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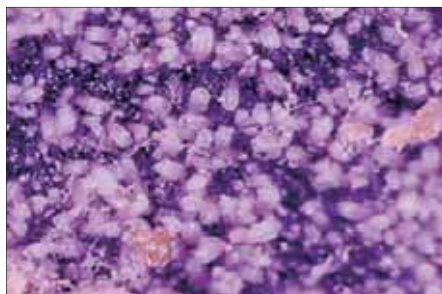
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## 2. Ready for Commercialization

### Closed system for mass production of predatory mites

#### Salient features

- Predatory mites are generally produced on a small scale on tetranychid mites on bean-leaves, which are placed on water-soaked sponges in trays (open system).
- Another method which is generally adopted is a large-scale production of predatory mites in nethouses on spidermite- infested bean-plants.
- The new system developed enables production of predatory mites on astigmatid mites in the closed units.
- The scale of production is high, while infrastructure required is simple; a room space with racks and items like trays, plastic-boxes, cloth-covers, vermiculite, yeast, wheat-germ and pollen.



- A simple method of release is also available for predatory mites produced by this system.
- The host (astigmatid) mites, which may be mixed with released predatory mites, do not harm plants, as they are killed within a few hours after release due to the absence of its requisite feed.
- This technology for large -scale production can be adopted even by polyhouse growers and farmers.
- Tetranychid mites and thrips play host to predatory mites.
- This product is exempted from the biosafety clearance from the Central Insecticides Board and Registration Committee.

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## Temperature- tolerant strain of *Goniozus nephantidis*

### Salient features

- *Goniozus nephantidis* is a well-known parasitoid of coconut black-headed caterpillar.
- A temperature -tolerant strain of *Goniozus nephantidis* has been developed.
- Effective parasitism of the pest (coconut black-headed caterpillar) is achieved by this parasitoid during hot summers when the pest population is at its zenith of activity.
- This parasitoid is the only one that thrives during hot summers when all others fail to survive.
- Use of the temperature-tolerant strain would substantially reduce pest populations.
- This product is exempted from the biosafety clearance of the Central Insecticides Board and Registration Committee.

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## Management of pests efficiently by semiochemical nanogel

### Salient features

- The specially formulated nanogels can be used in any season and at any temperature due to their oxidative, photochemical and thermal stability.
- The product will be useful especially in higher temperatures that may benefit growth of various pest species.
- The transportation of nanogels and their pheromones is also trouble-free due to significant mechanical strength of the nanogels.
- Other carrier system formulations have also been developed to control *Helicoverpa armigera*, *Scirphophaga incertulas*, *Leucinodes orbonalis*.
- This product is exempted from the biosafety clearance of the Central Insecticides Board and Registration Committee.

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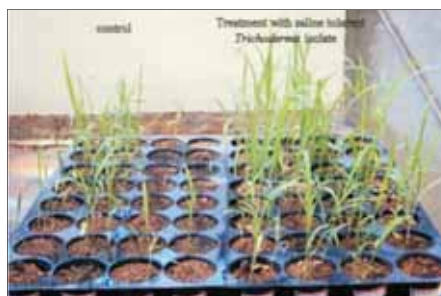
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## Bioformulations of salinity- tolerant isolates of *Trichoderma*

### Salient features

- Salinity- tolerant isolates of *Trichoderma* with biocontrol potential are suitable for crops grown in sodic soil; they also induce salinity tolerance in crop-plants with increased seed germination and growth.
- **Biosafety:** Toxicology data have been generated.
- **Label claims:** WP preparation is as per the CIB regulations. Promotes plant growth in saline soils, and also protects from salinity and diseases. Multilocation trials will be completed in March 2014, and formulations will be suitable for permanent registration.
- **Host range:** Oilseeds and pulses



