**DIRECTOR**

**SAMETI, Kudumiyanmalai.**

DEPARTMENT OF AGRICULTURE AND FARMERS' WELFARE

UNDER SSEPERS – ATMA -2021-2022

# LATEST CROP VARIETIES, PESTICIDES & FERTILIZERS

## TECHNICAL MANUAL

**DIRECTOR**

STATE AGRICULTURAL MANAGEMENT AND EXTENSION TRAINING INSTITUTE (SAMETI)

KUDUMIYANMALAI.

**DEPARTMENT OF AGRICULTURE AND FARMERS' WELFARE**

**UNDER SSEPERS – ATMA -2020-2021**

# LATEST CROP VARIETIES, PESTICIDES & FERTILIZERS

## TECHNICAL MANUAL

**DIRECTOR**

**STATE AGRICULTURAL MANAGEMENT AND EXTENSION TRAINING INSTITUTE (SAMETI)**

**KUDUMIYANMALAI.**

**DEPARTMENT OF AGRICULTURE AND FARMERS' WELFARE**

**P.SANKARALINGAM,** M.Sc., (Agri)
**Director**
**SAMETI, Kudumiyanmalai.**

## Foreword

Tamil Nadu is the 2nd largest contributor to India's GDP and one of the most urbanized States in India. In Agriculture front, the Government of Tamil Nadu has resolved to usher in a Second Green Revolution formulated to achieve equitable, competitive and sustainable growth in agriculture. There are about 82 lakh farm holdings in the State who depend on agriculture and allied sectors for their livelihoods.

Agriculture is the primary source of livelihood for about 58% of India's population. India is expected to achieve the ambitious goal of doubling farm income by 2022. India's Agriculture is composed of many crops, however, yields per hectare of crops in India are generally low compared to international standards.

Tamil Nadu Agriculture is the most overriding sector in the economy of the State and it is one of the major means of livelihood. Government of Tamil Nadu leads all the other States in introducing Special and Innovative Agriculture Technological initiatives to augment area, production and productivity of major crops. The Government is also taking up necessary steps to promote newly released high yielding crop varieties.

In **Tamil Nadu** the major crops sown are rice, jowar, ragi, bajra, maize, pulses and oil seeds. Few other crops that are highly cultivated in the regions of **Tamil Nadu** are cotton and sugarcane. In modern Agriculture high yielding latest crop varieties, new generation Pesticides for crop protection and proper source of Fertilizers to rectify the nutrient deficiencies are the important factors to save the farming community and enhance the economic status of the farming community.

Fertilizer is the deciding critical input for production and productivity of crops. On an average, Tamil Nadu consumes 23 Lakh Metric Tonnes of Chemical Fertilizers every year. Besides, Agriculture Department is encouraging Farmers to use Biofertilizers and Organic Fertilizers to maintain Soil Health and reduce dependence of Chemical Fertilizers.

Plant protection chemical is also important to prevent the losses caused to crops by pests, diseases and weeds.

In this connection, a training on **"Latest Crop Varieties, Pesticides and Fertilizers"** has been arranged at SAMETI, for technical personnel of Department of Agriculture and Farmers' Welfare. A manual for the aforesaid training has been prepared with the technical contribution by the personnel identified by this institute.

I appreciate the efforts taken up by the resource personnel and Staff of SAMETI to bring this technical manual with relevant technical information.

Best Wishes

Date:- 02-07-2021

Place:- Kudumiyanmalai

**Director,**
**SAMETI, Kudumiyanmalai**

# INDEX

# LATEST CROP VARIETIES OF IMPORTANT CEREALS AND MILLETS AND THEIR FEATURES

**Dr.M.Madhan Mohan, Dr.N.A.Saravanan** and **Dr.M.Umadevi**
**Department of Crop Improvement**
**Agricultural College & Research Institute, Kudumiyanmalai,Tamil Nadu Agricultural University**

---

Tamil Nadu Agricultural University (TNAU) has released 14 new Crop varieties for the benefit of the farming community. As a Pongal gift Dr. N. Kumar, Vice-Chancellor, TNAU has released the varieties viz., Rice VGD1, Rice ADT 53, Little millet ATL1, Greengram VBN 4, Groundnut BSR 2, Castor YTP 1, Kadam MTP 1, Bottlegourd PLR 2, Garlic Ooty 2, Star Jasmine CO 1, Kufri Sahyadri, Banana Kaveri Saba, Kaveri Kalki, Kaveri Sugantham. These varieties were approved for release by the State Variety Release Committee of Govt. of Tamil Nadu on 07.01.2019.

Rice VGD 1 is a Semi-dwarf with 130 days duration, high tillering, non lodging plant. Cooking quality and organoleptic characters are similar to Seeragasamba. It is mildly scented and suitable for making briyani and khuska dishes. Mean yield recorded was 5850 kg/ha. Moderately resistant to leaf folder, blast and brown spot, highly suitable for biriyani preparation. The descriptor details are furnished below.

