



International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
NAAS Rating (2025): 5.20
www.agronomyjournals.com
2025; 8(11): 499-511
Received: 12-09-2025
Accepted: 16-10-2025

Barikara Umesh
Senior Scientist and Head, ICAR-
KVK, Bidar, UAS, Raichur,
Karnataka, India

JB Kambale
Associate Professor, Department of
Soil and Water Engineering,
Agriculture College, Kalaburgi,
UAS, Raichur, Karnataka, India

Shreevani GN
Scientist, Department Agri
Entomology, ICAR-KVK,
Raichur, UAS, Raichur,
Karnataka, India

Mallikarjuna Muddappa
Assistant Professor, College of
Agricultural Engineering, UAS,
Raichur, Karnataka, India

Corresponding Author:
Barikara Umesh
Senior Scientist and Head, ICAR-
KVK, Bidar, UAS, Raichur,
Karnataka, India

Studies on improved technologies and aquacrop model performance for groundnut (*Arachis hypogaea* L.) production in Yadgir district of Kalyan Karnataka region, India

Barikara Umesh, JB Kambale, Shreevani GN and Mallikarjuna Muddappa

DOI: <https://www.doi.org/10.33545/2618060X.2025.v8.i11g.4221>

Abstract

Yadgir is the major producer of groundnut in Karnataka, and average yield of rainfed groundnut is 17.5 to 20 q ha⁻¹, which is comparatively less than country average due to lack of high-yielding groundnut varieties, poor soil fertility, scattering rainfall, high incidence of pests & diseases. To address these problems, University of Agricultural Sciences, Raichur introduced (K-1812) groundnut variety, bio controlling agents for soil born disease management, integrated nutrient management, sprinkler irrigation, groundnut digger cum elevator at 15 farmers field in Yadgir district of Karnataka during 2021 and 2022 of *kharif* and *rabi* seasons. The average groundnut yield under technologies field was 25.91q ha⁻¹ (18.68%) as well as 31.34q ha⁻¹ (18.13%) as compared to 21.83q ha⁻¹ as well as 26.53q ha⁻¹ under farmer's practices during *kharif* as well as *rabi* seasons respectively as well as helped to achieve BC ratio of 3.77 compared to 1.58 under farmer's practices by reducing cost of production by 15 to 20%. Average two-year *kharif* and *rabi* seasons field data had been utilized for calibration as well as validating model. AquaCrop model has been calibrated for simulation of groundnut yield as well as biomass for technologies plot, as well as prediction error statistics were 0.96 <E< 0.88%, 0.08 RMS< 0.63 qha⁻¹ and 0.87 <MAE< 0.70 qha⁻¹. During validation, model functioned well with model efficacy of 93% as well as 83% for groundnut pod yield as well as biomass, respectively, as well as are within acceptable limits. AquaCrop model performed well, and it can be used for future studies on effect of climate change as well as agronomical practices on groundnut yield as well as biomass in study area.

Keywords: Crop modelling, improved varieties, mechanization, soil health, and precise irrigation

Introduction

Agriculture is an important source of food security as well as livelihood for rural population in India (Kadiyala *et al.*, 2021) [30]. Agricultural production in India mainly depends on rainfall and other agronomical management practices (Reddy *et al.*, 2020) [41]. Over the past few decades, there have been substantial changes in agricultural productivity due to changes in climate, land utilization and cropping patterns (Umesh *et al.*, 2022) [58]. India is still dedicated to ensuring food, nutritional security and employment through several government initiatives (Panda 2023) [61]. However, climate change, land degradation and high crop inputs cost lead to severe challenges for agricultural production, particularly under rainfed situations (Datta *et al.*, 2022) [17]. These challenges are presumed to decrease food production as well as increase food prices, which leads to malnourishment and hunger-related problems in the country (Reddy *et al.*, 2022) [43].

Groundnut (*Arachis hypogaea* L.) is an essential oilseed crop in India, which occupies 1st position in terms of area as well as 2nd position in terms of production (Rohtas *et al.*, 2016; Srujana and Zacharia, 2020) [45, 53]. It is mainly cultivated under rainfed conditions (83%) during June to October, as well as remaining seventeen percent is grown under irrigated conditions in post-monsoon (Singh *et al.*, 2014b) [50]. It is one of the few crops that can be cultivated even on marginal lands under low-input conditions (Chibbarabada *et al.*, 2020) [12]. Production and productivity of groundnut crop are the major indicators for enhancing income of groundnut

farmers, and both are influenced by various factors (Mwalongo *et al.*, 2020) [36]. The constraints in groundnut production adversely affect the productivity of crop. Understanding of these factors and their linkage with each other is essential. Many researchers across the country studied the constraints and factors influencing groundnut production in the country. The main reasons for low productivity in groundnut crop are non-availability of quality seeds of new varieties (Mwalongo *et al.*, 2020 and Deva *et al.*, 2023) [36, 18], lack of knowledge on soil fertility (Choudhary *et al.*, 2011) [13], non-adoption of insitu soil moisture conservation practices (Soni *et al.*, 2016 and Mamatha *et al.*, 2022) [51, 33], improper pest and disease management (Murthy *et al.*, 2018) [35], non-availability of suitable mechanization timely production technologies to combat with adverse climate changes (Srinivasa *et al.*, 2022) [52] and operational problems (Behura *et al.*, 2020) [10]. Study on these factors and their impact on groundnut production in near future through crop modelling is essential.

Crop growth models use mathematical and empirical linkages to simulate growth as well as growth of crops under various environments (Rauff and Bello, 2015) [40]. These models act as decision-supporting tools in agricultural production. Modelling of groundnut production was done by (Jones *et al.*, 2003) [29] using Decision Support System for Agrotechnology Transfer (DSSAT) and Agricultural Production Systems Simulator (APSIM) by Robertson *et al.*, (2002) [44]. However, these models require huge amount of input data that is difficult to get under field conditions, which requires more time and resources (Corbeels *et al.*, 2016; Jones *et al.*, 2017) [15, 28]. AquaCrop needs comparatively few input parameters (Umesh *et al.*, 2022) [58]. This model is intended for end users, including farmers, policy officials, and students, in addition to scientists (Steduto *et al.*, 2009) [55]. AquaCrop provides opportunity to simulate crop yield under various agroecological practices (Raes *et al.*, 2009; Steduto *et al.*, 2009) [39, 55]. This model was utilized for prediction of crop yield for several crops, viz, maize (Heng *et al.*, 2009, Umesh *et al.*, 2022) [25, 58], cotton (Farahani *et al.*, 2009) [22], wheat (Andarzian *et al.*, 2011) [5] and sorghum (Araya *et al.*, 2016) [6]. Globally, AquaCrop model was used for very few oilseed crops, such as soybean (Adeboye *et al.*, 2017) [4] and bambara groundnut (Karunaratne *et al.*, 2011) [31]. Kadiyala *et al.*, (2021) [30] reported that, there is -2.3 to 43.2 percent alteration in groundnut yields by 2050 throughout different areas in India when climate alone has been factored in. However, no detailed information is available at regional level, particularly in southern Indian part. The calibration as well as validation of AquaCrop helps to comprehend effect of various factors on groundnut production in arid as well as semi-arid areas of Indian sub-continent, particularly major groundnut growing states like Gujarat, Karnataka, Maharashtra and Andhra Pradesh

(Chibabada *et al.*) This validated model offers the opportunity to predict groundnut yield under different climate change situations at regional level.

Yadgir is the new district in North-Eastern dry zone of Karnataka. This agro-ecological zone is a major groundnut-producing belt with an area of about 1.50 lakh ha, production of 1.14 lakh tonnes, as well as productivity of 742 kg ha⁻¹ (Biradar *et al.*, 2024) [11]. Groundnut production in the district covers 40% of (43358 ha) and the productivity of groundnut is 17.5 - 20 q ha⁻¹, which is very low as compared to state average 20 - 30 q ha⁻¹ (YDG, 2022-23). The major constraints for low productivity in groundnut yield in the district are non-availability of quality seeds of new varieties, lack of knowledge on soil fertility, in-situ soil moisture conservation practices, pest and disease management, non-availability of timely production technologies to combat with adverse climate changes and operational problems (PLCP, NABARD, 2023). Hence, there is an urgent need to educate the groundnut farmers in the Yadgir district through demonstration of improved technologies in groundnut cultivation and which increases the productivity of the groundnut and increases the farm income for sustainable development of the small and marginal groundnut farmers. Understanding this, ICAR-Krishi Vigyan Kendra (KVK) conducted research on effect of climate change as well as different factors on groundnut yield through assessing improved technologies viz, new varieties, integrated nutrient management (INM), integrated pest & disease management (IPDM), sprinkler irrigation (SI), as well as mechanization at 15 locations in Yadgir district. AquaCrop model was validated and used for forecasting groundnut production under various climate change scenarios in the Yadgir district with the following objectives: Conducting field demonstration of improved technologies for their assessment, calibration, along validation of AquaCrop model for groundnut crop production.

Materials and Methods

This study assessed the improved technologies at 15 locations on field scale across the Yadgir district along with farmer's practices to study their effect on groundnut yield in near future through aquacrop model.

