MANDATE :

Main functions	: Groundnut and groundnut based cropping Systems, Soil and Water management.
Verification functions	: Pulses, Bio-fuels, Watershed management and fodders.

Institute of Frontier Technologies was established in RARS, Tirupati with modern infrastructure and State of the Art lab facilities to support field research with advanced technologies viz., Biotechnology, Bioinformatics, Nanotechnology, Bio control lab, Soil and water analytical lab and quality lab.

CROP IMPROVEMENT:

GROUNDNUT

- **12 groundnut varieties were released from this centre (1979-2013). Out of these, Narayani and Dharani have become popular among farmers of the state.**

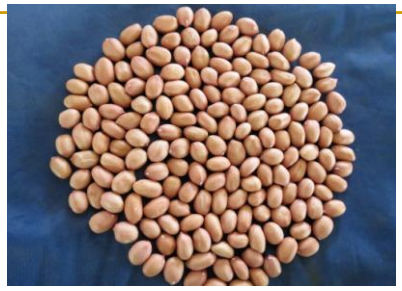
- **Narayani,** derivative of the cross, JL 24 × Ah 316/S is early maturing, drought tolerant with consistent performance across different soil types and environments has replaced 20% of TMV 2 and JL 24 area. The characteristic features of the variety are:

Characteristic features

Duration (days)	**:**	**100 kharif, 105 rabi**
Pod yield (q/ha)	**:**	**20-25 kharif, 40-45 rabi**
Shelling out-turn (%)	**:**	**75-76**
Oil content (%)	**:**	**49**
100 kernel weight(g)	**:**	**42-45**
Special characters	**:**	**Uniform maturity, suitable for low to medium rainfall areas, tolerant to drought, high frequency of mature kernels (95%), red testa variety.**

- **TCGS 1043**,released in 2013 as 'Dharani is drought tolerant, water use efficient, tolerant to stem and dry root rots, PBND and PSND. The performance of TCGS 1043 under different situations is given hereunder:

Dharani (TCGS 1043), high yielding drought tolerant groundnut culture released by state varietal release committee on 11-7-2012

❖ **Characteristic features**

- **Pedigree : VRI 2-XTCGP-6**
- **Duration : 100-105 days**
- **Pod yield : 16-26 q/ha(Kharif-Rainfed)**
  37-43 q/ha (Rabi)
- **Shelling out-turn : 75-77%**
- **Oil content : 50 %**
- **100-seed weight : 40-43g**

- **Special features : Drought tolerant, withstands up to 35 days dry spell, Uniform maturity, High SMK%, Attractive pods, Moderate stature, Tolerant to low light conditions**

Other research activities

- TCGS 1073 with high yield potential and water-use efficiency is proposed for minikit testing during *rabi*.
- The profiles of SSR markers, pPGS seq 14H6 and pPGS seq 16G8 have been found useful to differentiate resistant and susceptible lines of kalahasti malady. These are being validated in F_2 and elite cultures with known phenotype.
- Recombinant inbred lines for root traits, SCMR and SLA are being developed (F_3 stage).
- Marker studies are initiated for identification of high O/L lines in breeding populations.

PULSE CROPS

1. Redgram varieties LRG 38 and LRG 41 with bold seed and better recouping capacity found superior to LRG-30 were identified.

2. Identified genotypes suitable to light shallow soils viz., TRG-22, TRG-7 and TRG-33 with earliness and yield. TRG-22 with 160 days duration with seed yield of 16q/ha released in 2010.

3. Identified Redgram lines TRG-38, TRG-59 for wilt resistance through Molecular maker technique and in first year minikit testing.

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4. TFB-1, field been variety with photoperiod insensitivity, earliness and high green pod (40 q/ha) released in 2006. Field been variety TFB-2 with 160-180 days duration and pod yield 35q/ha suitable to rainfed, inter cropping systems released in 2010