| | | |
|---|---|---|
| Plant height | : | 87- 97 cm |
| Early plant vigour | : | Good |
| Coleoptile | : | Green |
| Basal leaf sheath colour | : | Green |
| Leaf blade colour | : | Green |
| Leaf pubescence | : | Glabrous |
| Auricle | : | Present, light green |
| Anthocyanin pigment | : | Absent |
| Collar | : | Light green |
| Ligule | : | White |
| Septum | : | Cream |
| Flag leaf angle | : | Erect |
| Days to 50% flowering | : | 97 - 102 days |
| Panicle exertion | : | Well exerted |
| No. of productive tillers | : | 20 - 35 |
| Stigma color | : | White |
| Apiculus color | : | Straw |

| | | |
|---|---|---|
| Panicle length | : | 20.0 - 26.0 cm |
| Filled grains/panicle | : | 250 - 280 grains/panicle |
| Average single plant yield | : | 37.0 - 45.0 grams |
| Panicle type | : | Compact and slightly drooping. |
| Awns | : | Absent |
| Hull colour | : | Straw |
| Seed coat (kernel) colour | : | Light brown |
| Threshability | : | Easy |
| Aroma | : | Lightly present |
| Grain / Paddy | : | - |
| L x B x T (mm) | : | 5.8 x 2.2 x 1.35 |
| 1000 grain weight (g) | : | 8.9 g |
| Brown rice | : | - |
| L x B x T (mm) | : | 3.7 x 1.8 x 1.25 |
| L/B ratio | : | 2.1 |
| Rice grade | : | Short bold |
| Milled Rice colour | : | White |
| Abdominal white | : | Absent |
| Translucency | : | Translucent |
| Maturity (range in number of days) (from seedling/ transplanting to flowering, seed to seed) | : | Seed to Seed : 127 - 132 days |

**Rice ADT 53**

Rice ADT 53 is a short duration variety (105 - 110 days) suitable for cultivation as transplanted rice during Kuruvai / Kodai / Navarai seasons of Tamil Nadu. The average yield obtained was 6340 kg/ha. Non lodging compact plant type, medium slender rice with high milling out turn, cooked rice is white with intermediate amylose, moderately resistant to blast, sheath rot, stem borer and leaf folder.

| | | |
|---|---|---|
| Parentage | : | ADT 43 / JGL 384 |
| Duration / season | : | 105-110 days<br>*(Kuruvai/ Kodai/ Navarai)* |
| Grain Yield | : | 6334 kg/ha |

**சிறப்பியல்புகள்/ Salient Features**

- நடுத்தர உயரம், சாயாத தன்மை கொண்ட கச்சிதமான செடி அமைப்பு மற்றும் முற்றும் வெளிவந்த நெருக்கமான நெல் மணிகள் கொண்டது.

  Medium tall erect variety, non loading compact plant type with well excerted dense panicle

- 1000 நெல் மணிகளின் எடை : 14.8 கிராம்

  1000 grain weight : 14.8 g

- நடுத்தர சன்ன அரிசி. அதிக அரவைத்திறன்.

  Medium Slender rice with high Milling outturn

- புகையான் மற்றும் இலைமடக்குப்புழுவிற்கு மிதமான எதிர்ப்பு திறன் கொண்டது.

  Moderatly resistant to Brown plant hopper and leaf folder

- குலைநோய், இலைஉறை அழுகல் மற்றும் செம்புள்ளி நோய்களுக்கு மிதமான எதிர்ப்பு திறன்.

  Moderately resistant to blast, sheath rot and brown spot

- நடவுமுறை நெல் சாகுபடி மூலம் தமிழ்நாட்டின் அனைத்து மாவட்டங்களிலும் பயிரிடலாம்.

  Suitable for cultivation as transplanted rice through out Tamil Nadu

**Rice ADT 54:**

| | | |
|---|---|---|
| Parentage | : | Imp.White Ponni / Banskathy |
| Duration / season | : | 130 - 135 days |
| Grain Yield | : | 6307 Kg/ha |
| Special character | : | Medium Slender white rice, Intermediate amylose |
| Pest and disease reaction | : | Moderately resistant to Leaf folder |

## RICE ADT 51 :

**The descriptor details of Rice ADT 51 are furnished below.**

| | | |
|---|---|---|
| Parentage | : | BPT 5204 / Improved White Ponni |
| Duration / season | : | 154 days similar to CR 1009 |
| Grain Yield | : | 6533 kg/ha |
| Suitable for | : | *Samba* season (August sowing) in Thanjavur, Thiruvarur, Nagapattinam, Cuddalore, Pudukkottai, Trichy, Karur, Ariyalur and Perambalur Districts of Tamil Nadu. |
| Pest and disease reaction | : | Resistant to blast and moderately resistant to pests like leaf folder, stem borer, brown plant hopper and diseases like sheath blight and sheath rot. |
| Plant height | : | 115 – 126 cm |
| Early plant vigour | : | Good |
| Coleoptile | : | Green |
| Basal leaf sheath colour | : | Green |
| Leaf blade colour | : | Green |
| Leaf pubescence | : | Glabrous |
| Auricle | : | Present, light green |
| Anthocyanin pigment | : | Absent |
| Collar | : | Light green |
| Ligule | : | White |
| Septum | : | Cream |
| Flag leaf angle | : | Semi Erect |
| Days to 50% flowering | : | 120-128 days |
| Panicle exertion | : | Well exerted |
| Stigma color | : | White |
| Apiculus color | : | Straw |
| Panicle length | : | 27.3 cm (25.6 – 28.5) |
| Filled grains/panicle<br>Average single plant yield | :<br>: | 187 - 225 grains/panicle<br>43.5 grams |
| Grain / Paddy | | |
| L x B x T (mm) | : | 8.5x 2.6 x 1.69 |
| 1000 grain weight (g) | : | 23.9 g |
| Brown rice | | |
| L x B x T (mm) | : | 6.3x 2.3 x 1.56 |
| L/B ratio | : | 2.74 |
| Rice grade | : | Medium slender |
| Seed rate | : | 25 kg/ha |

One of the most important rice variety released during 2017 was Paddy CO52/ MGR 100. MGR 100, yet another medium duration, high-yielding fine variety of rice, released by the Tamil Nadu Agricultural University (TNAU) to mark the centenary of the late Chief Minister and AIADMK founder M G Ramachandran . This paddy variety is meant for the second season (samba and thaladi).It is a derivative of cross BPT 5204/ CO(R) 50 and it matures in 130-135 days. It is a good replacement for BPT 5204 due to its high grain yield, superior grain quality and pest and disease resistance. Way back in 1970, the State Agriculture Department released a variety Karuna and in 1992, another variety JJ-1992, a basmati rice variety. In 1994, MGR1, a hybrid variety of rice was released.