Description of the Study Area

Research has been carried out during *kharif* 2021 as well as 2022 and *rabi* 2021 & 2022 at Yadgir district in North Eastern Dry zone, Karnataka (India) by ICAR-Krishi Vigyan Kendra (KVK) Yadgir at 15 locations consist of ten small farmers (SF) & five marginal farmers (MF) supported by regional office, NABARD (Karnataka) for two years on the basis of different climatic condition and soil characteristics. Map of study area is presented in Fig 1.

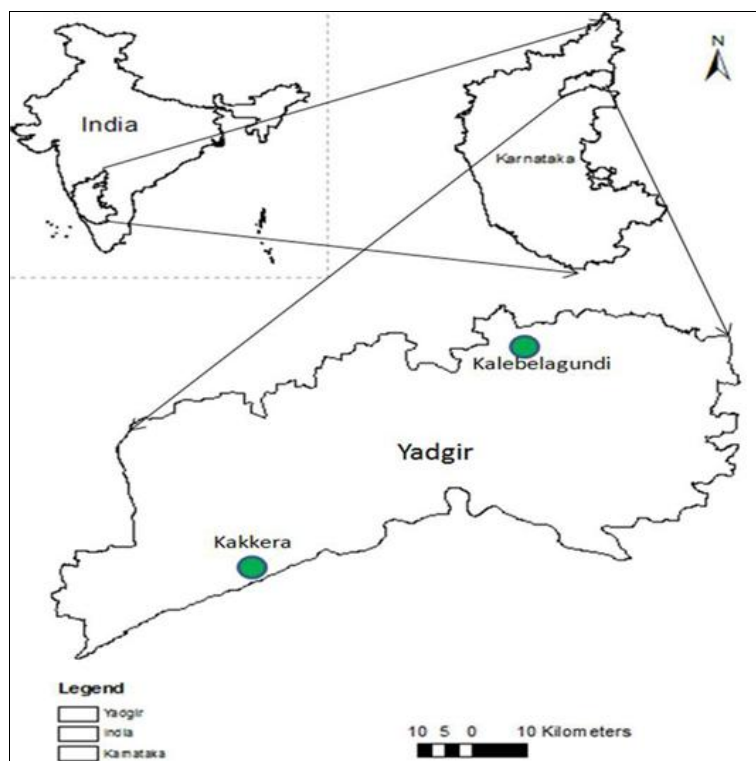


Fig 1: Study Area Map

Technologies assessed

The details of improved technologies assessed during study period are presented in Table 1 and these technologies are of package of practices for groundnut production for zone-II

developed and released by University of Agricultural Sciences (UAS), Raichur (POP, UASR, 2024). The selected technologies were implemented in one acre each at 15 locations and compared with farmer practices for better understanding.

Table 1: Details of technologies assessed at farmer's field

Sl no	Problems Identified	Farmers practices	Technologies demonstrated
1	Unavailability of high yielding groundnut seeds	Local variety or K-9	Groundnut variety K-1812 (Kadiri lepakshi)
2	Poor soil fertility and less knowledge on soil health management	Indiscriminate chemical fertilizer application	Soil health card based nutrient management. Application of zink sulphate, magnesium sulphate & boron of each 05 kgs for soil nutrient management
3	Water scarcity during crop critical stages	Surface irrigation	Sprinkler irrigation system
4	High pest and disease incidence during crop period	Indiscriminate chemical pesticides spraying	Introduced bio controlling agents such as <i>trichoderma</i> , <i>metarizhium</i> & <i>pseudomonous</i> for eco-friendly and integrated pest and disease management
5	Labour problem during groundnut harvesting	Manual harvest	Groundnut digger cum elevator

Weather data

Karnataka State Natural Disaster Monitoring Centre (KSNDMC), located in Bengaluru, provided everyday climate data on rainfall, minimum as well as maximum temperatures, relative humidity, solar radiation, as well as wind speed during crop-growing season. In Yadgir district under study, average annual rainfall was 710 mm, while average seasonal rainfall was 448mm. With average minimum as well as maximum temperatures of 9.21 as well as 42.22 °C, respectively, research area's average temperature was 26.4 °C.

AquaCrop model description and input data

The present version of *AquaCrop* (7.1), the crop-water productivity model established by FAO, is now available with its standard user interface (GUI), and database has been utilized in current research. The model involves 6 input files for simulation: soil file, initial soil water conditions, crop file, climate file, irrigation file as well as field management file. The

model provides the opportunity for user-specific. Crop file includes both non-conservative (user-specific parameters) and conservative parameters (that are location-invariant). Detailed information on AquaCrop model can be seen in (Feng *et al.*, 2022)^[23].

Climate data

Climate data on mean daily minimum as well as maximum air temperature, rainfall, reference crop evapotranspiration (ETO) with mean annual carbon dioxide concentration (CO₂) were collected for 15 locations from KSNDMC, and average values were used for running of AquaCrop model. Mean daily ETO was calculated through FAO ETO Utilized daily maximum as well as minimum temperature, wind speed at 2m above ground surface, solar radiation as well as mean relative humidity (RH). Mean regular rainfall depths, temperature variations, as well as ETO during experiments of 2021 & 2022 are shown in Fig 2 (a to d).