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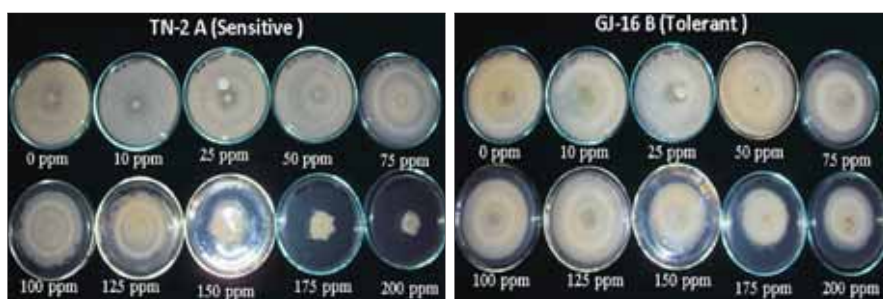
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## Formulations of carbendazim -tolerant isolates of *Trichoderma*

### Salient features

- These bioformulations of carbendazim- tolerant isolates of *Trichoderma* with biocontrol potential would be suitable for different crops. Carbendazim - tolerant *Trichoderma* with carbendazim will be effective against different plant pathogens.
- **Biosafety:** Toxicology data have been generated.
- **Label claims:** WP preparation is as per the CIB regulations. Multilocation trials will be completed in March 2014, and formulations will be suitable for permanent registration.
- **Host range:** Oilseeds and pulses



### Impact and benefits

- This technology (bioformulation) will help in control of plant diseases and also help in plant germination and growth.
- Six companies are ready to buy this technology.

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## Powder- based formulation of *Bacillus megaterium* (NBAIL 63) as phosphate solubilizer

### Salient features

- Powder- based formulation of bacterium *Bacillus megaterium* strain NBAIL 63 ( $10^8$ cfu of bacteria/g) has been found promising and effective antagonist against bacterial wilt caused by *Ralstonia solanacearum* in tomato and brinjal.
- It is also an efficient phosphate-solubilizing organism.
- The dosage and methods of application of the formulation against bacterial wilt disease have been standardized.
- The antagonist induced systemic resistance against wilt disease through activity of phenolic enzymes, peroxidase, polyphenol oxidase and phenols.
- The bacterium induced growth and yield increase in brinjal and tomato plants due to its better root colonization and phosphate-solubilizing ability.
- It has a shelf-life of eight months.



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## *Pseudomonas fluorescens* (NBAIL-PFDWD), a DAPG-producing abiotic stress- tolerant isolate for rainfed and stressed agricultural soils

### Salient features

- *Pseudomonas fluorescens* NBAIL-PFDWD isolate can be used as an effective bioagent and plant-growth promoter in pulses, oilseeds rice and vegetables in rainfed and stressed soils.
- Multilocation testing of this isolate is being carried out in stressed soils of Gujarat, Tamil Nadu and Karnataka.
- **Biosafety:** Toxicology data will be generated by March 2014 (sanctioned under the NAIP).
- **Label claims:** WP preparation is as per the CIB regulations. Promotes plant growth in saline soils; and also protects from salinity and diseases. Inducer of systemic resistance. Multilocation trials will be completed in March 2014 for permanent registration.
- **Host range:** Oilseeds, cereals and pulses



### Performance results

- Field evaluation on groundnut-crop of the powder-based formulation of PFDWD (10g/kg of seed) in saline -affected areas of Udupi district yielded 13.5 quintals per acre compared to untreated (12.0 quintals).

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## Mycelial formulation of *Hirsutella thompsonii*

### Salient features

- Mite-pests in crops are known to be infected by *Hirsutella thompsonii*.
- The myco-parasitism could be enhanced with the novel mycelial formulation.
- In the field, the mycelial formulation of *H. thompsonii* applied after tank-mixing separately with three selected adjuvants brought down post-treatment population of coconut mite (*Aceria guerreronis*) by 85.6-97.1%.
- Application of the fungus in combination with glycerol resulted in a tolerable mean nut damage score of 2.0 during pre-harvest stage, compared with an acute score of 4.0 in control palms.
- Other phytophagous mites such as the citrus rust mite (*Phyllocoptruta oleivora*) and litchi erinose mite (*Aceria litchii*) are also prospective targets of this product.
- **Biosafety:** Toxicology data are yet to be generated

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## Mass production of parasitoids, *Trichogramma chilonis* and *Trichogramma embryophagum* using Eri silkworm eggs

### Salient features

- Production of these parasitoids (using conventional grain-moth host, *Corcyra*) improved using Eri silkworm eggs; which are abundant and easy to produce in manufacturing unit.
- High yield of *Trichogramma* adults was achieved from each parasitized egg of Eri silkworm in comparison to *Corcyra*.
- This technique yields robust parasitoid adults with superior biological attributes and higher female progeny production.
- The technology has been evaluated for the suppression of stem borer in rice in Mandya and sugarcane stem borer, and gave excellent results as compared to the ones reared on *Corcyra*.
- This product is exempted from the biosafety clearance of the Central Insecticides Board and Registration Committee.