**Paddy MGR 100**

| S.No | Particulars | Discription |
|---|---|---|
| 1. | Grain | Medium Slender |
| 2. | LXB | 5.50x1.80 mm |
| 3. | L/B ratio | 3.00 |
| 4. | Rice grade | Medium slender |
| 5. | Milled rice colour | White |
| 6. | Abnormal white | Occasionally present |
| 7. | Two important morphological features to differentiate the CB 09123 from other released varities | Two contrasting characters- long droopy panicles and erect flag leaf |

**The descriptor details of MGR 100 or Paddy Co52 are furnished below.**

**The culture No. for Paddy CO52 is CB09123.**

| | |
|---|---|
| c) Specific areas of its adoption | Suitable for cultivation as transplanted rice throughout Tamil Nadu during late samba/thaladi season. |
| Recommended ecology | Irrigated condition as a transplanted crop in late samba/ thaladi season. |
| Description of variety / hybrid | |
| a. Plant height | 100-105 cm |
| b. Distinguishing morphological characters | DUS descriptors |
| Early plant vigour | Good |
| Coleoptile | Green |
| Basal leaf sheath colour | green |
| Leaf sheath | green |
| Leaf blade colour | green |
| Leaf pubescence | Intermediate |
| leaf length | 40.0 cm (± 5.0 mm) |

| | |
|---|---|
| Leaf width | 1.20 cm (± 0.2 mm) |
| Days to 50% flowering | 100-105 days |
| Panicle exertion | Well exerted panicle |
| Stigma colour | White |
| Apiculus colour | Light green |
| Number of effective tillers | 25-30 |
| Panlcle length (cm) | 29-30cm |
| No. of Grains/panicle | 450-475 |
| Panicle type | Long, compact & droopy |
| Awning | Absent |
| Days to maturity (days) | 135 days |
| Seed coat (Kernel) colour | White |
| Junction of auricle | Pale green |
| 1000 grain weight (g) | 14.10g |
| Hull (husk) colour | Straw |
| Threshability | Good |
| Aroma | absent |
| Grain yield per plant (g) | 50-55g |

**Rice CO 53**

| | |
|---|---|
| Culture name | CB 06803 |
| Parentage | PMK (R) 3 x Norungan |
| Breeding method | Pedigree selection |
| Duration | 115–120 days |
| Season | September – October sowing |
| Yield | 3718 kg/ha under dry condition 3866 kg/ha under semi dry condition |
| Area of adoption | Suitable for cultivation in drought prone districts of Tamil Nadu viz., Ramnad, Sivagangai and Virudhunagar |
| Special features | Medium plant height; 8-10 tillers/plant; White short bold rice with high milling percentage (69.6), head rice recovery (59.6%) and suitable for idly making |
| Reaction to major pests and diseases | Moderately resistant to WBPH; Moderately resistant to multiple diseases viz., leaf blast, neck blast, sheath rot, brown spot and Rice Tungro Disease. |

**Maize single cross hybrid VaMH 12014 as Maize VGIH 1**

- ❖ The proposed maize hybird culture VaMH 12014 (Maize VGIH 1) is a single cross derivative of UMI 1200xVIM 357 developed at AICRP- Maize, Maize Research Station, Tamil Nadu Agricultural University, Vagarai.
- ❖ Normal medium Maturity maize hybrid with Yellowish Oranage bold grains of Semi flint Type.

- Highly suitable for Zone III for the states of Bihar, Jharkhand, Odisha< uttar Pradesh (Eastern region) and West Bengal
- The hybrid was tested in 19 locations over three years (2015-2017) during kharif season which recorded the average grain yield of 6938 kg/ha in Zone III and also had high shelling percentage.
- Recorded consistent superiority in yield over checks viz., Bio 9637(16.0%) HM 9 (55.8%) PMH 4 (20.9%) qualifying hybird JKMH 4103(6.8%) and released hybrids of medium maturity (ZoneIII) viz., PMH 6 (10.1%) cmh 08-350(8.4%) and DHM 121 (28.5%) during kharif.
- The hybird was found significantly superior at higher nutrient levels (250:80:100 NPK kg/ha) and low plant density (66,000) over the best check (BIO 9637) at Bahraich (6490 kg/ha) and high plant density (83000) at Kalyani (13504 kg/ha).
- The proposed hybrid was also found to be superior in yield perfomance in all nutrient levels (State recommendation – 120:60:60 NPK kg/ha – Kalyani; 200:65:80 NPK kg/ha;250:80:100 NPK kg/ha) over the checks and qualifying hybrids which recorded the over mean yield of 6129 kg/ha at Bahriach in low plant density (66000) and 12664 kg/ha Kalyani in high plant density (83000)
- Multiple disease resistance viz., resistant to Curvalaria Leaf Spot and Rajasth Downy Mildew and moderately resistant to Maydis Leaf Blight, Turcicum Leaf Blight , Banded Leaf Sheath Blight, Charcoal Rot, Fusarium Stalk Rot and Bacterial rot under artificial conditions over qualifying and check hybrids.
- Moderately resistant to stem borer *Chilo partellus*
- It possesses special attributes such as high Starch (75.50%), high Protein (10.85%) high Beta carotene (0.44 mg/100g) with moderate level of Fat (4.05%) and Crude (1.33%).