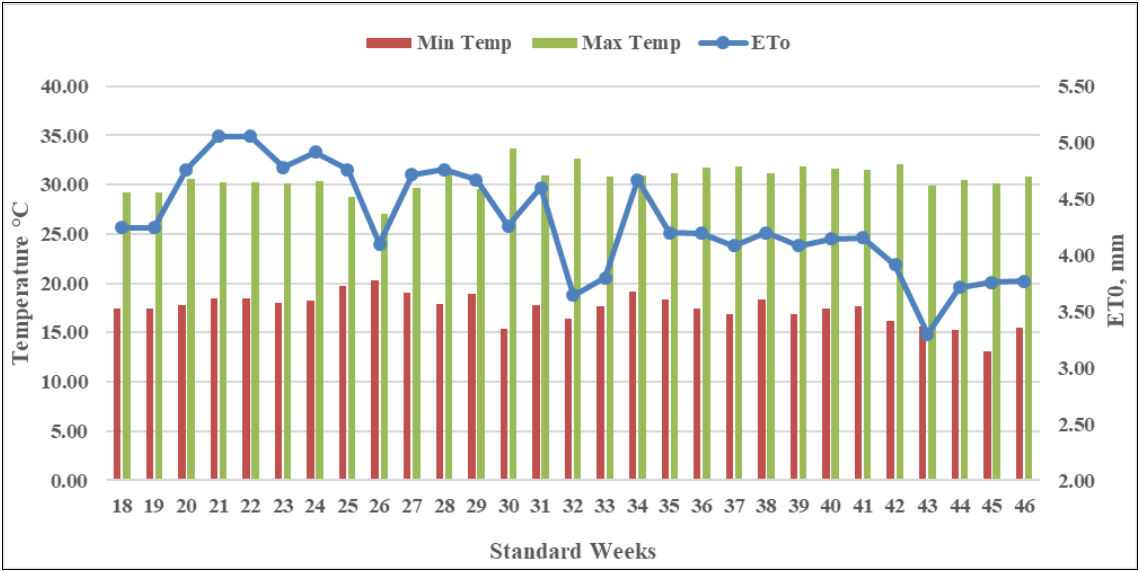


Fig 2 (a): Mini and maxi temperature (°C) and ETO (mm) during study period 2021

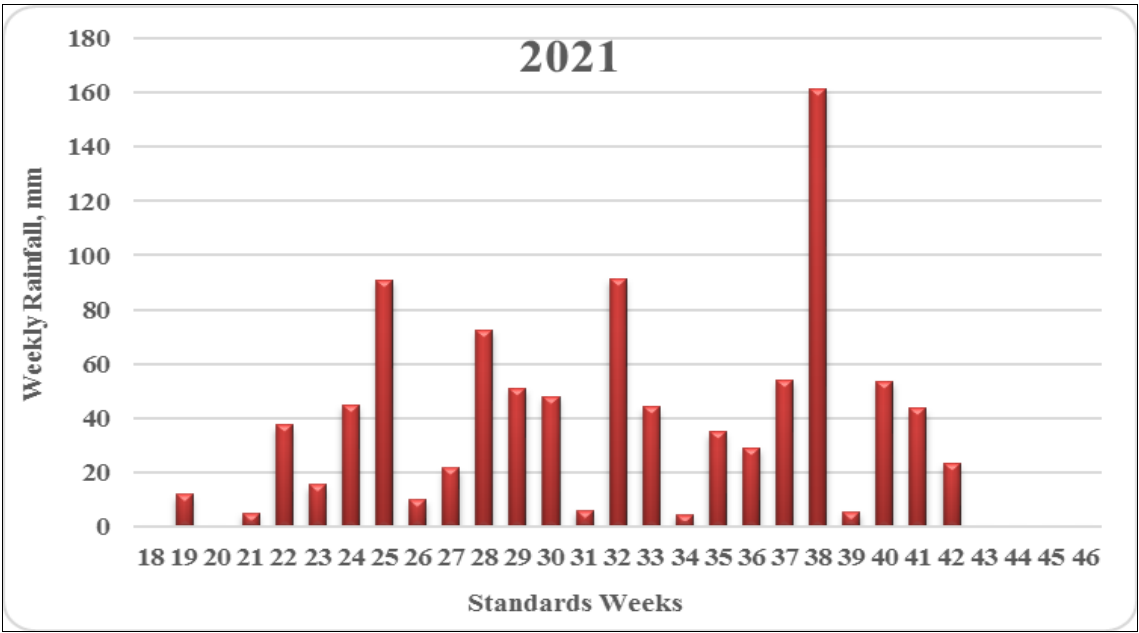


Fig 2 (b): Standard weekly rainfall (mm) during study period 2021

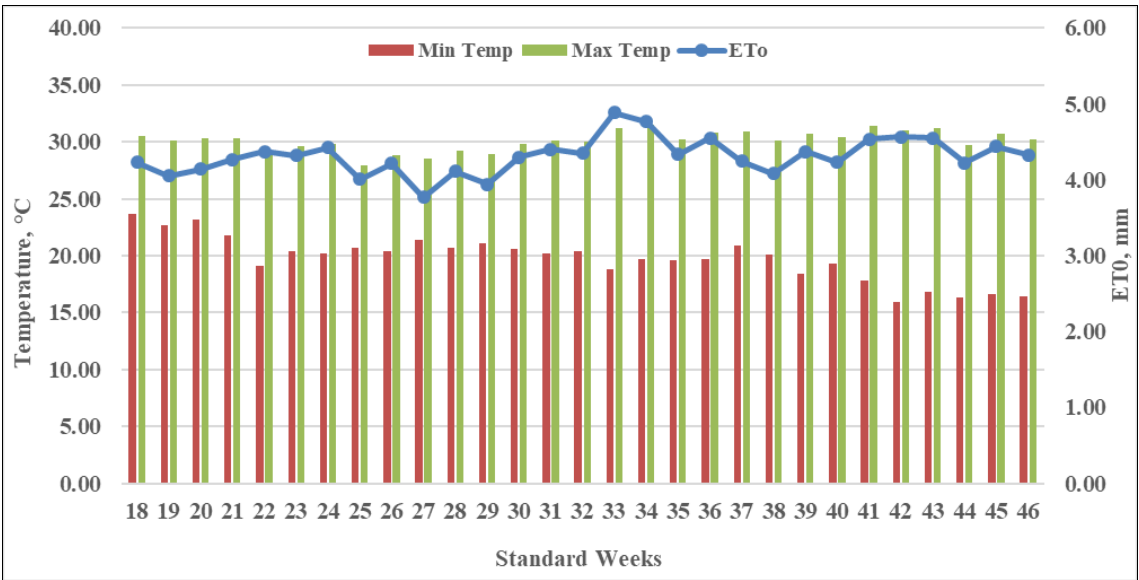


Fig 2 (c): Mini and maxi temperature (°C) and ETO (mm) during study period 2022

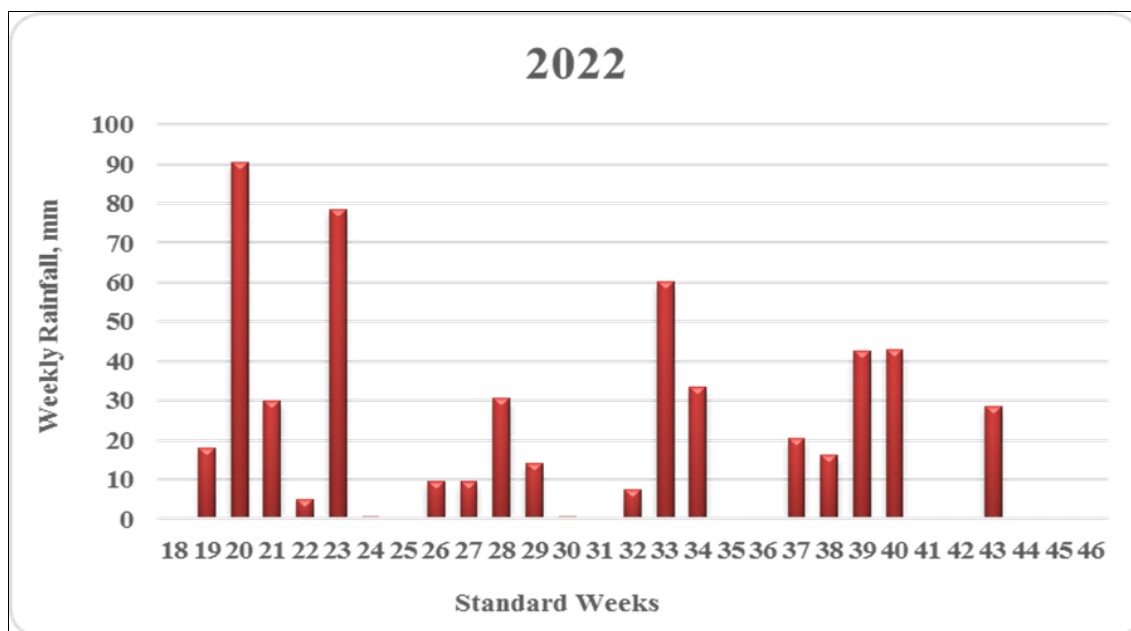


Fig 2 (d): Standard weekly rainfall (mm) during study period 2022

Crop parameters

Crop file consists of conservative as well as non-conservative parameters. In current research, values for conservative parameters had been obtained from (Chibarabada *et al.*, 2020)^[12], who calibrated as well as validated AquaCrop for groundnut crop. During calibration of model, these values were adjusted using field scale data collected at 15 locations during *kharif* 2021. The maximum effective rooting depths at selected locations were estimated at harvesting stage. However, values for water extraction pattern were obtained from AquaCrop defaults files. The observations made during field study on assessment of technologies and farmers' practices during *kharif* & *rabi* of 2021 and 2022 were used to create the crop file (.CRO). Data on plant growth metrics, including plant height, root length, aboveground biomass, as well as leaf area index, are collected for the study using random sampling at regular intervals. Plant height, leaf area, as well as root depth observations had been made at intervals of 15 days from the date of seeding to the harvest stage. Days associated with flowering, germination, maximum root depth, maximum canopy, senescence, as well as maturity have also been noted. Parameters for groundnut crop's canopy decline coefficient, crop coefficient for transpiration at complete canopy cover, soil water depletion thresholds for stomatal conductance and leaf growth inhibition, as well as canopy senescence acceleration, had been accepted by (Chibarabada *et al.*, 2020)^[12].

Irrigation and field management parameters

Irrigation file in AquaCrop model consists of information on rainfed and depth of irrigation applied. To investigate irrigation effect, two to three critical irrigations with 50 mm through pressurized sprinkler irrigation system were applied during long dryspells and no irrigation was applied under farmer's practices during study period. Field management comprises soil fertility management. In current research, recommended dose of fertilizer RDF) was applied, as well as 50% less RDF was applied under farmers' practices. Water productivity under supplemental irrigation and rainfed is computed utilizing below formula:

Water productivity ($\text{kg ha}^{-1} \text{mm}^{-1}$) =

$$\frac{\text{Crop yield (kg)}}{\text{Total quantity of irrigation water applied (ha mm)}} \text{ -----(1)}$$

Calibration and validation of AquaCrop model

Model parameters are adjusted during calibration to bring simulated results up to a predefined level, often that of an observation (Abedinpour *et al.*, 2012)^[21]. In current research, AquaCrop model has been calibrated using pooled observed data from 15 locations in the study area during *kharif* season of 2021 and 2022 to simulate groundnut yield as well as water productivity. Objective of the calibration is to decrease prediction error between model-predicted as well as observed values through trial-as well as-error technique by taking one specific input variable as reference, as well as adjusting only those parameters (Diaa *et al.*, 2021)^[20]. Days to germination and complete maturity, days to senescence, maximum canopy cover, Canopy growth coefficient (CGC), as well as canopy decline coefficient (CDC), are influencing the groundnut crop canopy. The trial-and-error method was used to minimize prediction error between field as well as simulated values. Values of crop parameters obtained during calibration of Aquacrop model are observed in table 2. Values obtained for CGC as well as CDC during calibration were $11.82\% \text{ day}^{-1}$ as well as $0.674\% \text{ day}^{-1}$, respectively. Harvest index has been computed using economic yield and total biomass obtained under technology fields as 26% at harvest. The water productivity value of 16 g m^{-2} was determined using equation 1 and used for calibrating the model. Crop water stress category, factors about expansion stress, stomatal closure, as well as early senescence stress had been adopted from (Chibarabada *et al.*, 2020)^[12], which are moderately tolerant, moderately sensitive and moderately tolerant respectively. These calibrated crop water stress function coefficients were used to simulate the groundnut yield under technologies and farmers' practices fields.

AquaCrop model has been validated employing pooled data of *rabi* season of 2021 and 2022 from 15 selected locations to assess its functioning in simulating groundnut yields. It is necessary to validate Aquacrop model to simulate crop yield under local conditions, as well as determine model's ability to

replicate the data, as well as compare synthetic data with those done in earlier research (Zhu *et al.*, 2021)^[60]. The statistical indicators are widely used for assessing the model's performance (Diaa *et al.*, 2021 and Feng *et al.*, 2022)^[20, 23]. In current study, root mean square error (RMSE), coefficient of determination (R^2), prediction error (Pe), mean

absolute error (MAE), as well as model efficiency (E) were utilized as per equations mentioned by (Umesh *et al.*, 2022)^[58]. The model's predictive capability is indicated by E and R^2 , whereas the degree of error accompanying model prediction is indicated by Pe, MAE, and RMSE (Abedinpour *et al.*, 2012)^[2].

