

Theme 1: Identification of temperature tolerant rice and maize varieties for North Eastern hill ecosystem

Evaluation of major food crops for tolerance to climatic stresses and genetic enhancement of tolerance

RICE

Heat Tolerance in Rice (Umiam)

- Identification of a **mini core of nine heat tolerant genotypes** after screening of 600 rice genotypes under high temperatures at early vegetative stage and reproductive stage, respectively. These are **RCPL 1-74, RCPL 1-132, RCPL 1-136, RCPL 1-185 , RCPL 1-186, RCPL 1-188, RCPL 1-409, RCPL 1-460** and **RCM-17**.
- Generation of phenotypic information of the mini core based on germinability, plumule growth and survival under heat stress.
- A forward subtracted library was constructed from cDNAs isolated from leaves of RCPL 1-460. A total of 200 unigenes of average 658bp were isolated. It includes ~60 heat responsive genes involved directly or indirectly in abiotic stress regulation. Transcription factors such as NAM, proteasome pathway genes like ubiquitin ligase, heat shock proteins etc. identified.
- Generation of genotypic information of the mini core with 72 SSR markers.
- Differential expression pattern of heat-tolerant genotype **RCPL-1-188** was evaluated in early vegetative stage after being subjected to 45°C for 1H, 3H, and 24H, respectively, using quantitative RT-PCR. Expression of the following putative genes identified. Glutathione S-transferase, Jacalin-like lectin containing protein are upregulated while downregulated genes include Zinc ring finger protein, putative thioredoxin, glyoxalase family protein.



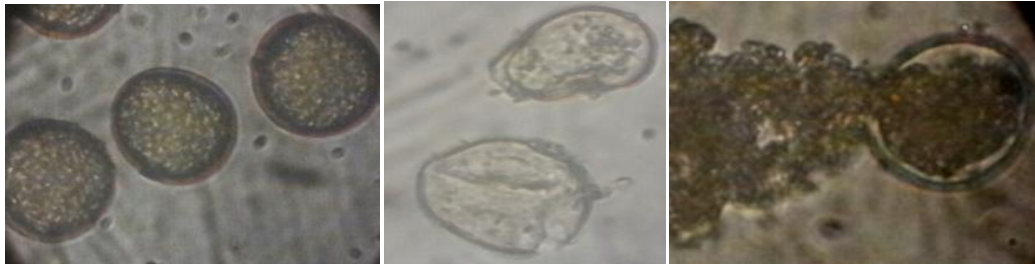
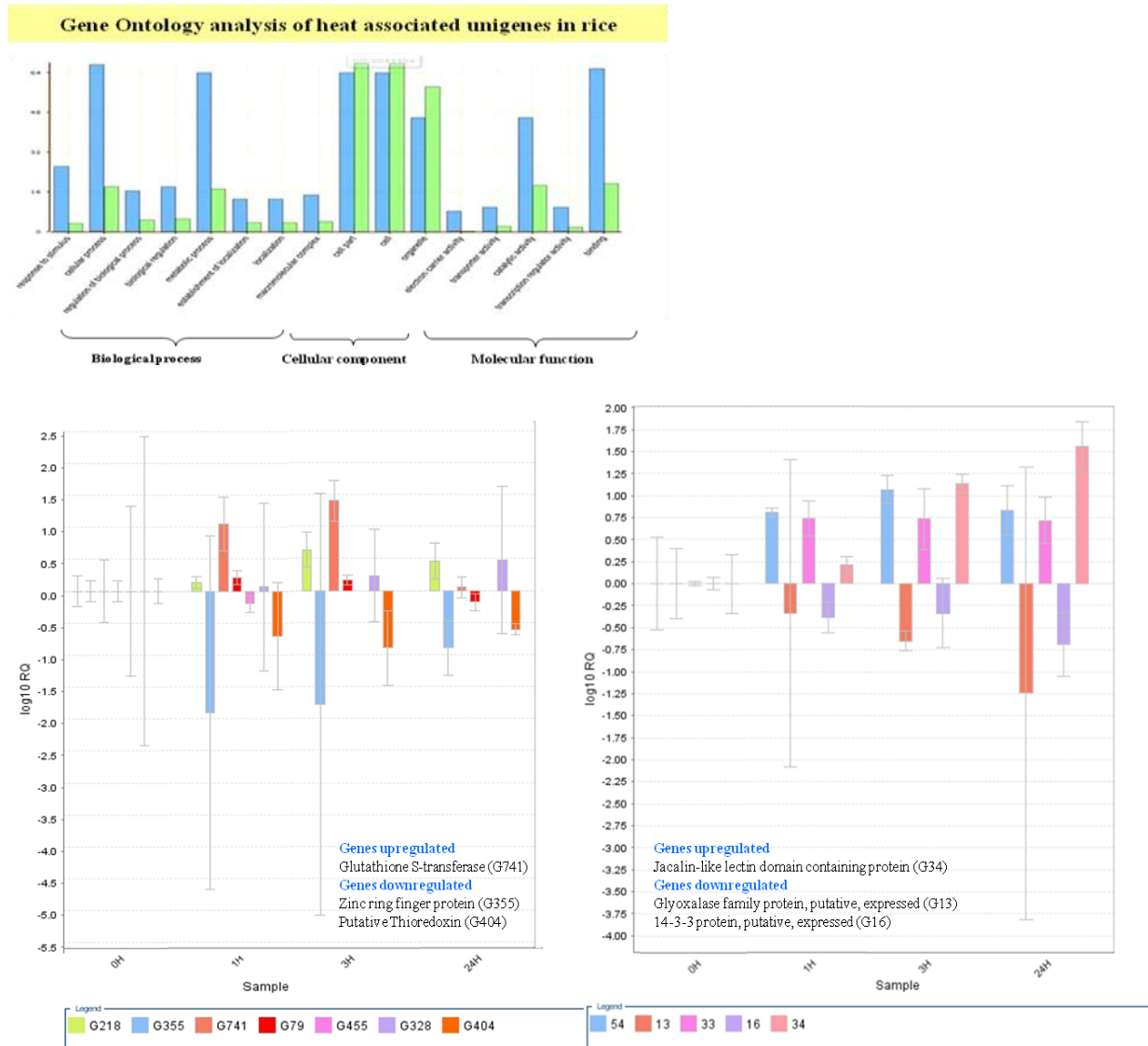