**New Sorghum Variety CO 32**

**Special features:**

- Dual purpose variety suited for grain and fodder
- Short duration (105-110 days)
- Rainfed condition
  - Grain yield of 2445 kg/ha
  - Dry fodder yield of 6490 kg/ha
- Irrigated conditions
  - Grain yield of 2911 kg/ha
  - Dry fodder yield of 11710 kg/ha
- Moderately resistant to shootfly and stemborer
- Moderatly Resistant to Downy mildew and grain mould diseases.
- Yellow white grains
- Grain has high protein content (11.31-14.66%) and fibre content (4.95 -5.8%)
- Stover quality is best with 6.15 % protein and In Vitro Dry Matter Digestibility (IVDMD) of 54-58%.
- Suitable for cultivation in all over Tamilnadu both under rainfed and irrigated conditions

**ATL 1 Samai**

- Rainfed samai variety recommended for Dharmapuri, Tiruvannamalai, Vellore, Salem and Krishnagiri districts.
- The mean yield was 1590 kg/ha.
- Drought tolerant and suitable for mechanical harvesting
- Nutrient rich grains with high milling recovery.
- Palatable and nutritious straw

Tamil Nadu Agricultural University (TNAU) has released the following crop varieties during 2018. These varieties were approved for release by the State Variety Release Committee of Govt. of Tamil Nadu on 10.02.2018.

**A High Yielding Tenai ATL 1**

Tenai is grown as a rainfed crop during south west (June-July) or north east (September-October) monsoon in about 5,000 ha in Tamil Nadu. It is a cross derivative of PS 4 x Ise 198 and evolved by Centre of Excellence in Millets, Athiyandal. This variety has recorded 2117 and 2785 kg/ha of grain and straw yield respectively in a total of 233 trials under rainfed condition with a duration of 80-85 days. Its yield superiority has been observed as 9.6 and 14.8 per cent increase in terms of grain and straw yield over the check variety, CO (Te) 7 respectively. The grain and straw yield. It has a strong and sturdy culm with long and compact panicles. It is drought tolerant. The plant has 5-7 productive tillers and non-shattering grains. It is endured with special attributes like easy threshability, synchronized maturity and non-lodging growth habit. The grains are bold and attractive brownish yellow in colour. The grains are nutritious with preferred grain qualities for cooking and value addition.

The nutrient rich straw is palatable and highly suitable for cattle feeding. With high bulk density and milling out turn, the proposed variety is preferred by consumers and entrepreneurs. In general, there is no serious pest and disease problem in Tenai. However, this culture is tolerant to shoot fly incidence and occurrence of blast and rust diseases under field and control conditions. In view of stable yield performance across seasons and locations and special attributes with drought tolerance, the Tenai culture TNSi 331 is proposed for release as ATL 1 to fulfill the long felt need of the dry lands and hilly and tribal areas in Dharmapuri, Thiruvannamalai, Vellore, Salem, Namakkal, Villupuram, Virudhunagar and Krishnagiri districts of Tamil Nadu where Tenai is predominantly grown under rainfed condition.

**Banyard millet MDU 1**

- Released during 2017
- Pure line selection from Arupukkottai local
- Compact and pyramidal shaped panicle
- Early maturity – 95-100 days.
- High iron content (16 mg/ 100g).
- High milling percent (70%)
- Good quality and taste

# LATEST CROP VARIETIES OF IMPORTANT OILSEEDS AND PULSES AND THEIR SPECIAL CHARACTERS

**Dr.P.Shanthi and Dr. M.Gunasekaran**
**National Pulses Research Centre,**
**Tamil Nadu Agricultural University, Vamban – 622 303, Pudukkottai District**

---

**Pulses are rich sourch of protein**

Pulses are rich source of protein (20 to 25%) ability to fix atmospheric nitrogen (30-150 kg $ha^{-1}$) and consistent source of income and employment to small and marginal farmers; and thus hold a premier position in the World Agriculture. In India, pulses constitute a group of 12 crops that include mainly redgram (*Cajanus cajan* L.), chickpea (*Cicer arietinum* L.), greengram (*Vigna radiata* L. Wilczek), blackgram (*Vigna mungo* L. Hepper), lentil (*Lens culinaris* L.) and fieldpea (*Pisum sativum* L.). India is the largest producer of pulses contributing 25.7% to the World production.

In Tamil Nadu the important pulses crops include redgram, greengram, blackgram and cowpea. Some part of Coimbatore and Dharmapuri districts chickpea, horse gram and motchai are also cultivated. It covers 7.89 lakh hectares and production is 3.39 lakh hectares and productivity is 432 kg/ha. The important research institutes involved in pulses research are National Pulses Research Centre, Vamban, Department of Pulses, Coimbatore, Tamil Nadu Rice Research Institute, Aduthurai (exclusive research on rice fallow pulses), Agriculture Research Station, Kovilpatti (exclusive research on rainfed Agriculture), Agriculture Research Station, Virunjipuram. Agriculture College and Research Institute, Killikulam and Agriculture College and Research Institute, Madurai.