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## ***In- situ* rearing of tachinid parasitoid *Sturmiopsis inferens* on diet-reared sugarcane shoot borer**

### **Salient features**

- Rearing method has been developed for *Sturmiopsis inferens*, a tachinid parasitoid of sugarcane early shoot borer *Chilo infuscatellus* and of stalk borer *Chilo auricilius*.
- The parasitoid has a potential to regulate pest number through augmentative releases.
- The earlier method available for mass multiplication of the parasitoid on diet-reared larvae was labour-intensive, produced contamination and generated low output.
- This method is based on the inoculation of parasitoid stages on the diet-reared larvae *in situ*; it has overcome the drawbacks of the previous method.
- Patent is pending: Application No. 658/CHE/2008, dated 17/03/2008.

### **Cost**

- ₹ 300 per 100 puparia of the parasitoid

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## Suspension concentrate formulation of *Bacillus thuringiensis* var. *kurstaki*— spores and crystals

### Salient features

- Formulation has been developed in oil with fine particles of *Bt* powder along with synergists.
- Aim is at improving efficacy of the product, thereby reducing effective dose, giving faster kill of larvae and improving delivery by making it suitable for power sprayers for effective coverage even on the under surface of the foliage.
- Formulation volume will be lowered.
- Data will be generated for registration with the Central Insecticides Board, GOI, in accordance with their guidelines.

### Performance results

- Studies are underway.

### Impact and benefits

- Majority of the available formulations of *Bt* are wettable powders of bulky nature and cannot be used with power sprayers that give better coverage and thereby increase efficacy.
- This formulation is aimed at giving faster kill of insects at a lower dose.
- Lower formulation volume will reduce packing and transport costs.
- It is an eco-friendly technology, safe to natural enemies of crop-pests, is degradable, and does not leave residue, so is safe to humans and animals.

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## *Trichoderma harzianum*, Th4d SC

### Salient features

- Liquid formulation of this fungal biocontrol agent for control of foliar- and soil- borne pathogens has a shelf- life of more than 18 months.
- Toxicology data are to be generated as per the Central Insecticides Board and Registration Committee.

### Performance results

- Effective against *Alternaria*, *Botrytis*, *Sclerotium*, *Macrophomina*, *Fusarium* and *Phytophthora* diseases.

### Impact and benefits

- Its long shelf- life will help entrepreneurs to stock the product for a long duration, and its broad host range (broad spectrum) and growth- promoting abilities attract entrepreneurs and farmers alike. It also improves soil health by reducing fungicide usage.

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## Suspension concentrate formulation of a combination of *Bacillus thuringiensis* var. *kurstaki* and *Beauveria bassiana*

### Salient features

- Formulation has been developed using *Bt* powder containing spores and crystals in combination with conidia of *B. bassiana* as an active ingredient
- It is a suspension concentrate (37% active ingredient) based on the mineral oil.
- Oil-based nature renders it longer field persistence, enables its usage under low humidity and enables faster spread of the inoculum on the insect surface and into the inter-segmental regions where cuticle is thin; thus resulting in faster germination, infection and kill.
- Formulation has an extended shelf-life of 24 months at a room temperature.
- Formulation is effective against *Helicoverpa armigera*, a polyphagous pest, and hence can be used on several crops.
- Formulation has the advantage of a simultaneous double-pronged attack on the insect; leading to higher stress that results in much faster kill of the insects in comparison to the time taken by either of the microbials singly.
- Formulation is effective against older larvae also.
- This is the first instance of development of a combination formulation of *Bt* and *B. bassiana*. Data requirements are yet to be formulated by the Central Insecticides Board (CIB), GOI, for generation of registration data. Request has been sent to the CIB and matter will be pursued.