Fig: Rice pollens in control plants; damaged and bursted pollens under treatment



Gene specifications: G218 – Metallothionein; G355 – zinc RING finger protein; G741 – Glutathione; G79 – ZOS1-06-C2H2 zinc finger protein; G455 – Ser/Thr receptor like kinase; G328 – Translationally-controlled tumor protein homolog; G404 – putative thioredoxin; G54 – ATP – dependent Clp protease ATP – binding subunit precursor; G13 – Glyoxalase I; G33 – Heat shock protein 90; G16 – Hypothetical protein OsI_29320; G34 – Salt stress - induced

Gene expression was measured in Log₁₀ (RQ) units using 18sRNA gene (not shown) as an endogenous control and 0H (untreated) as the baseline.

Fig: Expression analysis of the identified putative genes using RT-PCR

Identification of major QTLs for grain yield under drought stress in rice varieties for use in marker assisted breeding to improve yield (Tripura)

- Drought scoring completed for 863 upland and lowland rice.
- Genotyping of 45 genotypes collected from jhum areas in Tripura completed so far with 200 SSR markers.
- **Development of mapping populations**
Four most drought tolerant lines from the evaluated 78 jhum and other lines from north east region were crossed with high yielding but drought susceptible varieties Naveen and Swarna.
Six mapping populations for QTL studies on drought tolerance in rice: RCPL 1-128 x Naveen, Bhalum 3 x Naveen, Fulbadam x Swarna, Kataktara x Naveen, Fulbadam x Naveen and Kataktara x Swarna were advanced to F4.
- Phenotyping of the mapping population (CT 9993-5-10-1-M/2*SAMBHA MAHSURI) for drought QTL identification has been conducted. Presently the mapping population has 311 RILs. Selections were made for high yielding entries under severe drought stress. Selections were also made for the entries with early duration and fine grain quality like Sambha Mahsuri. Under severe drought stress, Sambha Mahsuri did not produce any yield at all, whereas some of RILs produced significantly good yield under severe drought stress.