Table 2: Selected crop parameters and values used for the calibration of aquacrop

Parameter	Value	Unit
Base temperature	21	°C
upper temperature	28	°C
Spacing	30×15	Cm ²
Plant population	333333	Plants hectare ⁻¹
Initial canopy cover (CCo)	0.27	%
Time to maturity CCx	125	Growing Degree days
Time to maximum canopy cover (CCx)	68	% Growing Degree days
Time to canopy senescence	592	Growing Degree days
Canopy decline	23	Days
Canopy growth coefficient (CGC)	12.2	%/day
Canopy growth decline (CDC)	0.683	%/GDD
Length building up HI	943	Growing Degree days
Duration of flowering	798	Growing Degree days
Time to flowering	595	Growing Degree days
Determinacy linked with flowering	No	-
Minimum effective rooting depth	0.3	M
Water productivity (WP)	15	(g)/(m ²)
Reference HI (HI ₀)	24	%
Overview of water stress effects on HI	6	%
Canopy expansion: (Response to water stress)	-	Moderately tolerant
Stomatal closure (response to water stress)	-	Moderately sensitive
Early canopy senescence (Response to water stress)	-	Moderately tolerant
Aeration stress to waterlogging	-	Moderately tolerant

Source: Chibarabada *et al.*, (2020)^[12]

Results and Discussion

The results of the improved technologies assessed at 15 selected farmer's field during *kharif* and *rabi* of 2021 and 2022 are presented and discussed in this section.

Supplemental irrigation and soil moisture distribution

The supplemental irrigation with 50 mm depth through pressurized sprinklers during 50 per cent soil moisture depletion at long dry spells of *kharif* 2021 & 2022 and *rabi* 2021 & 2022, and the details of soil moisture distribution are presented in Fig. 3 (a-d). The average soil moisture content ranged from 12.92 to 36.10 (%) under demo field and 8.7 to 15.20 (%) under farmer's practices during *kharif* 2021. During *Rabi* 2021, the soil moisture ranged from 13.24 to 33.50 (%) and 9.5 to 16.90 (%) under demo and farmers' fields, respectively. The soil moisture content of *kharif* season 2022 ranged from 10.1 to 25.60 (%) and 12.5 to 18.30 (%) under demo and farmers' fields, respectively. The same trend was observed during *Rabi* 2022, where the soil moisture ranged from 6.6 to 15.40 (%) and 10.71 to 30.60 (%) under demo and farmers' fields, respectively. The results clearly showed that there was good soil moisture distribution throughout the crop growth period during both the seasons of 2021 and 2022 under demonstrated fields, where fields were given supplemental irrigation through pressurized sprinklers. The high uniformity and application efficiencies enhanced soil moisture availability throughout crop period and saved 25% of irrigation water. The farmer's fields irrigated with surface irrigation were reported to have less moisture

distribution due to uneven irrigation, runoff and seepage losses. Traditionally, farmers were irrigating through surface channels, which led to 30 per cent of irrigation loss through seepage and percolation losses (Abou Kheira, 2009)^[1]. The irrigation efficiency of surface irrigation is merely 40 to 50 per cent and which can be increased up to 80 per cent by shifting to sprinkler irrigation (Dong *et al.*, 2024)^[21]. The water productivity of surface irrigation is very less as compared to sprinkler irrigation (Rojh *et al.*, 2021)^[46]. Farmers are educated on use of sprinkler irrigation for irrigation management during crop critical stages. The use of sprinkler irrigation would help to save water and increase the water productivity in groundnut production (Girehsingh and Mahindra, 2016 and Soni *et al.*, 2016)^[24, 51].

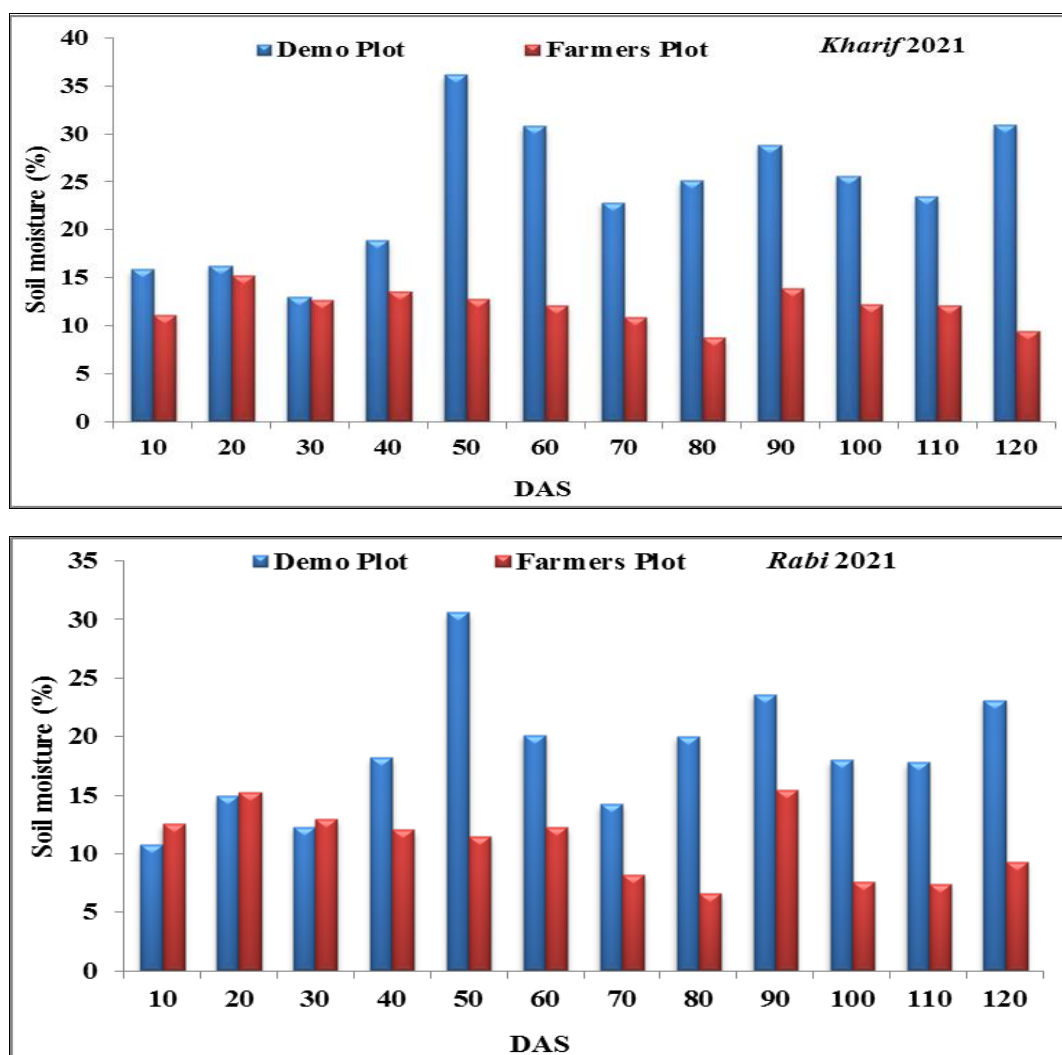
Groundnut Yield

Groundnut yield from technology demonstrated & farmers' practices were collected in one acre each and are compared to study the impact of improved technologies on groundnut production. The results of demonstrated and farmers' practices are shown in Table 3. Results clearly show that, adaptation of improved technologies in groundnut production significantly increased the groundnut production. The groundnut yield during *kharif* season was in the range of 22.53 to 31.55q ha⁻¹ as well as 22.95 to 28.73q ha⁻¹ under demonstration field during 2021 and 2022, respectively, as compared to 19.18 to 26.45q ha⁻¹ and 19.35 to 23.63q ha⁻¹ under farmers' practices. The groundnut yield during *rabi* season was in the range of 27.93 to 34.95q ha⁻¹

as well as 28.40 to 37.45q ha⁻¹ under demonstration field during 2021 and 2022, respectively, as compared to 24.25 to 29.73q ha⁻¹ as well as 24.65 to 32.40q ha⁻¹ under farmers' practices. The lower groundnut yield in farmers' practices was due to use of low-yielding old varieties, poor soil nutrients, occurrence of dryspell and high pest and disease incidence during crop growth period. The introduction of high-yielding groundnut variety K-1812 (Deva *et al.*, 2023) ^[18] with soil health card-based nutrient management (Jat *et al.*, 2023) ^[27]. Precise irrigation water management has significantly increased groundnut yield under demonstration field (Waseem *et al.*, 2017) ^[59]. The use of bio-controlling agents such as *metarhizium* and *trichoderma* (Sharma *et al.*, 2017) ^[47] under integrated pest and disease management has reduced pest and disease incidence, thereby increasing groundnut yield under demonstration field (Sharma *et al.*, 2012; Srujana and Zacharia, 2020 and Arunasri *et al.*, 2021) ^[48, 53, 8]. The increase in soil fertility through application of micro nutrients such as boron, zinc and magnesium sulphate has helped to increase the groundnut yield, and alike outcomes have also been noticed by (Nagaraj *et al.*, 2018 and Subbiah, G. (2023) ^[37, 56].