### Performance results

- Formulation has been found effective against gram pod borer on pigeonpea and capitulum borer on sunflower.

### Impact and benefits

This formulation gives faster kill of insects in comparison to the time taken by either of the microbials singly, and gives a knock-down effect with performance on a par with chemical insecticides like spinosad and profenophos, and hence superior to all other microbial pesticide formulations with less input cost. It is an eco-friendly technology, safe to natural enemies of the crop-pests, is degradable and does not leave residue; so is safe to humans and animals.

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## Process for nano-formulation of imidacloprid based on amphiphilic polymers

### Salient features

- High water solubility (0.51g/ L) and low Koc of imidacloprid indicate its low tendency to be adsorbed on to the soil particles, and thus ensuing potentiality to leach down to groundwater. Activity of the insecticide gets reduced due to higher photodegradation. Thus, there is a need of a special delivery system for controlled release of the insecticide at the target sites.
- This nano-formulation will enhance bioactivity of the systemic insecticide imidacloprid by extending release time and at the same time by higher penetration to the target sites due to nano size.
- This can be successfully utilized to reduce dosage and frequency of application.
- Seed-coats with nano-formulation of the present invention will help in improving germination, viability, plantability /or vigour of a plant grown from a seed and planted in a location infested by insects or any other recognized pests of the plant against which the bioactive compound in reference has ability to combat.
- The product improves seed storability by checking insect /other pest infestations during storage. Additionally, product is safe to handle and is cost-effective.
- The new technology is bench-scale.
- The technology may be licensed to the interested agrochemical industry for further development and its possible commercialization.
- The product stands out as a distinct input for agriculture, particularly for safer agriculture.
- Development of a slow release nano-formulations of bioactive molecules and method of preparation thereof: Indian Patent Application 257/ DEL/2012.

### Cost

- Its cost is ₹ 2.5 lakh

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## Process for preparation of polymeric bioactive botanicals based seed-coats

### Salient features

- Botanical concentrate was dissolved in a suitable organic solvent.
- The organic solution was then poured into a mixture of adjuvants' solution, and this was agitated at a high speed.
- The resultant mixture (FS) may be applied to seeds for making polymeric coats.
- Bioactive botanicals-based seed-coats will help improve germination, viability, plantability /or vigour of a plant that is grown from a seed and planted in a location infested by insects or any other recognized pests of the plant against which the bioactive compound in reference has the ability to combat.
- The new technology is bench-scale.
- The technology may be licensed to the interested agrochemical industry for further development and possible commercialization.
- Polymeric seed-coats-based bioactive botanicals: Indian Patent No. 244542
- Joint development plan can be worked out to generate data for various regulatory purposes.

### Cost

- ₹ 2.5 lakh

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## ELISA-kit for detection of tospo viruses

### Salient features

- Polyclonal antibodies (PABs) of recombinant nucleocapsid protein (rCP) of Groundnut Bud Necrosis Virus (GBNV) were used in ELISA to detect virus in the crude extract.
- The CP gene of GBNV was cloned, and an expression construct was developed in pET vector; rCP was expressed in *E. coli* and purified. PABs were generated against rCP for broad spectrum detection of viruses.
- Enzyme-linked immunosorbent assay (ELISA) kit has been developed to detect tospo viruses under serogroup IV.
- This is versatile; could detect natural infection of Groundnut Bud Necrosis Virus, Watermelon Bud Necrosis Virus and Capsicum Chlorosis Virus affecting various crops.
- The ELISA-kit is sensitive to detect tospo virus infection in a crude leaf extract. The sensitivity limit is about 25 ng of virus.
- The kit has been validated by testing over 300 field samples of peanut, tomato, chilli and cucurbits. Indigenous diagnostic antibodies to plant viruses are not commercially available in India.
- The technology will benefit entrepreneurs to produce indigenous commercial kit.
- Diagnostic kit will help in decision-making on judicious application of insecticides for control of tospo viral diseases.
- The diagnostic kit will help develop resistant cultivars.