Submergence tolerance in rice (Manipur)

- Among five rice varieties viz., RC Maniphou-6, RC Maniphou-7, RC Maniphou-9, Akutphou and Taothabi, **RC Maniphou-7** performed better in terms of yield of at 8.4 t/ha and 6.45 t/ha under half submerged condition for 15 and 10 days, respectively.



Identification of temperature/drought tolerant rice varieties for Sikkim region

- About **255** rice germplasms were evaluated under direct seeded rainfed upland condition for identifying lines performing better under water stress conditions.
- Entries earliest in flowering were IRCTN 91-84 (52 days), Dular (72 days), IR-30-13 and Birsa 109 (73 days).

- Entries Dular (111 days), Lalna Kanda (115 days), RCPL1-468 (117 days) attained maturity earliest under upland conditions.
- Among local rice of Sikkim Takmaru (Lama Dhan) was earliest in maturity (119 days).

Performance of local rice of Sikkim under different moisture stress conditions

Rainfed upland (aerobic rice) condition

- Taichung (123 days), Red Zomu (125 days), Zomu (125 days) and Kalo Dhan (127 days) were earliest maturing.
- Days to 50% heading was earliest in Tabrey (84 days), Zornali (88 days), Zomu (89 days) and Taichung (91 days).
- Maximum number of filled grain per panicle recorded in Zokub, Takmaru Lowland Type, Ramsaree, Yeidehi, Sano Attey and Taichung.

Pot experiments under severe drought

- Of the 50 local rice cultivars only 18 cultivars showed grain filling.
- Among the 18 cultivars maximum number of filled grain per panicle was recorded in Nepal Dhan, Pahelo Dalle, Kalo Dhan and Attey.

Irrigated lowland conditions

- Earliest maturity was attained by Red Zomu (121 days), Taichung (123 days) and Kalo Dhan (125 days).
- Days to 50% heading recorded earliest in Red Zomu (88 days), Tabrey (89 days), Zomu (89 days) and Taichung (90 days).
- Maximum number of filled grain per panicle recorded in Japanese, Kaley Bungey, Takmaru Lowland Type, Pahelo Dalle, Yeidehi, Ramsaree and Taichung.

Evaluation of different rice varieties under upland conditions in Mizoram

- Five varieties *viz.*, Bhalum 1, Bhalum 2, Bhalum 3, Bhalum 4 and IURON-514 were tested under upland conditions. Bhalum 3 recorded significantly higher grain (26.8 q/ha) and straw yield (73.8 q/ha) followed by IURON-514 which recorded 24.6 q/ha grain yield and 70.6 q/ha straw yield, while lowest grain yield was recorded in Bhalum 2 at 16.5 q/ha and 42.8 q/ha straw yield.

Evaluation of different rice varieties under lowland conditions in Mizoram

- Among twenty two rice varieties evaluated, Shhsarang 1 showed higher grain yield (43.6 q/ha) followed by RCPL 1-408 (39.8 q/ha), whereas RCPL 1-111 recorded lesser grain yield (12.0 q/ha).

Evaluation of local germplasm of rice under upland conditions of Mizoram

- Seventy two upland indigenous rice varieties were collected from eight districts of the Mizoram and were evaluated for their yield potential. The results revealed that MZR-19 produced higher grain yield of 28.3 q/ha followed by MZR-53 (26.2 q/ha) and MZR-27 (25.5 q/ha), whereas lesser grain yield recorded from MZR-58 (3.2 q/ha).

Identification of temperature/drought tolerant rice varieties in Mizoram

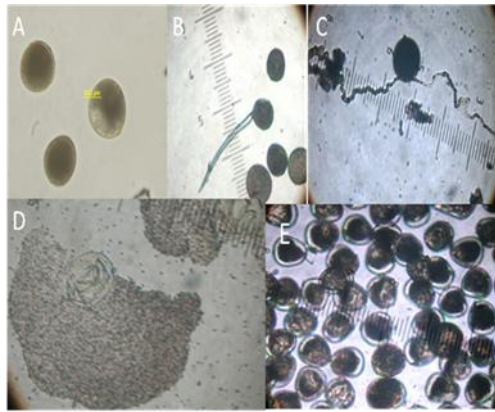
- Three lowland rice varieties *viz.*, RCM-9, RCM-10 and RCM-11 along with one local check were evaluated under different agro-climatic conditions of Mizoram *viz.*, Kawnpui (Kolasib district), Khawzwal and Champhai (Champhai district). RCM-10 recorded maximum yield at all locations (39.5 to 42.0 q/ha.) while local check recorded 19.8 to 33.6 q/ha. Leaf folder infestation was very

high in RCM-9 and RCM-11. Local check was highly susceptible to both leaf folder and ear head bug.