The two seasons' average groundnut yield under technologies demonstrated field of *kharif* 2021 and 2022 ranged from 22.95 to 28.84 q ha⁻¹ as compared to 19.79 to 24.11 q ha⁻¹ under farmers' practices. The two-year average groundnut yield during *rabi* season was 28.76 to 35.24q ha⁻¹ under technology demonstration field as compared to 24.28 to 29.93q ha⁻¹ under farmers' practices. Average groundnut yield of 15 selected farmers under technologies demonstrated field was 25.91q ha⁻¹ as compared to 21.83 q ha⁻¹ under farmers' practices during

kharif season. The average groundnut yield of 15 selected farmers under technologies demonstrated field was 31.34q ha⁻¹ as compared to 26.53q ha⁻¹ under farmers' practices during *rabi* season. The improved technologies positively increased groundnut yield by 18.68 (%) and 18.13 (%) during *kharif* and *rabi* seasons, respectively, as compared to farmers' practices. Statistical analysis indicates that there has been significant yield difference between demonstration as well as farmers' plots during both seasons (Fig 4). The increase of groundnut production under technologies demonstrated was because of employing high yielding types, soil health based nutrient management, use of bio controlling agents for integrated pest and disease management, soil moisture-based irrigation application and use of groundnut digger cum elevator during groundnut harvest. Improved technologies not only increased groundnut production but also saved the crop inputs such as seeds, fertilizers, chemicals, irrigation water and labour, along with time, and similar outcomes have also been stated by Sunandini, G., & Devi, I. S. (2020) ^[57] and Srinivasa *et al.*, (2022) ^[52]. Similar findings have also been obtained by (Das *et al.*, 2017; Sharma *et al.*, 2017; Kumar *et al.*, 2023 and Shikha *et al.*, 2023) ^[16, 47, 32, 49]. Using micronutrients for groundnut production. New groundnut variety K-1812 cultivated in Andhra Pradesh yielded 15 to 25% higher yield than traditional varieties (Deva *et al.*, 2023) ^[18]. The adoption of sprinkler irrigation in groundnut production has increased the groundnut yield, water utilize efficacy (8 kgha⁻¹ mm⁻¹) and saved 25% irrigation water in the present study, and same results were also recorded by (Giresingh and Mahindra, 2016; Waseem *et al.*, 2017; Dong *et al.*, 2024 and Rojh *et al.*, 2021) ^[34, 59, 21, 46].



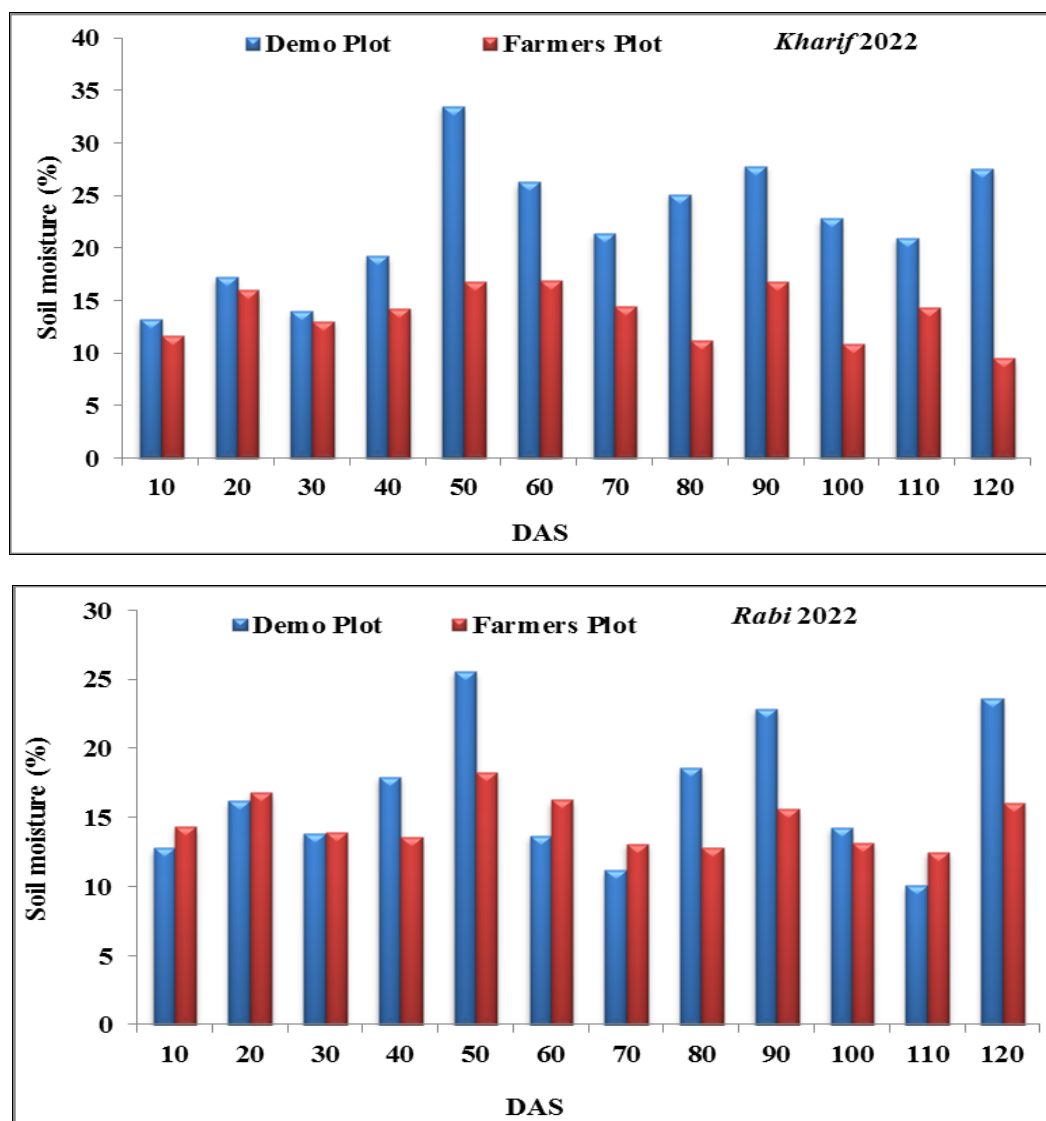


Fig 3: Soil moisture distribution in technologies and farmers' fields

Table 3: Groundnut pod yield during *kharif* and *rabi* season of 2021 and 2022 under technology demonstration and farmers practices field

Sl. n	Location	2021				2022			
		Kharif		Rabi		Kharif		Rabi	
		Demo plot	Farmers plot	Demo plot	Farmers plot	Demo plot	Farmers plot	Demo plot	Farmers plot
01)	Location 01	22.95	19.63	28.28	24.25	22.95	19.95	31.40	27.30
02)	Location 02	25.13	21.13	29.08	25.25	26.03	22.33	35.13	29.78
03)	Location 03	26.33	21.98	30.38	26.35	28.73	23.63	34.98	29.63
04)	Location 04	28.90	24.20	34.95	29.73	25.35	21.40	32.10	27.08
05)	Location 05	27.60	22.53	30.70	25.03	25.03	20.38	35.63	29.15
06)	Location 06	31.55	26.45	33.03	27.45	23.00	19.35	37.45	32.40
07)	Location 07	26.03	22.10	30.03	24.68	25.05	20.90	32.63	27.30
08)	Location 08	30.00	24.95	32.20	27.20	27.68	23.28	28.65	24.65
09)	Location 09	25.35	21.58	30.23	26.13	27.45	23.63	30.60	25.73
10)	Location 10	29.60	24.45	33.68	27.80	26.45	22.25	32.93	27.70
11)	Location 11	23.13	19.63	30.03	24.93	26.63	22.40	30.45	26.13
12)	Location 12	28.13	24.15	27.93	23.68	23.53	19.73	29.70	24.88
13)	Location 13	25.25	21.63	29.13	24.80	23.53	20.05	28.40	24.68
14)	Location 14	22.53	19.18	30.10	25.88	26.13	22.20	32.13	27.30
15)	Location 15	23.90	19.95	29.48	24.45	23.40	19.98	29.00	24.70
	Average	26.42	22.23	30.61	25.84	25.39	21.43	32.08	27.23