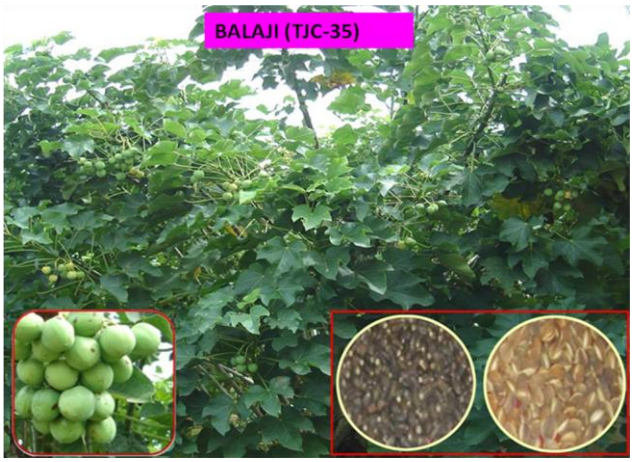
TFB1 **TFB2**

5. Identified YMV resistant shiny seed line TBG 104 using MAS and it is in minikit testing.

6. In cowpea TPTC 29 developed photo insensitive, short duration (80-90 days) bushy line suitable for different cropping systems and seasons.

7. In jatropha, TJC-35 is released as Balaji during April'2010**;**

Yield : 12-14.5 q/ha, Oil: 29 %



B. PRODUCTION TECHNOLOGIES

- ❖ Intercropping of groundnut with redgram or castor in 7:1 ratio is a profitable cropping system for rainfed red soils.

Groundnut +Redgram 7:1

Groundnut + Castor 7:1

❖ Under delayed monsoon, contingent crops namely redgram, castor, greengram, fieldbean, clusterbean and jowar were the best

Redgram

Castor

Greengram

Cluster Bean

Field bean

Jowar

❖ Bimodel distribution of rainfall in this district favors double cropping. Groundnut followed by greengram, blackgram, cowpea, field bean and horse -gram are beneficial double cropping systems.

❖ Among different pigeonpea based cropping systems tested Redgram + cluster bean (seed) in 1:7 ratio gave highest monitory returns/ ha.

❖ Redgram was found promising as suitable contingent crop when sown during August under rainfed condition.

❖ Guar as seed crop was found to be a suitable alternate crop in rainfed alfisols.

❖ Groundnut sown during December resulted in higher pod yields compared to January sowings in *rabi.*

❖ Groundnut sown during 1st fortnight of July gave higher pod yield compared to August sowing.

❖ Among rice based cropping systems, *kharif* rice followed by *rabi* groundnut system was found to be more remunerative.

- Groundnut production under rainfed conditions is affected in red sandy clay loams due to surface hardening. Application of groundnut shells @ 5 t/ha as a soil amelioration was found to be effective.

- Moisture stress at different stages of rainfed groundnut could be mitigated by following certain methods of soil surface manipulation like bed and furrow/dams, bed and ridges and also opening of dead furrow etc.

- Soaking of groundnut seed in 0.05% etheral solution for 8 to 10 hours followed by shade drying breaks the dormancy.

- Drying of rabi/summer groundnut under shade protects the seed viability upto 10 months after harvest.

- Mean of maximum and minimum temperatures above 25◦ C resulted in lower pod yields in groundnut.

- Threshold values of temperatures, (Maximum<350C, minimum>180C) relative humidity (FN above 65%, AN above 35%) and day length (shorter days < 12.30 hours) requirement for optimum yields have been worked out for groundnut.

- Weeds in groundnut can be controlled by pre-emergence application of butachlor at 1 lt / acre and with one hand weeding at 35 DAS

- Estimated the loss in groundnut pod yield due to moisture stress at critical phenophases. Moisture stress at flowering, pod filling and pod maturity stages reduced kernel yields by 12, 20 and 26 % respectively compared to irrigated control.

- Pre flowering moisture stress was beneficial resulting in synchronized flowering and reduced vegetative growth.

- In blackgram LBG 20, MBG 214, PBG 107 and in green gram LGG 521, 494, and MGG 351 were found to be most tolerant to end of season moisture stress.

- In Ragi PPR 2286, CHAMPAVATHI and MARUTHI were found to be tolerant to terminal droughts.

- Establishment of farm pond and utilizing the collected water for irrigating rainfed crops (groundnut based inter crops) through sprinkler irrigation showed enhanced yields


Contingent crops for delayed sowings in *Kharif*

Contingent crops sown – Redgram, Greengram, castor, field bean, Sorghum,

Dates of sowing: 1. Second fortnight of August; 2. First fortnight of September; 3. Second fortnight of September

Highest net monetary returns:

August sowing:
Redgram + Greengram **:** 2084 + 567 kg /ha
Sole Redgram : 2341 kg/ha

September I fortnight sowing
Redgram + Greengram **:** 2297 + 170 kg/ha
Sole Redgram : 2088 kg/ha