**BLACKGRAM**

Among the four important pulse crops blackgram cultivated in 4.36 lakh hectares with the production of 1.86 lakh tonnes and the productivity is 432 kg/ha. The following are the some of the important varieties under cultivation in Tamil Nadu.

| | |
|---|---|
| **Variety** | **Blackgram VBN (Bg) 6** |
| Parentage | Vamban1 x *Vigna mungo var silvestris1* |
| Duration | 65-70 days |
| Season | All seasons |
| Yield | Average yield : 871 kg/ha<br>Rainfed (Kharif) : 850 kg/ha<br>Irrigated (Rabi) : 890 kg/ha |
| Special attributes | Higher yield over VBN (Bg) 4 21.30 (%)<br>VBN (Bg) 5 15.82 ( %)<br>Resistant to Yellow Mosaic Virus (YMV)<br>Less damage of pod borer,<br>No incidence of leaf curl virus<br>Suitable for growing in all parts of Tamil Nadu during kharif season |
| **Variety** | **Blackgram VBN 8** |
| Parentage | VBN 3 x VBG 04-008 |
| Duration | 65-70 days |
| Season | All seasons for Tamil Nadu and for South Zone this variety is released for summer season. |
| Yield | Average yield : 1329 kg/ha (summer season)<br>Rainfed (Kharif) : 871 kg/ha<br>Irrigated (Rabi) : 988 kg/ha |
| Special attributes | Determinate plant type with synchronized maturity. Resistant to Mungbean Yellow Mosaic Virus (MYMV), Leaf Crinkle Virus, Leaf Curl Virus, Stem Necrosis; Free from Powdery mildew and *Cercospora* leaf spot and moderately resistant to root rot. |
| **Variety** | **Blackgram VBN 10** |
| Parentage | Vamban 1xUH 04-04 |
| Duration | 70-75 days |
| Season | Rabi season (Released for South Zone) |
| Yield | Average yield : 1126 kg/ha |
| Special attributes | Determinate plant type with synchronized maturity.<br>9.4, 16.2, 22.0 and 28.7 per cent increased yield over LBG 787, LBG 752, LBG 645 and CO 6 respectively.<br>Resistant to MYMV, Urdbean Leaf Crinkle Virus (ULCV) and LCVdiseases.<br>Recommended for Tamil Nadu, Kerala, Karnataka, Andhra Pradesh, Telangana and Odhisa. |
| **Variety** | **Blackgram VBN 11** |
| Parentage | PU 31 X CO 6 |
| Duration | 70-75 days |
| Season | Adi Pattam (June – July)<br>Purattasi Pattam (Sep. – Oct.)<br>Markazhi/ Thai pattam (Dec-Jan)<br>Chithirai Pattam (April – May) |
| Average yield (kg/ha) | Rainfed: 865; Irrigated: 940 |

**Special features**

Resistant to Mungbean Yellow Mosaic Virus (MYMV) and Urdbean Leaf Crinkle Virus (ULCV) and moderately resistant to powdery mildew diseases Excellent cooking quality traits with 22.6 % protein content. Based on the yield performance and resistance to diseases and pests, VBG 12-034 is being proposed for varietal identification for *rabi* cultivation in south zone.

| | | |
|---|---|---|
| **Variety** | : | **Blackgram CO 6** |
| Parentage | : | DU 2 x VB 20 |
| Duration | : | 60-65 days |
| Season | : | Adi Pattam (June – July)<br>Purattasi Pattam (Sep. – Oct.)<br>Markazhi / Thai pattam (Dec-Jan)<br>Chithirai Pattam (April – May) |
| Average yield | : | 773 (kg/ha) |
| Special features | : | Determinate plant type<br>Non- shattering of pods<br>Bold seeds (100 seed weight - 5.5 grams)<br>Resistant to MYMV and stem necrosis<br>MR to root rot Field tolerance to sucking pests |
| **Variety** | **:** | **Blackgram MDU 1** |
| Parentage | : | ADB 2003 x VGB 66 |
| Duration | : | 70-75 days |
| Season | : | Purattasi Pattam (Sep. – Oct.)<br>Markazhi / Thai pattam (Dec-Jan) |
| erage yield | : | 790 (kg/ha) |
| Special features | : | Moderately resistant to MYMV and pod borer<br>High yielding |
| **Variety** | **:** | **Blackgram ADT 6** |
| Parentage | : | VBN 1 x VBG 04-006 |
| Duration | : | 65-70 days |
| Season | : | Rice Fallow |
| Average yield | : | 741 (kg/ha) |
| Special features | : | Moderately resistant to MYMV, leaf folder and powdery mildew High yielding 5.7 % Arabinose. |
| **Variety** | | **Blackgram KKM 1** |
| Parentage | | COBG 643 x Vamban 3 |
| Duration | | 65-70 days |
| Season | | Rice Fallow |
| Average yield | | 741 (kg/ha) |
| Special features | | Moderately resistant to MYMV, leaf folder and Nematode resistance High yielding 6.7 % Arabinose. |

**GREENGRAM**

Greengram is cultivated in cultivated in 1.66 lakh hectares and production is 0.56 lakh tonnes and productivity is 338 kg/ha. The important varieties suitable for Tamil Nadu are listed below.