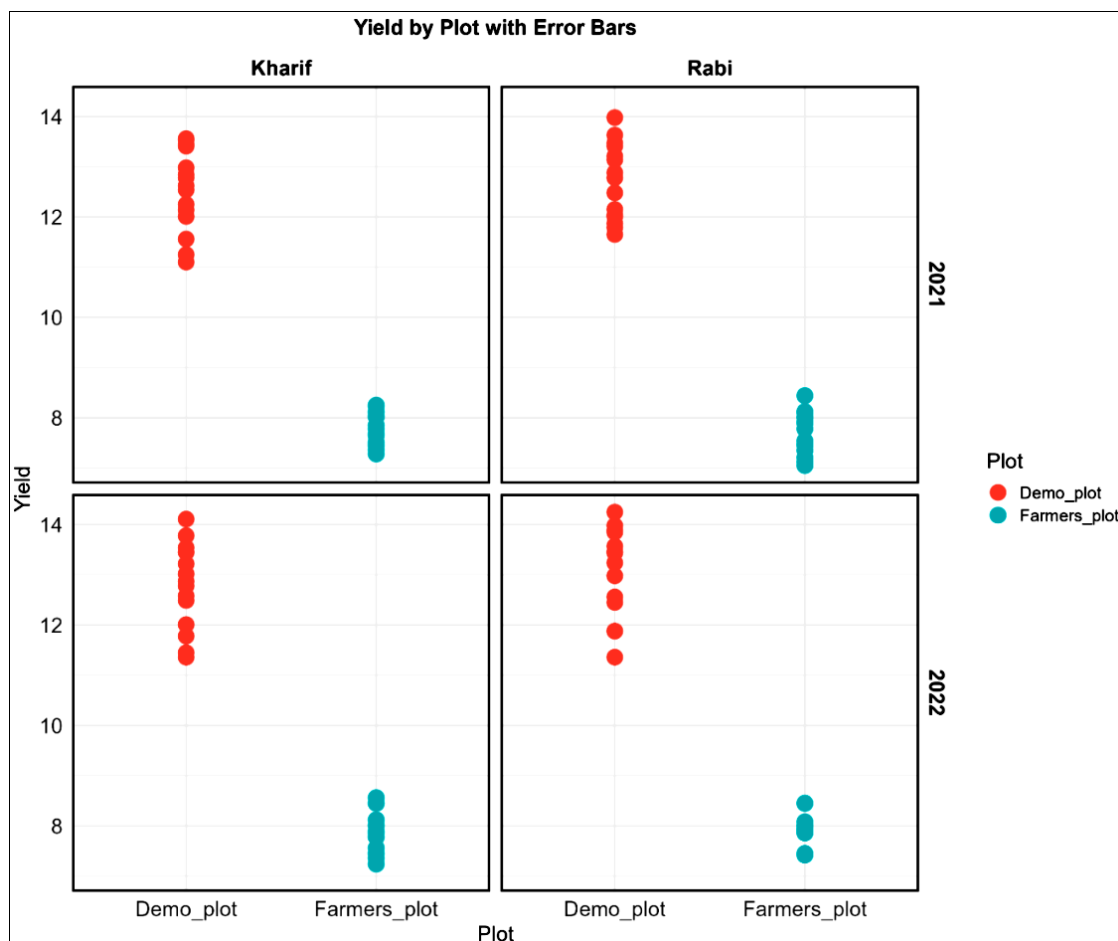


Fig 4: Groundnut yield difference in technologies and farmers field during study period

Aquacrop model calibration and validation

Aquacrop model has been calibrated utilizing *kharif* yield and biomass of 2021 and 2022. The statistical measures indicated aquacrop model was well forecast the yield as well as biomass of groundnut under farmers' practices and demonstration plots. During calibration, the values of statistical measures such as RMSE, MAE and E were 0.08, 0.87 and 0.96, respectively, for groundnut yield. The difference between simulated and observed groundnut yield was 9.54%, which is in acceptable range. The RMSE, MAE and E for groundnut biomass were 0.63, 0.70 and 0.88, respectively. The difference between simulated as well as observed groundnut biomass was 18.70%. The model prediction error between simulated as well as observed data was minimized by model fine-tuning. The values of plant growth parameters, temperature range, as well as harvesting index are shown in Table 2. Days to canopy decline (23), canopy growth coefficient (12.2) and canopy growth decline (0.683) were adjusted for during calibration to reduce model prediction error and biomass prediction. As per Chibarabada *et al.*, (2020) [12], biomass is utilized to simulate yield employing HI. The harvesting index (HI) and water productivity (WP) adjusted for groundnut yield prediction and values for the same were 24 and 15, respectively. The prediction error for biomass was higher than the yield, this is due to model underestimating the biomass.

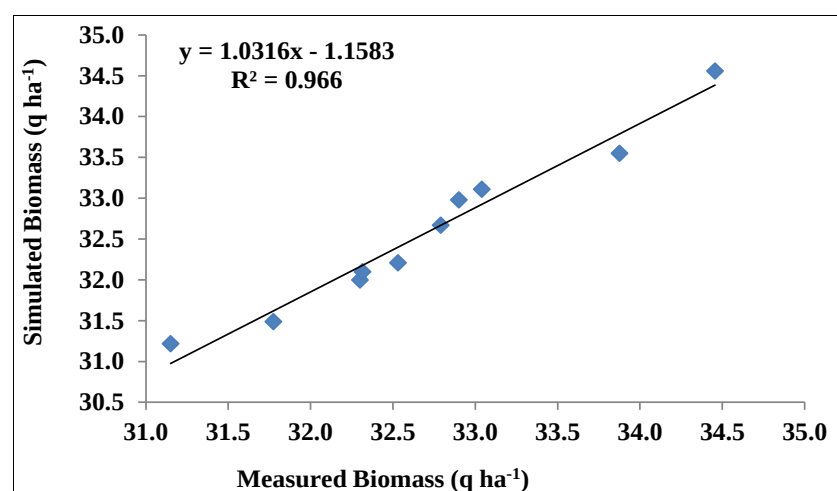
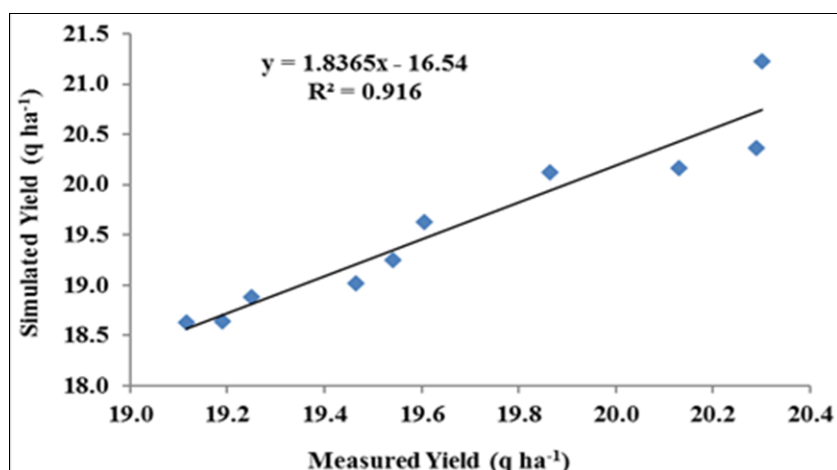
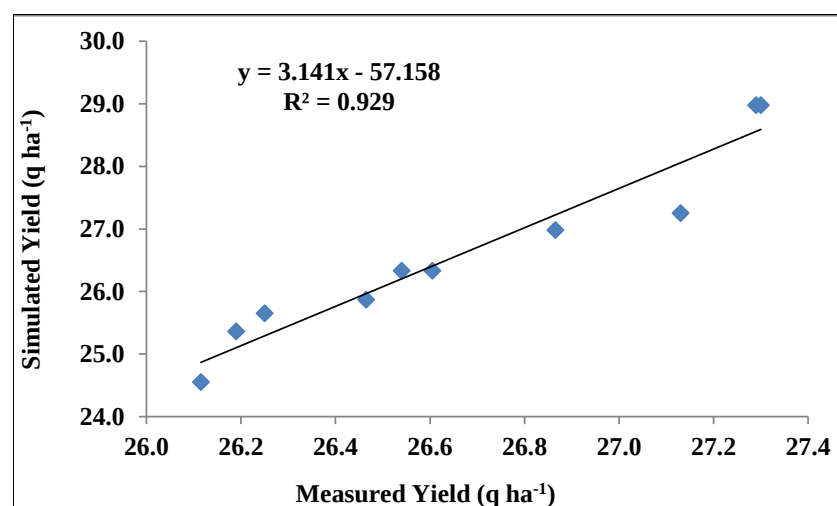
Data on groundnut yield and biomass of 2022 is utilized for validation of aquacrop model, and model showed that there was good agreement between simulated as well as observed values. Difference between simulated as well as observed groundnut yield as well as biomass was 14.13% and 15.80%, respectively.

The RMSE, MAE and E for groundnut yield were 0.07, 0.78, as well as 0.93, respectively. RMSE, MAE and E for groundnut biomass were 0.68, 0.68 and 0.83, respectively during validation (Table 04).

Performance of aquacrop model during calibration as well as validation is presented in Figures 5 and 6, respectively. Correlation (R^2) between simulated as well as observed values for groundnut yield and biomass was 0.92 and 0.97 under calibration. Similarly, under validation, correlation (R^2) between simulated as well as observed values for groundnut yield as well as biomass was 0.93 and 0.97. Many researchers used aquacrop model for its performance on different major crops viz, maize (Heng *et al.*, 2009, Umesh *et al.*, 2022) [25, 58], cotton (Farahani *et al.*, 2009) [22], wheat (Andarzian *et al.*, 2011) [5] and sorghum (Araya *et al.*, 2016) and reported that, aquacrop model performed well for all the crops. Chibarabada *et al.*, (2020) [12] utilized aquacrop model simulating groundnut yield under irrigation, as well as rainfed conditions, along with reported model performed well, with model efficiency more than 95%, and all the statistical parameters were within the acceptable range. In the present study, model output and statistical indicators showed good fit, as well as can be inferred that, aquacrop model is suitable for simulating the groundnut yield as well as biomass of groundnut crop under different agronomic practices and irrigation levels.