September II fortnight sowing
Redgram + Greengram **:** 1441 + 207 kg /ha
Redgram + sorghum :1258 + 176 kg/ha

Varieties identified for drought

- Groundnut: Ahaya(2006), Greeshma(2009), Rohini(2010)
- Rice: NLR 3010, NLR 40059, NLR 33671, NLR 34242, MTU 1010 , NLR 145
- Sugarcane: CO 6907,CO(O) 061, 2004 T 68, CO T 8201(Salinity Tolerance)
- Black garm: LBG20,MBG 214,PBG 107
- Green gram: LGG 521,LGG 494,MGG 351
- Ragi: PPR 2700,PPR 1006, PPR 2286,Champavathi,Maruthi
- Jatropa: BALAJI

Long term effects of manures and fertilizers on rainfed groundnut

Long term effects of manures and fertilizers on the productivity of rainfed groundnut and soil fertility have been initiated in 1981 with eleven treatments. The results 25 years of experimentation reveled that application of fertilizers to groundnut crop was better responded.

Effect on soil properties :

1. organic carbon content increased

- by about 60% in all the treatments
- by 70 % in FYM treatment.

2. Soil reaction changed to acidic in all the treatments (Initial pH 6.7, after 33 years around 5.8).

3. Depletion in available phosphorus in some of the treatments viz., only K, N&P and NPK+Lime was observed.

4. Build up of P was seen in all other treatments.

5. Build up of available potassium in all the treatments and highest accumulation was observed in continuous application of FYM for 33 years.

Effect on pod yield:

- Continuous use of manures and fertilizers over a period of 33 yrs increased pod yield significantly over no fertilized treatment.
- FYM treated plot- 2354 kg/ha (Highest pod yield)
- NPK+ Lime -2330 kg/ha.
- NPK+Gypsum+$ZnSO_4$ -2293 kg/ha.

❖ **Boron deficiency in groundnut growing soil of Chittoor district**

First time identified boron deficiency in the groundnut growing soils of Chittoor District and also conducted an experiment on application of boron and molybdenum to groundnut since three years and optimized the boron doses to groundnut (Southern zone soils)

RESEARCH ON BIO-DIESEL CROPS

At RARS, Tirupati research on Bio-diesel crops was initiated in 2004 with Jatropha under State Plan and RSAD Projects. The complete technical programme was taken up on germplasm evaluation, fertilizer management, Spacing and irrigation requirement and sufficient data was generated. Various pests and diseases affecting Jatropha were documented.

Of late work is also initiated on other bio-diesel crops Neem, Madhuca and Simarouba sps. Germpalsm of these species were obtained from Biotechnology Research Centre (BIOTRIM) and Forest nursery of TTD, Tirupati and planted at RARS, Tirupati. The following are the germplasm lines of Bio-diesel crops being maintained at RARS, Tirupati.

	Crop	Germplasm	Year of planting	Source
1	Jatropha	100	2004	Local, NBPGR, Agro-Forestry, Hyderabad
2	Pongamia	13	2006	BIOTRIM, Tirupati
3	Madhuca	2	2007	BIOTRIM, Tirupati
4	Neem	2	2007	BIOTRIM, Tirupati
5	Simarouba	1	2007	BIOTRIM, Tirupati

C. PLANT PROTECTION:

- **Studies on "Development of weather based fore-warning systems for groundnut insect pests" thrips population was collected from groundnut crop at RARS, Tirupati during 2011** was processed for molecular identification with ITS and mtD primers and identified as *Scirtothrips dorsalis*. Out of 100 individual thrips used in study, 43 specimens were amplified with the above two primers and sequencing was done. The sequences were matched with *Scirtothrips dorsalis* in NCBI database up to 85% similarity. These were deposited in NCBI GenBank with accession numbers, JQ352777, JQ352778, JQ352779 and JQ352780

- Identified *Anarsia ephippias* as emerging pest in groundnut

- Identified Root knot nematode *Meloidogyne arenareae* on groundnut in the coastal sand soils of Nellore district.

- **Management of Groundnut leaf miner with certain new insecticides for three seasons** (2009 to 2011) **revealed that** of management of GLM with certain new insecticides revealed that three insecticides viz., Quinalphos @ 2.0ml/l (**4.37%**), monocrotophos (4.25%) and Chlorpyriphos @ 2.5ml/l (4.04%) were more effective while pod yield was also high in all the three treatments 1498, 1347 and 1309 Kg/ha respectively when compared to control (740Kg/ha).