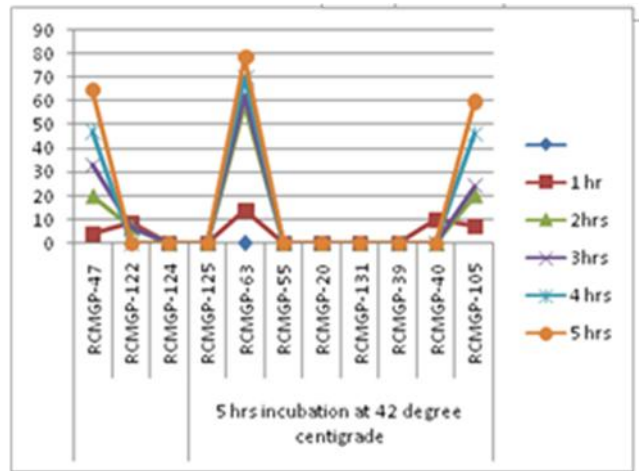
MAIZE

Heat tolerance in Maize (Umiam)

- Identification of a mini core set of eleven genotypes after screening for heat tolerance at germination, seedling, flowering and grain filling stages, respectively from 132 genotypes. These are **RCMGP 20, RCMGP 39, RCMGP 40, RCMGP 47, RCMGP 55, RCMGP 63, RCMGP 105, RCMGP 122, RCMGP 124, RCMGP 125** and **RCMGP 131**.



(A) Normal ungerminated pollen (B) Normal pollen germination at 25°C; Abnormal pollen tube growth (C) Pollen bursting (D) Shrinkage (E) after exposure to 36°C



Heat stress on pollen germination (%) in maize genotypes

- Biochemical studies on Antioxidant capacity and histochemical localization of reactive oxygen species (ROS) in seedlings of six prescreened genotypes concluded that with a stronger plant defense system **RCMGP 63** and **RCMGP 105** are relatively more tolerant to 37°C.

Genotypes	Ambient	Elevated
RCMGP 40		
RCMGP 47		
RCMGP 63		
RCMGP 105		
RCMGP 121		
RCMGP 124		

Histochemical localization of superoxide anion ($O_2^{\cdot-}$) at 20 day-old leaves using Nitroblue Tetrazolium (NBT). More blue formazan formation indicates more reactive oxidative tissue damage.

Screening of local maize genotypes against stem borer and cob borer (Umiam)

% Infestation	Genotypes
1-5%	RCMGP 58
5-10%	RCMGP 25, 35, 44, 49, 54, 55, 57, 60, 65, 88, 120,
10-15%	RCMGP 3, 6, 24, 47, 82, 89, 101, 132, 144, 164, 173, 240, 263, 340, 346
15-20%	RCMGP 4, 13, 3, 20, 36, 52, 63, 66, 96, 97, 105, 110, 115, 126, RCM 1-1
20-25%	RCMGP 2, 8, 9, 30, 41, 61, 62, 72, 76, 95, 109, 112, 113, 117, 121
25-30%	RCMGP 39, 43, 46, 91, 94, 96, 114, 118
30-35%	RCMGP 29, 39, 51, 53, 56, 59, 74, 77, 100, 111
35-40%	RCMGP 79, 83, 89, 93,
40-45%	RCMGP 31, 106, 107,
45-50%	RCMGP 48, 86, 99, 102
50-55%	RCMGP 84
55-60%	RCMGP 87
60-65%	RCMGP 116
85-90%	RCMGP 10
No Infestation	RCMGP 5, 11, 12, 21, 22, 28, 32, 37, 40, 47, 70, 75, 81, 122, 108, 123, 125, 127, 131

Fig: Incidence of cob borer *Stenochroia elongella* in different maize accessions of North East India (natural conditions)

Performance of maize cultivars during *rabi* season under moisture stress condition (Nagaland)

- Seventeen germplasm of maize were evaluated for their performance under moisture stress conditions.
- Maximum grain yield was recorded with maize cv. VQPM-9 (3800 kg ha⁻¹), followed by cv. RCM-1-75 (3233 kg ha⁻¹) and Vijaya composite (2733 kg ha⁻¹). The minimum grain yield was recorded with cv. Yakmak onglak (300 kg ha⁻¹).
- Maize cultivars VQPM-9, RCM-1-75 and Vijaya composite have performed well under moisture stress conditions.