### Cost

- Its cost is ₹ 2 lakh.

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## ELISA-kit for detection of papaya ring-spot virus and other related poty viruses

### Salient features

- Polyclonal antibodies (PAb)s to recombinant nucleocapsid protein (rCP) of Papaya Ring-Spot Virus (PRSV) were used in ELISA to detect the virus in a crude extract.
- The conserved *CP* gene of PRSV was cloned and an expression construct was developed in pET vector; rCP was expressed in *E. coli* and purified. PAb)s were generated against rCP for broad spectrum detection of viruses.
- Enzyme-linked immunosorbent assay (ELISA) kit has been developed to detect poty viruses.
- It is versatile; could detect natural infection of PRSV, Potato Virus Y, Zucchini Yellow Mosaic Virus, Bean Common Mosaic Virus, onion Yellow Dwarf Virus and Chilli Veinal Mottle Virus affecting various crops.
- The sensitivity limit of the kit is about 10-25 ng of virus. Indigenous diagnostic antibodies to plant viruses are not commercially available in India.
- This field validated diagnostic kit will help detecting and managing PRSV and related viral diseases.
- This indigenous technology-based diagnostic kit will help develop resistant cultivars.

### Cost

- Its cost is ₹ 2 lakh.

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## *Trichoderma viride*-based biopesticide technology

### Salient features

- *Trichoderma viride* (strain 2953) used for developing this pesticide is a ubiquitous and cosmopolitan fungus that exhibits multitude of properties — potent antifungal activity, plant growth promotion property, phosphate solubilization and compost decomposition effects.
- Its use in the crop has effected on stimulating seed germination, early flower formation and addition of nutritive value to vegetables, fruits, pulses and cereals in addition to disease control.
- The product has a year's shelf-life, and this technology is ready for commercialization. All the necessary data for registration with the Central Insecticides Board under section 9(3b) and 9(3) have been generated.

### Performance results

- The product has been tested on different crops against various soil- borne diseases, and 10-30% yield increase was recorded.

### Impact and benefits

- The technology is eco-friendly and user-friendly.
- In Indian context, use of biopesticides assumes special significance because size of individual farm holdings is going down gradually owing to growth in population.
- The interaction between microbes and plants has developed with the evolution process in plants, and hence use of biopesticides is pre-adapted to fit into long-term IPM strategies.
- Delivers a number of benefits including plant nutrition, disease resistance, and tolerance to adverse soil and climatic conditions.
- The use of such microorganisms as biopesticides helps as non-chemical means of disease management, and may help in economizing crop production.

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## Solar-powered knapsack sprayer with tilting arrangement

### Salient features

- It is a modified battery-operated sprayer, which can be used in places facing long electricity power cuts, where electrically charging of the battery is not possible.
- This innovation uses solar power to continuously charge battery and provide a cut-off beyond a range of voltage to minimize variations in droplet-size generation.
- A novel feature of the sprayer is the tilting arrangement provided, so that the solar panel could be given the desired inclination of  $15^{\circ}$ - $18^{\circ}$  N-S to maximize the catch of the incident sun rays, depending on the direction of the travel of the operator.
- Sprayer manufacturers, farm implements manufacturers, private entrepreneurs, agro-industries are the potential clients.
- Published by the Patent Office (Govt of India) Patent No. 1559/MUM/2009; Published on 20/01/2012

### Performance results

- Due to simultaneous charging of the battery while spraying, constant pressure could be maintained, thus generating uniform droplet size over the battery-operated sprayer. The pressure could be sustained 50% more over the latter.



### Cost

- ₹ 7,000

### Impact and benefits

- Using this technology can result in saving of costly pesticide, saving of environment and better control of insects; ultimately resulting in reduced cost of cultivation.