- **Effect of newer insecticides against the insect pests of groundnut during** three seasons (2010-2012) revealed that pre treatment per cent defoliation due to *Spodoptera litura* was ranging from 26.35 to 34.45 per cent. Post trearment data one week after spray was reduced in most of the treatments and lowest incidence was recorded in rynaxypyr (14.67%), thiodicarb (15.25 %) and novaluron (15.54 %). In case of leaf hoppers, lowest damage was recorded in thiacloprid (9.53%) and thiamethoxam (10.29%) which were on par with each other. Regarding yield, highest pod yield was recorded in novaluron 10EC @ 1ml/l (2315.1 Kg/ha), thiodicarb @ 1g/ lt (2352.8 Kg/ha) and thiacloprid (2201.1 Kg/ha) which were on par with each other.

Intensification of IPM (*Evaluation of IPM modules in groundnut*)

a. **Effect of different seed rates and Spacing (Plant Population) on thrips incidence indicated that t**hrips incidence was high in the seed rates from 40-60kg/ac sown in 30x10cm spacing and the PBND is also high where as the incidence of PBND and Thrips was low in seed rates from 70-100kg/ac sown at 22.5x10cm spacing. Highest pod yield was recorded in treatment T8(70 Kg/ac with 22.5x10 spacing)

b. ***Evaluation of different chemical insecticides against thrips:*** **Pooled analysis for 3 years** from 2009-2011 indicated that all the insecticide treatments were effective and on par with each other in reducing thrips damage in groundnut (5.22 to 7.08 per cent) compared to untreated control (12.21%). Highest pod yield was recorded in treatment with imidacloprid @0.25ml/l followed by chlorfenapyr @2ml/l and emamectin benzoate. Similar tend was recorded in case of benefit cost ratio and added returns over control.

- **Evaluation of botanical insecticides against thrips during 2009-2011 (**Pooled analysis): Pooled analysis of the three seasons indicated that NSKE5% (6.00%) is more effective among the 8 botanical insecticides evaluated against thrips in groundnut which is on par with spinosad (4.58%). Pod yield also high in both the treatments (1307 and 1472 Kg/ha) when compare to untreated control (927.6 Kg/ha)

- ***Evaluation of eco-friendly measures for groundnut Insect pests and diseases*** pooled data analysis for three seasons (2009-2011) indicated that treatments NSKE5% and Neem oil 0.5% were effective in controlling thrips damage. These two treatments recorded highest pod yield compared to other eco-friendly products.

Production of bioagents and evaluation against different pests and diseases

- Collection of soil samples from different zones of A.P. and isolation of *B.t*: 119 isolates of Bt were identified by gram staining and crystal protein staining. Crystal structure analysis indicated that majority of native *Bt* isolates contain Spherical crystals (28%).
- Among 32 isolates tested against *Spodoptera litura*, isolate No. 375 recorded mortality of 80% which was on par with HD1

- **Forty two *B.t. i*solates recorded more than 50% mortality against II and III instars of *H. armigera*: (42/119) and a**mong all the 42 isolates evaluated isolate 22 and 122 recorded highest mortality of *H. armigera*

  Two *Bt* strains *i.e* 375 and 122 were sequenced confirmed that these two isolates are *Bacillus thuringiensis* and deposited with accession numbers JN798215.1 and JN798214.1
- Field evaluation of native *Bt* strains in two different formulations against *Spodoptera litura* in groundnut revealed that, solid formulation of *Bt*405 (7.98%) and *Bt*375 (9.89 %) were on par with novaluron (6.47%) as against 22.95 per cent damage in untreated control. In case of liquid formulations, *Bt*87 (9.23%) recorded lowest damage by *Spodoptera* followed by *Bt*83 (13.85%). Solid formulations were more effective compared to liquid formulations.

- A total 13 *Beauveria bassiana* isolates were collected from infected silkworm, *Spodoptera* and as well soil samples of Chittoor, Anathapur and Kurnool districts.