| | | |
|---|---|---|
| **Variety** | **:** | **Greengram CO(Gg)7** |
| Parentage | : | MGG 336 x Co GG 902 |
| Duration | : | 60-65 days |
| Season | : | Adi Pattam (June – July)<br>Purattasi Pattam (Sep. – Oct.)<br>Markazhi / Thai pattam (Dec-Jan) |
| Average yield | : | 837 (kg/ha) |
| Special features | : | Determinate growth habit,<br>Pods visible at the top of the crop canopy, High yielding |
| Variety | | **Greengram CO8** |
| Parentage | | COGG 923 x VC 6040A |
| Duration | | 55-60 days |
| Season | | Adi Pattam (June – July)<br>Purattasi Pattam (Sep. – Oct.)<br>Markazhi / Thai pattam (Dec-Jan) |
| Average yield | | 845(kg/ha) |
| Special features | | Short duration<br>Determinate growth habit and synchronized maturity, suitable for machine harvesting. High yielding, Moderatley resistant to MYMV, aphid and stem fly. |
| Variety | | **Greengram VBN 4** |
| Parentage | | PDM 139 x VB 2664 |
| Duration | | 65-70 days |
| Season | | Adi Pattam (June – July)<br>Purattasi Pattam (Sep. – Oct.)<br>Markazhi / Thai pattam (Dec-Jan)<br>Chitirai pattam (April) |
| Average yield | | 845(kg/ha) |
| Special features | | Multiple blooming and non shattering, High yielding,<br>Moderatley resistant to MYMV, powdery mildew and leaf crinkle |

**COWPEA**

Next to greengram, cowpea is the another important pulse crop the popular varieties in cowpea are

| | | |
|---|---|---|
| Variety | : | Cowpea CO(Cp)7 |
| Parentage | : | **Mutant of Co 4 ( 20 KR)** |
| Duration | : | 75-80 days |
| Season | : | Purattasi Pattam (Sep. – Oct.) |
| Average yield | : | Rainfed : 1000(kg/ha)<br>Irrigated: 1600 kg/ha |
| Special features | : | High yielding<br>**Dull brown seeds** |

| | | |
|---|---|---|
| Variety | : | **Cowpea VBN 3** |
| Parentage | : | TLS 38 x VCP 16-1 |
| Duration | : | 75-80 days |
| Season | : | Purattasi Pattam (Sep. – Oct.) |
| Average yield | : | Rainfed : 1013(kg/ha) |
| Special features | : | High yield, determinate plant type and synchronized maturity, 17.0% and 17.2% yield increase over VBN 1 (866 kg/ha) and CO (CP) 7(864 kg/ha) respectively.<br>Multiple resistance to Bean Common Mosaic Virus (BCMV), rust and anthracnose diseases.<br>Resistant to pod borer and pod bug Protein content of 25.22 percent Maximum yield of 1680 kg/ha was recorded in Sathyamangalam, Erode District Suitable for growing in all districts of Tamil Nadu except Nilgiris and Kanyakumari. |

## OILSEEDS

A wide range of oilseed crops are produced in different agro-climatic regions of the country. Among the oil seeds groundnut (*Arachis hypogaea* L.) also called peanut, is one of the most important oilseed crop in the World. It is known as a "wonder legume" for its flowering, pegging and pod formation pattern. The important varieties in ground nut are

| | | |
|---|---|---|
| Variety | : | **Groundnut TMV 14** |
| Parentage | : | VRI 6 x R 2001 -2. |
| Duration | : | 95-100 days days |
| Season | : | Aadi pattam (June-July)<br>Margali Pattam (Sep. – Oct.) |
| Average yield | : | Kharif : 2124 kg /ha Rabi: 2286 kg/ ha |
| Special features | : | Shelling of 70.6 % Completely resistant to rust disease and tolerant to late leaf spot Pod and kernel characteristics of this culture are most acceptable to the farmers Suitable for growing in all districts of Tamil Nadu except Nilgiris and Kanyakumari. |
| Variety | : | **Groundnut VRI 8** |
| Parentage | : | ALR 3/AK 303 |
| Duration | : | 105-110 days |
| Season | : | Aadi pattam (June-July)<br>Margali Pattam (Sep. – Oct.) |
| Average yield | : | Rainfed : 2130 kg /ha Irrigated: 2700 kg/ ha |
| Special features | : | Moderately resistant to Late Leaf Spot (LLS) and Rust<br>70% Shelling<br>49 % oil content<br>Medium bold kernels |
| Variety | : | **Groundnut BSR 2** |
| Parentage | : | VRI 2 x TVG 0004 |
| Duration | : | 105-110 days |
| Season | : | Aadi pattam (June-July)<br>Margali Pattam (Sep. – Oct.) |
| Average yield | : | Yield : Rainfed (2220 Kg/ha)<br>Irrigated (2360 kg/ha) |
| Special features | : | High oil content of 46.5%,<br>High Shelling (70.2%) outturn<br>Moderately resistant to late leaf spot and rust diseases |
| Variety | | **TNAU Groundnut CO 6** |
| Parentage | | CS 9 x x ICGs 5 |
| Duration | | 100-105 days |
| Season | | Aadi pattam (June-July)<br>Margali Pattam (Sep. – Oct.) |
| Average yield | | Yield : Rainfed (1914 Kg/ha |
| Special features | | High oil content of 49.5%,<br>Moderately resistant to late leaf spot and rust diseases<br>Tolerant to drought |