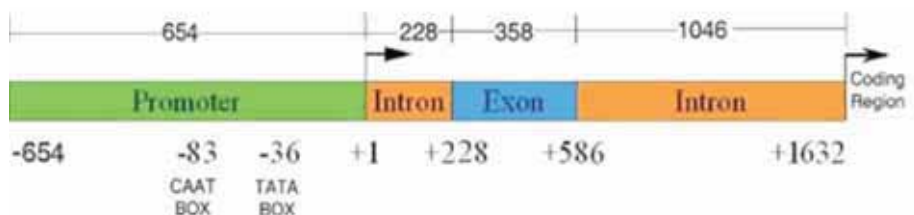
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## *Port ubi 2.3* promoter



### Salient features

- Constitutive promoter for enhanced expression of transgenes in sugarcane has been isolated from *Porteresia coarctata*.
- It avoids homology dependent transgene silencing in transgenic plants.
- Patent pending; Application No. 3421/CHE/2010 dated 15 November 2010.

### Performance results

- Level of expression is double in sugarcane and five times in rice as compared to *CaMV35S* promoter.

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## Bud-chips for rapid seed multiplication of sugarcane

### Salient features

- Scoop out bud-chips from freshly harvested healthy sugarcane stalks.
- Soak them in specially formulated plant growth regulator (etherel 100ppm) and  $\text{CaCl}_2$  0.1% for 2h.
- Treat with fungicide and plant them in cups/trays filled with a mixture of soil and organic matter.
- Bud-chips can be transplanted in fields after 6-7 weeks.
- Frequent and light irrigations for early establishment are required.

### Performance results

- Higher seed multiplication rate, easy for transportation.
- Higher bud germination (~90%) and higher number of millable canes.

### Impact and benefits

- Helps in saving of seed material, and fast multiplication gives ~90% germination as compared to 30-35% in the conventional three-budded setts.
- The left-over cane can be processed for other uses.
- Bud-chips can facilitate easier transportation.
- Saving of seed material and easier transportation.
- Higher rate of germination and number of millable canes help in increasing profit of growers.

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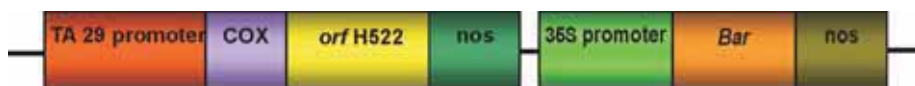
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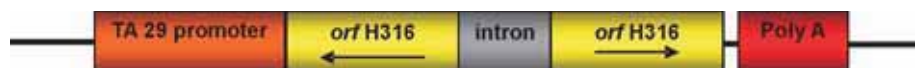
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## Gene constructs



A. pCAMBIA0390-TCONBAR



B. pCAMBIA1300-T-*orf-ihp*

### Salient features

- **For induction of sterility:** Gene constructs with *orfH522* gene based on PET1 based CMS system of sunflower; *orfH522* is targeted to mitochondria and is expressible only in the tapetum. This cassette designated TCON (for TA29-*coxIV-orfH522-nos*) was cloned in the binary vector pCAMBIA0390.
- **For restoration of fertility:** Vector is based on the post-transcriptional gene silencing (PTGS) containing a selected fragment of 316 bp (designated *orf316*) of *orfH522* cloned in opposite orientation upstream and downstream of catalase intron from castor, and is expressible only in the tapetum. The entire cassette is cloned in binary vector pCAMBIA1300. This vector would produce intron hairpin molecule which eventually produces siRNA molecules against *orfH522* transcripts in the tapetal cell layer. The vector has been designated pCAMBIA1300-T-*orf-ihp* (for TA29-intron hairpin against *orfH522*). This vector will restore fertility in plants where sterility was induced using TCON cassette.
- Non-exclusive licensing is through “Memorandum of Agreement”. Licensing Fee is to be decided by the ITMC. Once these gene constructs are used for developing a pollination control system in any crop, then the resultant transgenic lines could be commercialized only after the lines are tested for their biosafety as per the SOPs developed by the DBT and the MoEF.

### Performance results

- The constructs have been tested on tobacco and are shown to work as a pollination control system. The constructs are being used in safflower for developing a transgenic male sterility and fertility restoration system.

### Cost

- Investment cost on generation of technology is ₹ 5.00 lakh.
- Cost of production at the commercial level in terms of per unit output is ₹ 50,000 to ₹ 100,000.