Maize at flowering and cob development stage

Screening of indigenous maize (*rabi* maize) genotypes for cold tolerance study (Manipur)

- Fourteen local maize genotypes from Ukhrul, Chandel, Churachandpur and Mao regions were evaluated for suitability to early sowing to adjust with the untimely rains cold tolerance with Pusa Composite-3 as check.
- Tharathei, Khamathei white, Chechata and Purple maize found better suited for cold conditions under the minimum temperature range of 1.1 to 22.6°C and maximum temperature range of 14.2 to 35.9°C with cob yields of 3.83 t/ha, 3.48 t/ha, 3.44 and 3.34 t/ha, respectively.



Screening of indigenous maize genotype for cold tolerance

Physiological efficiency of maize genotypes for higher productivity under hilly ecosystem of Meghalaya (Umiam)

- Three varieties of maize *viz.*, **Vivek QPM-9**, **Prakash** and **Bio-9681** physiologically performed better for higher productivity in hilly ecosystem of Meghalaya.

Impact of climatic factor on production and productivity of tomato in NEH region (Manipur)

Screening for tolerance under heat and moisture-deficit conditions

- Eighteen tomato varieties were screened under polyhouse and natural field condition for two consecutive seasons. Plants under polyhouse condition were watered daily up to 15 days after transplanting, and thereafter, a restricted irrigation at 15 days interval.
- A rise in 4-5°C temperature from ambient decreased the tomato yield by 20% and lycopene content by 36%.
- Tomato varieties (Arka Meghali, Arka Rakshak and RC Manikhamenashinba-I) tolerant to heat and moisture-deficit condition have been identified
- Arka Meghali was found to be tolerant to frost condition (1.68 kg fruits/plant), followed by Arka Vikash (1.61 kg fruits/plant).

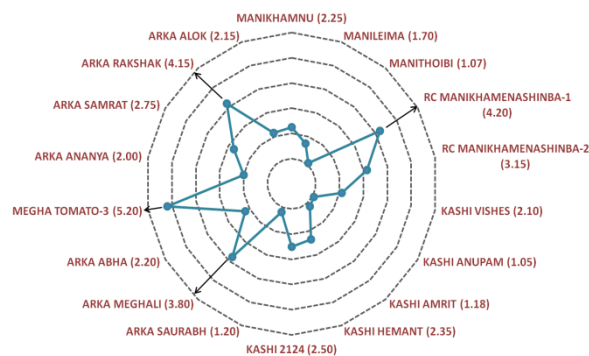
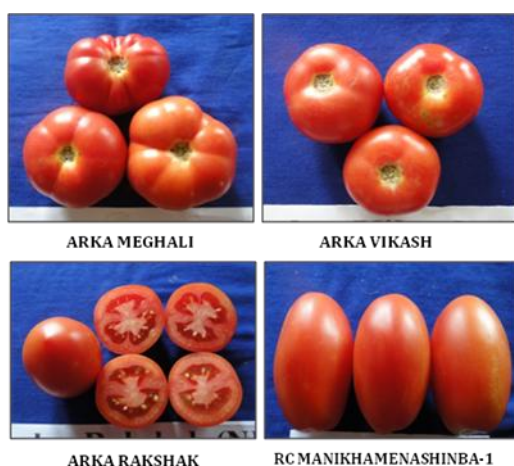
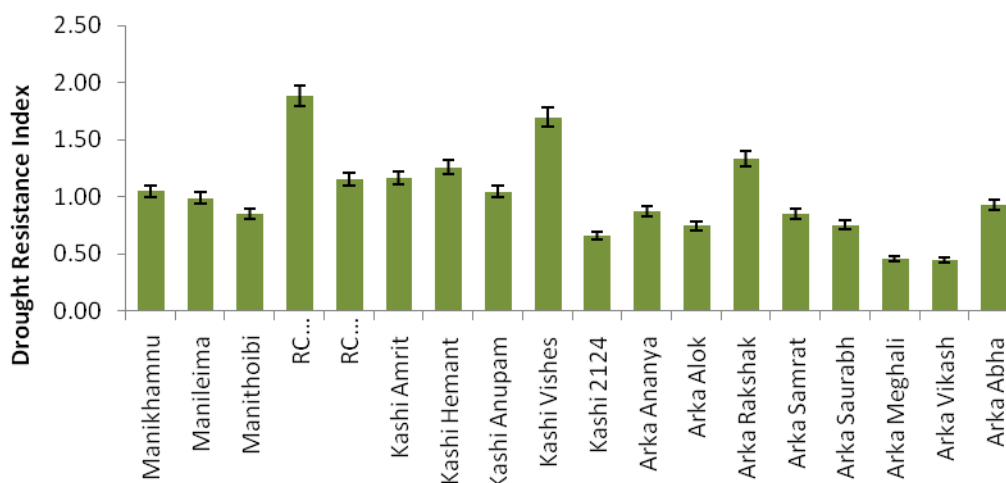