Table 4: Performance of aquacrop model during calibration and validation for groundnut

Calibration	Final Yield					
	RMSE	MAE	E	Simulated (q ha ⁻¹)	Observed (q ha ⁻¹)	Difference (%)
	0.08	0.87	0.96	21.58	19.52	9.54
	Final Biomass					
Validation	RMSE	MAE	E	Simulated (q ha ⁻¹)	Observed (q ha ⁻¹)	Difference (%)
	0.63	0.70	0.88	39.66	32.24	18.70
	Final Yield					
	RMSE	MAE	E	Simulated (q ha ⁻¹)	Observed (q ha ⁻¹)	Difference (%)
Validation	0.07	0.78	0.93	23.41	20.10	14.13
	Final Biomass					
	RMSE	MAE	E	Simulated (q ha ⁻¹)	Observed (q ha ⁻¹)	Difference (%)
	0.68	0.68	0.83	39.28	33.07	15.80

**Fig 5:** Simulated and measured yield and biomass during calibration of aquacrop model

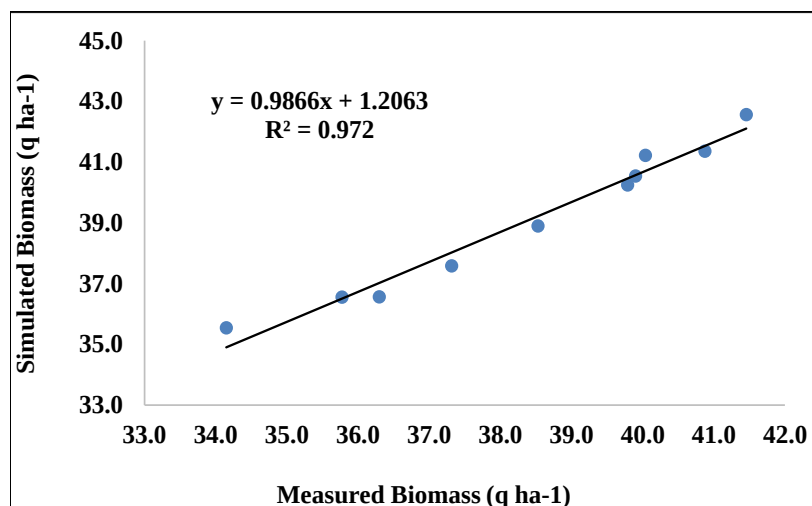


Fig 6: Simulated and measured groundnut yield and biomass during validation of aquacrop model

Conclusion

The improved technologies, such as high yielding variety K-1812, soil health-based nutrient management, IPDM and supplemental irrigation through sprinkler irrigation, positively increased the groundnut yield in the study area. The average groundnut yield under technologies demonstrated field was 25.91 q ha⁻¹ as compared to 21.83 q ha⁻¹ under farmers' practices during *khari* season. The average groundnut yield under technologies demonstrated field was 31.34 q ha⁻¹ as compared to 26.53 q ha⁻¹ under farmers' practices during *rabi* season. The improved technologies positively increased groundnut yield by 18.68 (%) and 18.13 (%) during *khari* and *rabi* seasons, respectively, as compared to farmers' practices and helped to minimize the cost of groundnut production. The BC ratio increased to 3.77 compared to 1.58 in farmer's field. AquaCrop model has been calibrated for simulation of groundnut yield as well as biomass for demonstration plot, as well as prediction error statistics were 0.96 <E< 0.88%, 0.08 <RMSE< 0.63 q ha⁻¹ as well as 0.87 <MAE< 0.70 q ha⁻¹. During validation, model performed well with model efficacy of 93% as well as 83% for groundnut pod yield as well as biomass, respectively and are within acceptable limits. AquaCrop model performed well, and it can be used for study on effect of climate change as well as agronomical practices on groundnut yield as well as biomass in study area.

Acknowledgement: University of Agricultural Sciences, Raichur (Karnataka) is expressing heartfelt gratitude to National Bank for Agriculture and Rural Development (NABARD), Regional Office, Bengaluru, for financial assistance provided for successful completion of this study.

References

1. Abdrabbo A, Abou Kheira A. Macromanagement of deficit-irrigated peanut with sprinkler irrigation. *Agric Water Manag.* 2009;96:1409-1420. doi:10.1016/j.agwat.2009.05.002.
2. Abedinpour M, Sarangi A, Rajput TBS, Singh M, Pathak H, Ahmad T. Performance evaluation of AquaCrop model for maize in a semi-arid environment. *Agric Water Manag.* 2012;110:55-66.
3. Abou Kheira AA. Macro-management of deficit-irrigated peanut with sprinkler irrigation. *Agric Water Manag.* 2009;96(10):1409-1420.
4. Adeboye OB, Schultz B, Adekalu KO, Prasad K. Modelling response of growth and yield of soybean to full and deficit irrigation using AquaCrop. *Irrig Drain.* 2017;66:192-205.
5. Andarzian B, Bannayan M, Steduto P, Mazraeh H, Barati ME, Barati MA, *et al.* Validation and testing of the AquaCrop model under full and deficit-irrigated wheat production in Iran. *Agric Water Manag.* 2011;100:1-8.
6. Araya A, Kisekka I, Holman J. Evaluating deficit irrigation strategies for grain sorghum using AquaCrop. *Irrig Sci.* 2016;34:465-481.
7. Archana P, Reddy KMM, Shaila O, Sridhar K, Swathi G, Kumar MS. A study on knowledge and adoption status of IPM practices in groundnut in Telangana. *Young.* 2024;22(37):28.
8. Arunasri P, Padmodaya B, Prasanthi A, Naidu M, Tirumala Reddy S, Reddi Kumar M, *et al.* Impact of integrated disease management practices on soil health and stem rot (*Sclerotium rolfsii* Sacc.) incidence in groundnut. *Pharma Innov J.* 2021;10:1349-1357.
9. Babu S, Panduranga G, Madhuri K, Saheb YP, Sreenivas A. Assessment of organic, inorganic and integrated nutrient management practices on yield and economics of groundnut during Kharif. *J Exp Agric Int.* 2024;46(8):9-14.
10. Behura D, Halder S, Teufel N, Charyulu DK, Variath MT, Pasupuleti J. Status of adoption of improved groundnut technologies in Odisha. *ICRISAT.* 2020;1-12.
11. Biradar SS, Ragini H, Harshith K. Modeling and optimization of groundnut production in Vijayapura district of Karnataka, India. *J Exp Agric Int.* 2024;46(5):202-219.
12. Chibabada TP, Modi AT, Mabhaudhi T. Calibration and evaluation of AquaCrop for groundnut (*Arachis hypogaea*) under water deficit conditions. *Agric For Meteorol.* 2020;280:107850.
13. Choudhary S, Jat M, Sharma S, Singh P. Effect of INM on soil nutrient and yield in groundnut in semi-arid Rajasthan. *Legume Res.* 2011;34(4):283-287.
14. Choudhary SK, Jat MK, Sharma SR, Singh P. Effect of INM on soil nutrient and yield in groundnut in semi-arid Rajasthan. *Legume Res.* 2011;34(4):283-287.
15. Corbeels M, Chirat G, Messad S, Thierfelder C. Performance and sensitivity of the DSSAT model in simulating maize yield under conservation agriculture. *Eur J Agron.* 2016;76:41-53.
16. Das S, Das A, Ramkrushna G, Layek J, Chowdhury S. Growth and physiology of groundnut influenced by micronutrients and liming in acidic soil of NE India. *Indian*