- 12 new *Beauveria* isolates were collected and conducted bioassay against *Spodoptera litura* I, II and III instars and found 42.2 to 88.9 % mortality against I instar, 33.3 to 86.7% mortality in II instar and 13 to 60 % mortality against III instar. Highest mortality was recorded with SGB isolate. Gene sequences of five effective strains were deposited in Genbank, Bethesda, USA with the following accession numbers JX173280.1 and, JX313063.1JX313064.1, JX313065.1, JX313066.1

- Effect of seed treatment chemicals against ragi insect pests indicated that, seed treatments with imidacloprid 600FS (0.76%), thiamethoxam 35 FS (1.18%), recorded lowest stem borer damage(% dead hearts) as against 13.34 per cent in untreated control. Application of granules of cartap hydrochloride @8kg/ac (1.12%), fipronil @8kg/ac(1.20) and carbofuran @ 10kg/ac(1.75%). Highest grain yield was recorded in the treatments with cartap hydrochloride (3253.3 kg/ha), fipronil (3213.3 kg/ha) and imidacloprid (3120 kg/ha) which were on par with each other

- **Screening of sugarcane entries against pest complex against insect pests indicated that,** Incidence of internodes borer was recorded from mid late varieties (MYT- mid late trial) and incidence was ranged from 4.08 to 22.00 per cent in different varieties and lowest incidence was recorded in Co86032 as against highest per cent incidence in 2009T61(22.00%)

- **Evaluation of different chemical insecticides against *Spodoptera litura* during *rabi*, 2013-14** with nine chemical insecticides indicated that, rynaxypyr @0.3ml/L of water found to be effective against *S.litura* followed by indoxacarb @1.0ml/l and thiodicarb @1.0g/l.

AFLATOXIN RESEARCH RESULTS IN GROUNDNUT

Ideal conditions for aflatoxin contamination identified

Soil fungal counts > 1000CFU/g. of soil

Soil temperature > 28^0C

Kernel moisture content < 30%

Leaf water content (RWC) < 50%

1. Genotypes J11, ICGV 89104, ICGS76, CSMG 84-1, TCGS-APNL-888, TCGS-APNL-913 were found to have low aflatoxin levels across locations.
2. Quantification of aflatoxins through ELISA and HPLC were standardized.
3. Two competitive *Trichoderma viridae* and *T.virens* strains (Indian type culture collection Accesion No-6359.06 and 6360.06) were identified which can use as biocontrol agents against *Aspergillus flavus.*
4. Two non-toxic and competitive isolates of *Aspergillus flavus* were identified with the absence of aflatoxin producing genes (Afla R, Vir)
5. Non-toxic and toxic *A.flavus* isolates were sequenced and deposited in International gene bank, Betesda, USA (Toxic-EF 030718, Non-toxic- EF 030719).
6. A potential bioagent against toxic *Aspergillus flavus* i.e., non toxic *Aspergillus flavus* (TGF-37) was identified and method of application was standardized.
7. A botanical compound was developed for post harvest prevention of Aflavus infection.

IV. NANOTECHNOLOGY

Nanotechnology is the key technology of the 21st century and will reorient the applications in technologies including biology. Despite being in its early stages the future for nanotechnology in agriculture appears to be bright. Nano-form materials are small in size and because of the size the mobility may be increased and which enable efficient nutrient uptake and utilization. There is a direct impact of these nano-form materials on the lowering the cost

of cultivation, disease resistance and quality improvement because of the higher nutrient use efficiency.

Facilities Created

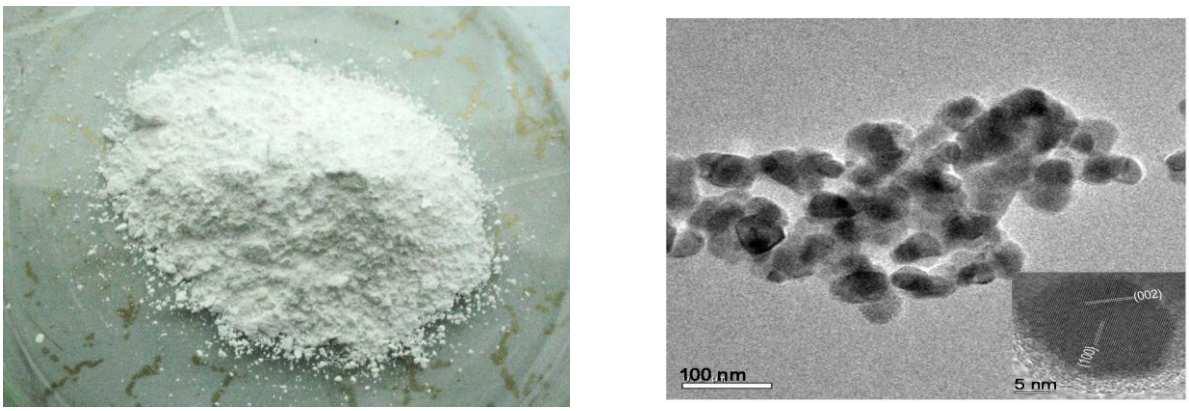
- Nano-particle analyzer, Scanning UV-Vis Spectro-photometer, Fourier transform- infrared spectroscopy (FT-IR) and Inductively coupled plasma optical emission spectroscopy (ICP-OES).