| | | |
|---|---|---|
| | | Shelling out turn 73.5 % |
| Variety | | **Groundnut CO 7** |
| Parentage | | ICGV 87290 x ICGV 87846 |
| Duration | | 100-105 days |
| Season | | Aadi pattam (June-July)<br>Margali Pattam (Sep. – Oct.) |
| Average yield | | Yield : Rainfed (2300 Kg/ha)<br>Irrigated (2806 kg/ha) |
| Special features | | High oil content of 51 %,<br>Moderately resistant to late leaf spot and rust diseases<br>Tolerant to drought |
| Variety | | **Gingelly VRI 3** |
| Parentage | | SVPR 1 x TKG 87 |
| Duration | | 75-80 days days |
| Season | | Aadi pattam (June-July)<br>Margali Pattam (Sep. – Oct.) |
| Average yield | | Yield : 1000 kg/ha (Karthigai pattam)<br>1060 kg/ha (Masi Pattam) |
| Special features | | White seeded gingelly<br>High oil content – 50.1 % |
| Variety | | **Castor Hybrid YRCH 1116 (YRCH 2)** |
| Parentage | | M619 – 1 x SKI 215 |
| Duration | | 180 days |
| Season | | May - June<br>July – August<br>November – December |
| Average yield | | Yield : 2089 kg / ha |
| Special features | | Oil content : 49 per cent Yield potential :3750 kg/ha |
| Variety | | **Castor YTP 1** |
| Parentage | | TMV 6 x Salem local |
| Duration | | 115-120 days |
| Season | | May - June<br>July – August<br>November – December |
| Average yield | | 1456 kg/ha |
| Special features | | Oil content 49%<br>Resistant to semilooper, *Spodoptera,* thrips and capsule borer |

# LATEST AND RULING CROP VARIETIES OF COTTON AND SUGARCANE AND THEIR SPECIAL CHARACTERS

**Dr.M. Sakila[1], S.Mohan[2], N.Vinothini[3] and M.Mathialagan[2]**
[1] Assistant Professor (PBG), Sugarcane Research Station, Sirugamani
[2] Teaching Assistant, Sugarcane Research Station, Sirugamani
[3] Assistant Professor (SST), SRM, Chennai.

---

Variety selection is one of the most important decisions a cotton farmer will make for the entire growing season. The variety, and associated traits in that variety, set the stage for harvest at the time of planting. All other input decisions become supplemental after the variety is selected. Variety selection has become increasingly important since the introduction of transgenic cottons and concurrent increases in seed costs and technology fees. Moreover, variety selection is the one decision a producer makes that is not influenced by weather or other environmental factors. Therefore, choosing a high yielding variety with acceptable fiber quality that is adapted to local growing conditions should be given careful consideration because of the tremendous importance of this decision for the entire season.

In India, there are nine major cotton growing states which fall under three zones viz. the North Zone (Punjab, Haryana and Rajasthan), the Central Zone (Maharashtra, Madhya Pradesh and Gujarat), and the Southern Zone (Andhra Pradesh, Karnataka and Tamil Nadu). Nearly 65 percent of the cotton crop is cultivated under rainfed conditions in the country.

In Tamilnadu, the crop is generally grown in medium to deep black clayey soil, but is also grown in sandy and sandy loam soil through supplemental irrigation by farmers. Cotton is best grown in soils with an excellent water holding capacity. Aeration and good drainage are equally important as the crop cannot withstand excessive moisture and water logging.

The major soil types suitable for cotton cultivation are alluvial, clayey and red sandy loam. Cotton is grown both under irrigated and rainfed conditions. Being a cash crop, cotton is known for its intensive cultivation. The following varieties are recently preferred by Farmers for their special features.

| S. No | variety/ Hybrid | Origin | Year of Release | Yield (kg/ha) | Duration in days | Special features |
|---|---|---|---|---|---|---|
| 1 | SVPR 1 | A hybrid derivative of the cross MCU 7 and AC. 129/2 | 1991 | 1225 (I) | 135 | Upper Half Mean Length-25.7mm: Fibre Strength-26.0 g/tex: Fibre Fineness-3.9µ: Ginning outturn- 33.7% Can spin 40's count. Notification No:: 615 (E) / 17.08.1993 |
| 2 | SVPR 2 | A hybrid derivative of the cross TSDT 22 and JR 36 | 1996 | 1658 (I) | 160 | Upper Half Mean Length-24.8mm: Fibre strength-26.3 g/tex: Fibre fineness-3.9µ: Ginning outturn- 36.4% Can spin 40's count. Tolerant to drought and moderately resistant to Jassid, *Alternaria* leaf spot Suitable for summer and winter irrigated tracts of Tamil Nadu Notification No::360 (E) dated 01.05.1997 |
| 3 | SVPR 3 | A hybrid derivative of the cross LH 900 and 1301 DD | 2000 | 1294 (I) | 135 | Upper Half Mean Length-23.4mm:Fibre strength-26.5 g/tex: Fibre fineness-3.6µ: Ginning outturn: 35.2% Can spin 30-40's count. Moderately resistant to Jassid, *Alternaria* leaf spot and Bacterial blight Notification No::821 (E) dated 13.09.2000 |
| 4 | SVPR 4 | A cross derivativ e of MCU 5 and S 4727 | 2009 | 1583 | 150 | Upper Half Mean Length-27.5mm: Fibre strength-28.4 g/tex: Fibre fineness-4.2µ: Ginning outturn 36.2% Can spin 40's count. Tolerant to Jassid Notification No::2137 (E) dated 31.08.2010 |
| 5 | SVPR 5 | Hybrid derivative of NDLH 1658 x Surabhi | 2014 | 1845 (I) | 150 | Upper Half Mean Length-29.0mm: Fibre strength-27.8 g/tex: Fibre fineness-3.6µ: Ginning outturn: 34.9% Can spin 50's count Moderately resistant to Jassid Notification No:: S.O. 3540(E) dated 22.11.2016 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 6 | SVPR 6 | Hybrid derivative of SVPR 2 and BJA 592 | 2017 | 2232 (I) | 150-155 | Upper Half Mean Length-29.1mm: Fibre strength-27.3 g/tex: Fibre fineness-4.0µ: Ginning outturn: 33.4% Can spin 40's count Moderately resistant to Jassid Notification No:: S.O. 1379(E) dated 27.03.2018 |
| 7 | Cotton Hybrid SVPR 1 | $F_1$ of TSH 311 × TSH 306 | 2015 | 2286 (I) | 165 | Upper Half Mean Length-28.1mm: Fibre strength-27.0 g/tex: Fibre fineness-4.0µ: Ginning outturn: 35.8% Can spin 40's count Moderately resistant to Jassid Notification No:: S.O. 3540 (E) dated 22.11.2016 |
| 8 | CO 14 | (MCU 5 x TCH 92-7) x MCU 5 -1 | 2016 | 1768 | 150 | Mean fibre length 35.0 |
| 9 | CO 17 | TCH 1819 | 2020 | 2361 kg/ha | 125 –135 | Compact and erect plant type (95- 100 cm) Zero monopodia Short sympodial branch Number of bolls /plant (15-20) Medium boll size (3.5 – 4.0 g) Synchronized boll maturity Suitable for two pickings Ginning outturn: 35 % Upper Half Mean length of fibre :27.0 mm (medium long staple) Bundle strength : 26.9 g/tex It can spin upto 40's counts Moderately resistant to root rot and *Alternaria* leaf blight Suitable for high density planting System Suitable for rice fallow, winter rainfed and summer irrigated tracts of Tamil Nadu |
| 10 | K12 | K11 x K9 | 2017 | 1193 | 135-140 | Early duration: 135-140 days, 2.5% span length 27.7mm, can spun upto 30's counts. Resistance to drought, leaf hopper |