- J Hill Farming. 2017;29(2):40-47.
17. Datta P, Behera B, Rahut DB. Climate change and Indian agriculture: A systematic review. *Environ Challenges*. 2022;8:100543. doi:10.1016/j.envc.2022.100543.
 18. Deva S, Lakshmi RP, Jyosthna M. Performance evaluation of groundnut variety Kadiri Lepakshi (K-1812) in Chittoor district. *J Res ANGRAU*. 2023;51(2):37-42.
 19. Deva S, Prasanna Lakshmi R, Jyosthna MK. Performance evaluation of groundnut variety Kadiri Lepakshi (K-1812) in Chittoor district. *J Res ANGRAU*. 2023;51(2):33-38. doi:10.58537/jorangrau.2023.51.2.04.
 20. Diaa FH, Ati AS, Abdul Khalik, Neima S. Calibration and evaluation of AquaCrop for maize (*Zea mays* L.) under different irrigation and cultivation methods. *J Ecol Eng*. 2021;22(10):192-204.
 21. Dong J, Shen X, Li Q, Xue Z, Hou X, Miao H, *et al*. Irrigation and fertilization scheduling for peanut cultivation under mulched drip irrigation in a desert-oasis area. *Plants*. 2024;13(1):144.
 22. Farahani HJ, Izzi G, Oweis TY. Parameterization and evaluation of the AquaCrop model for full and deficit-irrigated cotton. *Agron J*. 2009;101:469-476.
 23. Feng DR, Li GY, Wang D, Wulazibieke M, Cai MK, Kang J, *et al*. Evaluation of AquaCrop model performance under mulched drip irrigation for maize in Northeast China. *Agric Water Manag*. 2022;261:107372.
 24. Gireshsingh M, Mahindra C. A study on the effects of different irrigation methods and fertilizer regimes on groundnut (*Arachis hypogaea* var. cabri). *Scholars J Agric Vet Sci*. 2016;3(1):9-19.
 25. Heng LK, Hsiao T, Evett S, Howell T, Steduto P. Validating the FAO AquaCrop model for irrigated and water-deficient field maize. *Agron J*. 2009;101:488-498.
 26. Yang H, Dobbie S, Ramirez-Villegas J, Chen B, Qiu S, Ghosh S, *et al*. South India projected to be susceptible to high groundnut failure rates under climate change and geo-engineered scenarios. *Sci Total Environ*. 2021;747:141240.
 27. Jat RA, Jain NK, Yadav RS, Reddy KK, Choudhary RR, Zala PV, *et al*. System-based integrated nutrient management improves productivity, profitability, energy efficiency and soil quality in peanut-wheat sequence in light black soils. *Sustainability*. 2023;15(2):1361.
 28. Jones JW, Antle JM, Basso B, Boote KJ, Conant RT, Foster I, *et al*. Brief history of agricultural systems modeling. *Agric Syst*. 2017;155:240-254.
 29. Jones JW, Hoogenboom G, Porter CH, Boote KJ, Batchelor WD, Hunt LA, *et al*. The DSSAT cropping system model. *Eur J Agron*. 2003;18:235-265.
 30. Kadiyala MDM, Nedumaran S, Padmanabhan J, Gumma MK, Gummadi S, Srigiri SR, *et al*. Modeling potential impacts of climate change and adaptation strategies on groundnut production in India. *Sci Total Environ*. 2021;776:145996.
 31. Karunaratne AS, Azam-Ali SN, Izzi G, Steduto P. Calibration and validation of FAO-AquaCrop model for irrigated and water-deficient bambara groundnut. *Exp Agric*. 2011;47:509-527.
 32. Kumar TS, Mehera B, Kumar P, Kumar B. Effect of micronutrients on growth and yield of groundnut (*Arachis hypogaea* L.) varieties. *Int J Environ Clim Change*. 2023;13(5):269-275.
 33. Mamatha A, Sridhar K, Kumar KA, Lakshmi DV. Yield performance of groundnut (*Arachis hypogaea* L.) varieties under varied soil moisture regimes of micro-sprinkler irrigation. *Biol Forum Int J*. 2022;14(3):189-193.
 34. Gireshsingh M, Mahindra C. A study on effects of different irrigation methods and fertilizer regimes on groundnut (*Arachis hypogaea* var. cabri). *Scholars J Agric Vet Sci*. 2016;3(1):9-19.
 35. Murthy PS, Kumari JPR, Basavaraju N, Janardhan D, Devamma MN. *In vitro* influence of biocontrol agents against *Sclerotium rolfsii* causing stem rot of groundnut (*Arachis hypogaea* L.). *Pharm Innov J*. 2018;7:5-8.
 36. Mwalongo S, Akpo E, Lukurugu GA, Muricho G, Vernoooy R, Minja A, *et al*. Factors influencing preferences and adoption of improved groundnut varieties among farmers in Tanzania. *Agronomy*. 2020;10(9):1271.
 37. Nagaraj R, Hanumanthappa M, Kamath S. Effect of integrated nutrient management on yield, nutrient uptake, secondary nutrient availability and microbial activity in groundnut in coastal Karnataka. *J Pharmacogn Phytochem*. 2018;7(5):3028-3031.
 38. Paramasivan M, Kumar NS, Rajkumar A, Nallakurumban B, Rajasekar M, Rajkumar J, *et al*. Effect of integrated nutrient management practices on growth and yield of groundnut (*Arachis hypogaea* L.) in Alfisols of Tamiraparani tract. *Legume Res*. 2023;1:7.
 39. Raes D, Steduto P, Hsiao TC, Fereres E. AquaCrop The FAO crop model to simulate yield response to water: II. Main algorithms and software description. *Agron J*. 2009;101:438-447.
 40. Rauff KO, Bello R. A review of crop growth simulation models as tools for agricultural meteorology. *Agric Sci*. 2015;6:1098.
 41. Reddy KS, Ricart S, Vegapareddy M, Pankaj PK, Krishna TS, Reddy A, *et al*. Economic assessment of water harvesting plus supplemental irrigation for improving water productivity in pulse-cotton systems in Telangana, India. *Irrig Drain*. 2020;doi:10.1002/ird.2401.
 42. Reddy KM, Kumar DV, Reddy BR, Reddy BS. Mechanization of groundnut crop in Anantapur district of Andhra Pradesh. *J Pharmacogn Phytochem*. 2020;9(1):1550-1553.
 43. Reddy KS, Maruthi V, Pankaj PK, Kumar M, Pushpanjali, Prabhakar M, *et al*. Water footprint assessment of rainfed crops under critical irrigation across climate scenarios in SAT regions. *Water*. 2022;14:1206.
 44. Robertson MJ, Carberry PS, Huth NI, Turpin JE, Probert ME, Poulton PL, *et al*. Simulation of growth and development of diverse legume species in APSIM. *Aust J Agric Res*. 2002;53:429-446.
 45. Rohtas R, Saharan HS, Rathi AS. Management of collar rot of groundnut with bio-agents, botanicals and chemicals. *Biosci Biotechnol Res Asia*. 2016;13(3):1657-1663.
 46. Rojh MK, Bhunia S, Shivran H, Bhawariya A, Bawaliya S, Ramniwas MR. Effect of irrigation levels and intervals on groundnut (*Arachis hypogaea* L.) cultivars under drip system. *Int J Plant Soil Sci*. 2021;33(6):41-45.
 47. Sharma M, Jat RA, Ganesh SS. Effect of micronutrients and biofertilisers on morpho-physiological parameters and productivity of summer groundnut (*Arachis hypogaea* L.). *Indian J Fertil*. 2017;13(3):56-59.
 48. Sharma P, Saini MK, Deep S, Kumar V. Biological control of groundnut root rot in farmer's field. *J Agric Sci*. 2012;4(8):48.
 49. Shikha FS, Rahman MM, Sultana N, Mottalib MA, Yasmin M. Effects of biochar and biofertilizer on groundnut production: a perspective for environmental sustainability in

- Bangladesh. Carbon Research. 2023;2(1):10-19.
50. Singh P, Indi SS, Savithri HS. Groundnut bud necrosis virus encoded NSm associates with membranes via its C-terminal domain. PLoS ONE. 2014;9(6):e99370.
 51. Soni J, Kumar A, Kumar V, Rani S, Banerjee A. Response of groundnut under micro irrigation a review. Progressive Research-An International Journal. 2016;11(7):4455-4459.
 52. Srinivasa, Dayananda BS, Lokesh AC. A review on cultivation of groundnut and mechanization processes in India. International Journal of Innovative Research in Technology. 2022;9(4):160-163.
 53. Srujana P, Zacharia S. Management of stem rot of groundnut (*Arachis hypogaea* L.) using organic amendments and *Trichoderma viride*. International Journal of Current Microbiology and Applied Science. 2020;9(1):62-70.
 54. Sruthi B, Reddi RY, Reddy PKA, Reddy P. Integrated crop management for climate resilience in rainfed groundnut (*Arachis hypogaea*) cultivation. Research on Crops. 2021;22(4):813-820.
 55. Steduto P, Hsiao TC, Raes D, Fereres E. AquaCrop the FAO crop model to simulate yield response to water: I. Concepts and underlying principles. Agronomy Journal. 2009;101:426-437.
 56. Subbiah G. KVK interventions in yield and economics of groundnut cultivation in Chengalpattu district. Annals of Agricultural Research. 2023;44(4):524-530.
 57. Sunandini G, Devi IS. Economic analysis of groundnut production in Andhra Pradesh. International Journal of Economic Plants. 2020;7(4):176-179.
 58. Umesh B, Reddy KS, Polisgowdar BS, Maruthi V, Satishkumar U, Ayyanagoudar MS, *et al.* Assessment of climate change impact on maize (*Zea mays* L.) through AquaCrop model in semi-arid Alfisol of southern Telangana. Agricultural Water Management. 2022;274:107950.
 59. Waseem M, Kaleel Ibrahim, Mallikarjuna, Rahul P. Comparison of micro sprinkler irrigation and surface irrigation methods on growth and yield for groundnut under Raichur region. Agric Update. 2017;12(7):2031-2035.
 60. Zhu X, Xu K, Liu Y, Guo R, Chen L. Assessing the vulnerability and risk of maize to drought in China based on the AquaCrop model. Agricultural Systems. 2021;189:103040.
 61. Panda S, Marziani P, Czerny B, Rodríguez-Ardila A, Pozo Nuñez F. Spectral variability studies in active galactic nuclei: exploring continuum and emission line regions in the age of LSST and JWST. Universe. 2023 Nov 24;9(12):492.