## Impact and benefits

- The vectors developed could be used for the induction of transgenic male sterility and fertility restoration in crops. This would lead to development of pollination control system in crops, allowing exploitation of hybrid vigour in crops. This is a tool for exploiting heterosis reported in different crops.
- This is especially useful in such crops where exploitation of heterosis is hindered because of non-availability of a good pollination control mechanism.

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## Sunflower transgenic events resistant to necrosis disease

### Salient features

- Sunflower necrosis (SND) disease, caused by tobacco streak virus, belongs to subgroup ilarvirus, is a major disease posing serious threat to sunflower cultivation.
- Eradication of sunflower necrosis disease was not possible through integrated management or biological consortia and through breeding programmes.
- Transgenic approach is the best way to produce virus resistant transgenic-plants.
- A highly efficient protocol for genetic transformation using P<sup>CAMBIA</sup> 2301, putative transformants harbouring TSV-CP gene has been obtained with a frequency of 4%, and validated across genotypes.
- Non-exclusive licensing is through “Memorandum of Agreement” Licensing Fee – To be decided by the ITMC. The resultant transgenic lines could be commercialized only after the lines are tested for their biosafety as per the SOPs developed by the DBT and the MoEF.

### Performance results

- Molecular characterization and ELISA tests carried confirmed gene integration. Sunflower transgenic-plants (T<sub>4</sub>) harbouring TSV-CP gene were challenged with virus and found resistant to SND.

### Cost

- Investment cost on generation of technology- Aprox: ₹ 20.00 lakh.
- Cost of production at the commercial level in terms of per unit output is ₹ 3.00 lakh

### Impact and benefits

- Using regeneration, transformation protocols, TSV-CP gene can be introduced into any genotype of interest or hybrid. On completion of the necessary regulatory clearances / formalities the firm / entrepreneur can commercialize the product as SND resistant sunflower hybrid, which will have tremendous demand from the farming community.

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## PCR-based diagnostics for differentiating begomoviruses involved in causing yellow mosaic disease in pulse crops

### Salient features

- Virus-specific primers have been designed and PCR protocols have been developed. Primer pairs are for detection of four viruses known to cause yellow mosaic disease in legumes.
- Standard biosafety measures are required for laboratory undertaking such tests.

### Performance results

- Since the kit is specific for detection of the virus, performance results for efficiency are 100%. With equipped laboratory, it is feasible to apply the technology with field samples.

Primer sequence	Target virus	Annealing temp.	Expected size of DNA (of the virus) fragment to be amplified
5' GTA TTT GCA KCA WGT TCA AGA 3'/5' AGG DGT CAT TAG CTT AGC 3'	MYMIV	54	1000bp
5' ATG CTT GCA ATT AAG TAC TTG CA 3'/ 5' TAG GCG TCA TTA GCA TAG GCA 3'	HYMV	56	1050 bp
5' ATG GG (T/G) TCC GTT GTA TGC TTG 3'/5' GGC GTC ATT AGC ATA GGC AAT 3'	MYMV	54	1000bp
5' CTG TGA AAT TTG TGC AGG 3'/ 5' TAC GCG GTT GCG AAT ATG TAT 3'	DYMV	54	900bp

MYMIV= Mungbean yellow mosaic India virus; HYMV= Horsegram yellow mosaic virus; MYMV= Mungbean yellow mosaic virus; DYMV= Dolichos yellow mosaic virus

## Cost

₹ 5.0 lakh; Per sample (at commercial level): ₹ 500

## Impact and benefits

- This technology shall help develop virus-specific resistant genotypes. The farmer shall know about the causative agent of the disease, and accordingly he can devise methods for its management with the help of extension personnel.

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## CRIJAF microbial-retting consortium

### Salient features

- This microbial retting consortium consists of three pectinolytic bacteria having xylanase activity without any cellulose activity, and can ret jute and mesta within 12 to 15 days with improvement in fibre quality by at least 2 grades compared to 18 – 21 days required under conventional retting.
- By using this consortium, farmers can earn higher income by selling improved quality jute/mesta fibres in the market.
- Under drought situation, when there is less rainfall during retting period, jute-farmers are compelled to ret their jute in the muddy water, resulting in very low quality fibre. Under such a situation, this consortium can be used for quick retting of jute with improvement in fibre quality in artificial cemented or polythene-lined retting tank utilizing groundwater in a very short period of time with minimum volume of water.