Fig : Lycopene content (mg/100 g) in different tomato varieties under elevated temperature



Effect of climate change on the population dynamics of fruit flies in tomato (Mizoram)

- **Fruit flies infestation in tomato in North eastern India is reported for the first time.**
- Nine cultivars/hybrids of tomato were screened against fruit flies under open field conditions. Seasonal incidence of fruit flies on tomato crop using cue lure based para-pheromone traps revealed that the highest fruit flies adults were attracted during April to June. While maximum temperature showed a positive correlation, minimum temperature, relative humidity, rainfall and rainy days had a negative correlation with trap catches of fruit flies.
- **A Prediction model was developed for fruit flies prediction in tomato.**
The regression equation of the developed model for fruit flies prediction in tomato,

$$Y = -85.61 - 19.00 (X_1) + 19.00 (X_2) + 1.00 (X_3) - 0.50 (X_4) - 0.40 (X_5) - 0.51 (X_6)$$
 where X_1 : minimum temperature, X_2 : maximum temperature, X_3 : minimum RH, X_4 : maximum RH, X_5 : rainfall, X_6 : rainy days.
- **First report of economic injury due to *Bactrocera tau* (walker) on tomato in India.**
A pest survey and subsequent identification confirmed the presence of the tephritid fruit flies, *Bactrocera tau* (Walker) in tomato. This is the first report of the insect in the province and its outbreaks, resulting in serious damage to tomato.



Fig: *Bactrocera tau* infested tomato fruits

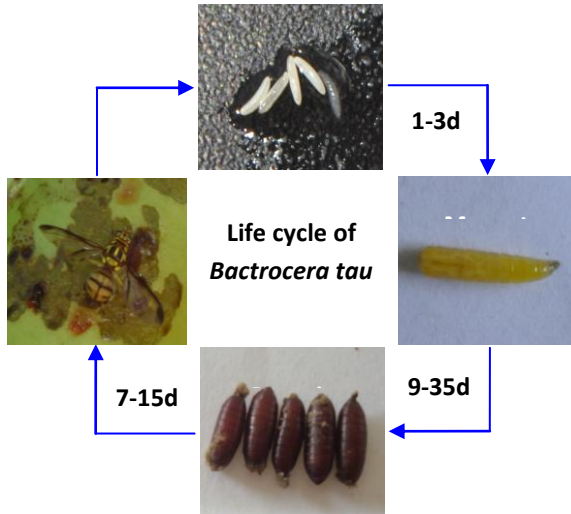
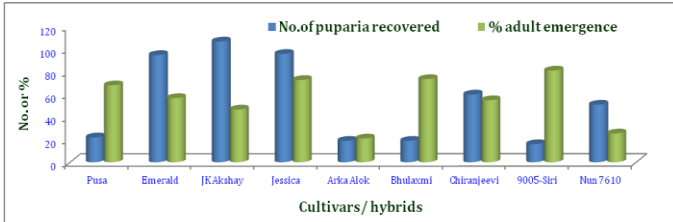


Fig: Life cycle of *Bactrocera tau* in tomato