Research work Initiated

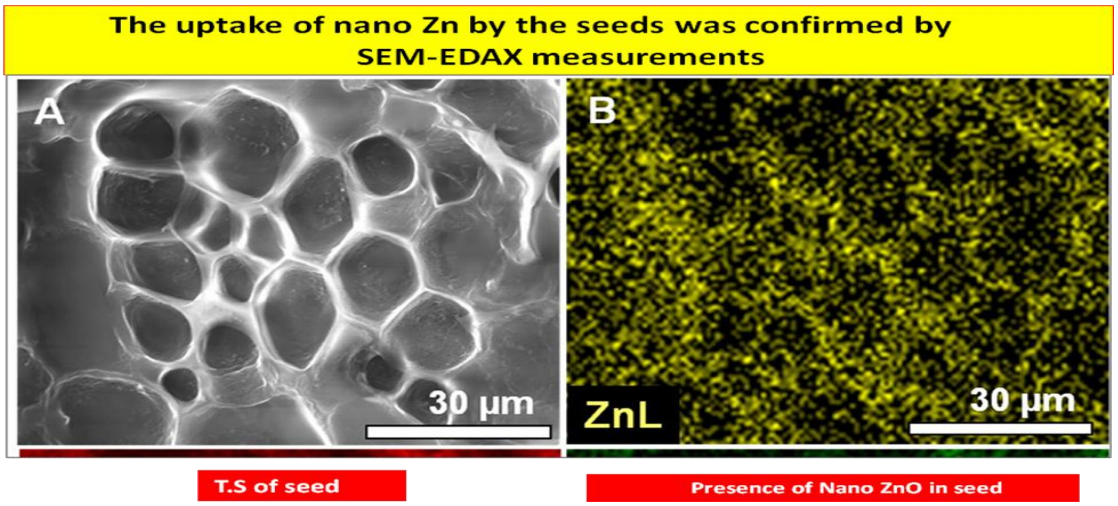
- Synthesised Nano sized micronutrients viz. ZnO, FeO, MnO, CuO, MgO
- Green synthesis of nano particles using plant material and microbes.
- Research on application of the nano materials in different crops and biosafety is under progress.

Patent submitted

One patent on *"Nano-material based novel growth medium for enhanced efficiency of agricultural beneficial bio-agents and plant growth promoting rhizobacteria"* was filed vide ref No. E-2/7123/2013-CHE



Nano Zinc Oxide Powder and HRTEM image (25 nm)



Future line of Research in nano technology

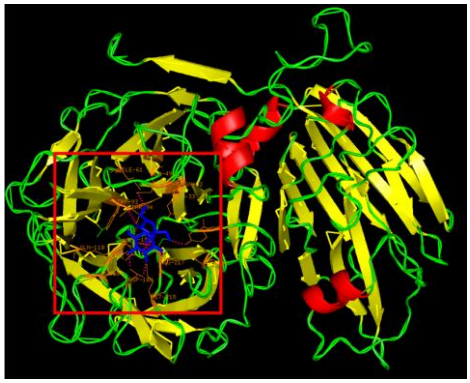
1. Development of crop specific nano-nutrient formulation
2. Development of bioagents with enhanced efficiency through nano material based formulation
3. Assessment of toxicity and bioavailability of nano materials in different soil matrices and plants.
4. Development of designer PGPR's with crop specificity
5. Development of disease diagnostic techniques through nano technological intervention.

