeks after planting

Source of variation	DF	Mean sum of squares							
		Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
Date of planting	3	94.093***	197.144***	703.89***	1020.21***	1747.19***	2523.75***	3051.44***	3249.2***
Error(a)	12	6.113	5.737	50.28	77.38	103.76	125.51	90.88	76.5
Irrigation levels	2	1.561	1.769	8.03	7.59	6.87	22.29	34.02	23.2
DOP x Irrigation levels	6	3.242	6.234	3.78	8.13	18.47	27.77	29.09	34.7
Error(b)	32	2.035	3.441	7.50	16.39	18.59	22.17	22.83	25.3

Source of variation	DF	Mean sum of squares							
		Week 9	Week 10	Week 11	Week 12	Week 13	Week 14	Week 15	Week 16
Date of planting	3	3511.6***	3204.8***	3337.2***	3322.0***	4025.8***	4428.5***	5028.3***	5809.5***
Error(a)	12	89.7	100.1	157.0	243.1	227.2	317.4	441.9	530.3
Variety	2	11.6	10.5	89.1**	237.1***	396.7***	558.1***	658.1***	826.4***
DOP x Irrigation levels	6	16.9	22.9	8.6	7.7	13.4	12.5	14.2	12.4
Error(b)	32	20.2	18.7	15.7	7.3	8.5	15.0	12.8	13.4

DF – degrees of freedom   -** Significant at 1% level   -* Significance at 5% level

Appendix II (contd.)

Dry matter accumulation at fortnightly intervals

Source of variation	**DF**	**Mean sum of squares**							
		15 DAP	30 DAP	45 DAP	60 DAP	75 DAP	90 DAP	105 DAP	120 DAP
Date of planting	3	5518.0	185337*	5735865***	10748706***	1537667**	5433439***	1818302***	5340340***
Error(a)	12	11255.5	37242	248968	431180	197888	200104	133134	457121
Variety	2	3406.7	671	60750	398728	64654	348967	231753	35194
DOP x Irrigation level	6	8218.6	6084	280028*	383577*	265327*	55785	1044422***	153652
Error(b)	32	3869.1	15738	100929	156523	107850	29266	105566	87193

Yield and yield attributes

Source of variation	**DF**	**Mean sum of squares**		
		Pod yield (kg ha^{-1})	Shelling percentage	Harvest index
Date of planting	3	68627***	26.205**	0.0015688*
Error(a)	12	1068	2.856	0.0003883
Variety	2	370884***	88.548***	0.0089234**
DOP x Irrigation level	6	819	1.671	0.0013623
Error(b)	32	1948	3.828	0.0010554

DF – degrees of freedom ** - Significant at 1% level * - Significance at 5% level DAP – days after planting

Appendix II (Contd.)

Leaf area index at fortnightly intervals

Source of variation	DF	Mean sum of squares							
		15 DAP	30 DAP	45 DAP	60 DAP	75 DAP	90 DAP	105 DAP	120 DAP
Date of planting	3	0.0254546**	0.087273*	0.224997*	0.39950*	0.115407	0.02537	0.04882	0.04759
Error(a)	12	0.0028778	0.020356	0.061050	0.09322	0.069738	0.16309	0.24087	0.19509
Variety	2	0.0024242	0.013496	0.002352	0.13991	0.221921	0.51075**	1.29704**	1.09341**
DOP x Irrigation level	6	0.0007264	0.003322	0.019233	0.02428	0.048358	0.08330	0.03630	0.04099
Error(b)	32	0.0012747	0.006879	0.029733	0.07118	0.079939	0.06833	0.06230	0.05919

CROP SIMULATION IN GROUNDNUT(*Arachis hypogaea* L.) USING DSSAT-CROPGRO MODEL

by

VINU K. S.

2018-11-113

ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the requirement for the degree of

MASTER OF SCIENCE IN AGRICULTURE

Faculty of Agriculture

Kerala Agricultural University

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Abstract

The field work was conducted at Instructional Farm, Vellanikkara by adopting split plot design with five replications. Variety used in the experiment was TNAU CO-6. Four dates of sowing such as November 1st, November 15th, December 1st and December 15th were used as main plot treatments and three irrigation levels of IW/CPE ratio 0.6, 0.8 and 1.0 were used as sub plot treatments.

The November 1st planting was produced significantly higher yield compared to the November 15th, December 1st and December 15th planting. All the growth characters like plant height, number of leaves and dry matter accumulation were found to be highest during November 1st planting. Shelling percentage and harvest index recorded during November 1st planting was on par with December 1st planting. Among the three irrigation treatments plant height, number of leaves, yield, shelling percentage and harvest index were found to be higher in IW/CPE ratio 1.0.

Number of days taken to reach each phenophases were different under each dates of planting. Maximum duration was recorded during December 1st planting and minimum duration was recorded during November 1st planting. Crop weather relationship studies suggested that maximum temperature and bright sunshine hours recorded during pegging to pod formation period showed a negative influence on yield and phenology. Only rainfall during this period showed a positive influence on yield.

The efficiency of every crop model depends on how accurately the genetic coefficients were calibrated. The genetic coefficients for DSSAT-CROPGRO Peanut model were calibrated for the variety TNAU CO-6 using the data sets generated during the field experiment. The goodness of fit between observed and simulated values were evaluated using root mean square error and d- stat index. The simulated value of yield, yield attributes and phenology of groundnut crop using DSSAT-CROPGRO Peanut model was in good agreement with observed value.