### Performance results

- This microbial consortium is highly efficient for jute/mesta retting under various agroclimatic situations. By using this, farmers can earn at least ₹ 4,000-5,000/ha extra income over the conventional method. The risk of non-retting of jute under drought situation due to shortage of rainfall can be overcome by using this consortium.

### Cost

- Complete biofertilizer unit with the facility of production of biofertilizer for a large scale use should have industrial fermenter with automatic sterilization facility, autoclave, BOD incubator, laminar flow etc.  
Initial cost: 2-3 crore; Cost of production of consortium as biofertilizer: ₹ 15/kg.

### Impact and benefits

- CRIJAF microbial consortium can help farmers ret jute-plants in an artificial polythene-lined retting tank or cemented retting tank in less volume of underground water. This consortium helps ret jute-plants in lesser period of time (12-15 days) with improvement in fibre quality (TD III to TD IV) compared to 18-21 days and lower quality (TDVI) under conventional method. Further, the colour and lustre of the fibre is also maintained. The use of consortium is environment-safe, and microbes used are not pathogenic, and handling, and use of the consortium is very easy.
- It reduces cost involved in retting by 15-20%. Farmers can earn an additional income of ₹ 4,000 to 5,000/ha. Health hazards can be reduced as the retting

is carried out in a controlled condition using non-pathogenic microbes, and bad odour coming out in a case of conventional method can also be minimized. The younger generation of farming family is not interested in fibre extraction work under the conventional method of retting because of bad odour, unhealthy condition; which can be overcome under this method. The dependence of jute-retting on rainfall can be minimized.

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## Process to recover pure solanesol and nicotine from tobacco

### Salient features

- The integrated approach adopted envisages sequential extraction of nicotine and solanesol from the same raw material. Patent No. 211204 dated 19.10.2007 has been granted for “Process for purification of solanesol (95 + %) from crude/enriched extracts of tobacco green leaf/tobacco cured leaf/tobacco waste”.
- Extraction with a polar solvent and subsequent enrichment by cooling make further purification easy, as solanesol of purity more than 95% obtained in the process can be utilized in development of drug. Economic viability of the process is enhanced by adsorbent used; and substantial reduction in adsorbent requirement as compared to the conventional column chromatography; single solvent employed for eluting the compound as against solvent mixtures reported; and regeneration of the adsorbent for reuse, thus, avoiding cost-intensive techniques like centrifugal liquid partition chromatography, molecular distillation, ultrafiltration, followed by membrane evaporation, gel-permeation chromatography etc. Adoptability for processing tobacco green leaf or cured leaf or waste or crude extracts for extraction of pure solanesol, thus broadens the raw material base.
- The ion-exchange resin technology adopted for nicotine recovery facilitates repeated use of the resin and the solvent; contributing to economic viability.
- The final product is free from kerosene smell as in the case NCL process. There is flexibility to produce pure nicotine or 40% nicotine sulphate as per the demand.

### Performance results

- A process was developed for recovery of solanesol of >95% purity with an overall recovery of 72%. Ion-exchange resin technology was adopted in the process for recovery of pure nicotine or 40% nicotine sulphate.

### Impact and benefits

- It is reported that pure solanesol, whether used for synthesizing CoQ10 or used as a drug itself, will usher in “Golden Period” in the market. In the international market, solanesol sales were 4,000 tonnes in 2004, 5,200 tonnes in 2006 and 7,500 tonnes in 2008, and the demand for the pure solanesol is predicted to reach 8,000 to 10,000 tonnes with an expected growth rate of 15-20%.
- During 2007-2010, nicotine sulphate 40%, pure nicotine and other value-added products worth ₹ 81, 539,298 were exported from India. It is estimated that a potential exists for 400 tonnes/annum of nicotine sulphate 40% and

1.5 tonnes/annum of value-added products of nicotine — Nicotine alkaloid, Nicotine Free Base, Nicotine USP/EP and Nicotine POLACRILEX 20% USP.

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