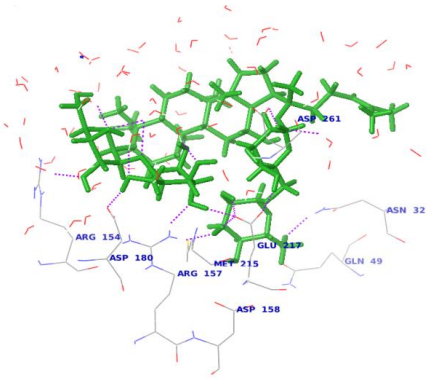
BIOINFORMATICS

Bioinformatics is an emerging interdisciplinary science encompassing application of information technology to handle biological information by addressing biological data collection and warehousing, data mining, database searches, analyses and interpretation, modeling and product design. Bioinformatics has a key role to play in areas like agriculture where it can be used for developing new varieties with improved resistance to fungal, insect or viral diseases, tolerance to abiotic stresses such as drought, cold salt, dehydration, heavy metal toxicity, numerous quality attributes such as taste, size, shape, color and ease of cooking and increasing the nutritional content, increasing the volume of the agricultural produce, designing agricultural chemicals etc. The use of bioinformatics tools has already generated a large amount of public resources such as genetic resources, genomic and genetic information, tools for the effective analysis, data mining and visualization of such information, and semantic web resources for data integration. Research utilizing Bioinformatics tools was initiated for the first time in ANGRAU at RARS, Tirupati during 2013-14. A 10 mbps BSNL internet connection is being utilized for this purpose. Two research projects were executed during 2013-14 on sugarcane.

1. Sugarcane Germplasm Database (SGDB) was developed for 45 descriptors on 131 germplasm accessions using MySQL 5.6 server, Dreamweaver web design tool, JAVA programming language and Apache Tomcat server. The information included data on 27 Distinct, Uniform and Stable (DUS) descriptors as described in PPV & FRA, India, 18 agronomic and quality descriptors and pictures in JPEG format on the most distinctive features. The database will be useful to sugarcane breeders to identify the accessions and in selecting parents for targeted traits in hybridization and crop improvement in sugarcane.

2. Structural analysis of soluble acid invertase was performed to obtain novel insight on overcoming post harvest sucrose loss in sugarcane. The 3D structure of Soluble acid invertase was developed and submitted to the protein model database (PMDB), which accepted the structure with less than 3% stereo chemical check failure (PM0076107). A set of 372 structural analogues of sucrose were obtained from one million compounds of ligand info Meta database. 15 leads were proposed as potential inhibitors of soluble acid invertase. Lead 1, showed the best Gscore (XP: -12.07 kcal/mol; QPLD: -13.07kcal/mol) and interactions with residues that are important for sucrose binding. The conformational and interaction stability of soluble acid invertase – lead1 docking complex was stable during 10ns molecular dynamic simulations. Therefore, lead1 was proposed as potential competitive inhibitor to sucrose.





3.

Homology model of soluble acid invertase (PM0076107) along with substrate, sucrose.

Invertase-lead1 complex after 10ns MD simulation; 17 hydrogen bonds compared to 11 in docking.

AGRICULTURAL ENGINEERING

- Established Mini sprinkler irrigation system to groundnut crop
- Installed drip irrigation to groundnut crop for about 2.00 ha
- Established drip irrigation system to maize and sunflower crops with pair row planting methods with water saving 30 – 40 %
- Established drip irrigation system to Pongamia and simaruba plantations
- Evaluation of different seed cum ferti drill for sowing of groundnut crop.

Groundnut Seed drill

ANGRAU Puddler
(water saving upto 28 %)

Sub soiler (up to 70 cm) for better moisture retention

GENE BANK DEPOSITIONS

The following gene sequences were deposited in NCBI, Betesda, USA.

- **A.flavus –** **2**
- **Trichoderma** **6**
- ***Bacillus thurengenesis*** **2**
- ***Bvaria*** ***5***
- **Thrips** **4**
- **Viruses** **52**

D. TRANSFER OF TECHNOLOGY:

- On-farm of improved varieties / technologies demonstrations during crop season
- Diagnositic visits for on the spot solutions to the farmers
- Conducting *Rytu Sadassus* at mandal level for location specific problems
- Adoption of villages and working for over-all development of community
- Training of AEOs and other line department personnel and NGO's in the district
- Conducting *Kisan melas* and agricultural exhibitions during the crop season
- Established agricultural information center for the benefit of farmers
- Agro advisory services through print and electronic media

Dr. T. Giridhara Krishna, ADR, RARS addressing at Kharif' 2012 Groundnut workshop at RARS, Tirupati

Demonstrating groundnut stripper

Kisan Mela organized at RARS, Tirupati on 27.02.12

Field day of Dharani at Narpala,