**Definition/terminologies**

**Staple length**

Graders estimate the fibre length by hand stapling and is called staple length and expressed in millimeter.

**Microniare**

It is the measure of the index of the fibre diameter and is assessed by determining weight per unit length of the fibre. It is expressed in micronaire value (µg/inch).

**Fibre strength**

Fibre strength is generally considered to be next to fibre length and fineness. It is referred as bundle or tensile strength, essential for high speed spinning. It determines yarn strength. Unit of this parameter was expressed ingms/tex.

**List of varieties/hybrids released**

| S. NO | VARIETY | YEAR OF RELEASE | GP | REGION | SPECIAL CHARACTER |
|---|---|---|---|---|---|
| 1 | MCU5VT | 1984 | 60s | Tamil Nadu | *Verticillium* wilt tolerant with yield potential upto 25 q/ha<br>Fiber quality: **length 32.16 mm**; strength 24.0 g/tex; GOT 35.43%. |
| 2 | Kanchana | 1988 | 40s | Whitefly prone area of southern cotton zone | Whitefly tolerant<br>Fiber quality: length 26.6 mm; strength 22.33 g/tex; |
| 3 | Surabhi | 1997 | 60s | South zone ideal for summer cotton | Resistant to *Verticillium* wilt, Bacterial blight, and *Alternaria* leaf spot. Extra long staple, yielding uptp 20 q/ha.<br>Fiber quality: **length 31.6 mm**; **strength 24.4 g/tex**; GOT 35.09%. |
| 4 | Sumangala | 2001 | 40s | South zone | Long staple variety, moderately resistant to sucking pest and yield potential upto 30 q/ha.<br>Fiber quality: length 26.5 mm; strength 21.2 g/tex; GOT 37.19%. |
| 5 | Pratima (CNH 120 MB) | 2001 | 30s | Irrigated areas of south zone, also suitable for rainfed condition. | Compact, early maturing, Tolerant to moisture stress and has synchronised boll opening, Medium staple with high fibre strength. Fiber quality: length23.2 mm; **strength 24.4 g/tex**; GOT32.1%. |
| 6 | Suraj (CCH 504-4) | 2008 | 50s | Irrigated areas of south zone. | Most adaptable, sucking pest tolerant, good yield with good fiber quality and has yield potential upto 25 q/ha.<br>Suitable for organic cultivation and HDPS.<br>Fiber quality: length 30.3 mm; strength 23.8 g/tex; **GOT 40.1%**. |
| 7 | CCH 2623 | 2015 | 40s | South Zone | High yieding medium staple variety, tolorant to jassids and major diseases. Fiber quality: length 25.4 mm; strength 21.1 g/tex; GOT 36.9%. |

**Transgenic cotton**

| | | | | |
|---|---|---|---|---|
| 1 | BN *Bt* | 2008 | -All cotton growing zones | Resistant to cotton bollworms. Fiber quality: length 26.6 mm; strength 22.33 g/tex; |
| ***Gossypium arboreum*** | | | | |
| 3 | Roja (CNA 1003) | 2011 | -Rainfed area of south zone. | ideal for High Density Planting System (HDPS). Resistant to major diseases and pests. Fiber quality: length 24.3 mm; strength 21.1 g/tex; GOT 35.7% |

## SUGARCANE

Sugarcane (*Saccharum officinarum L.)* is the main sources of sugar in India and holds a prominent position as a cash crop. India is the World's largest consumer and the second largest producer of sugar, topped only by Brazil. Nearly 2.8 lakh farmers have been cultivating sugarcane in the vast area of 4.4 lakh acres and over 11 crore people are directly or indirectly dependent on the sugar industry in the country. Sugarcane productivity in India is around 67 t/ha. It is one of the most important food-cum-cash crop grown in the country, providing employment to a larger number of people, in addition to earning considerable foreign exchange.

**Season**

Early –(December-January )

Midlate–(February –March)

Special season-(June –July)

**Tamilnadu Statistics on Sugarcane 2019-20**

| A= Area in '000 ha; | P= Production in '000 Tonnes; | Y = Yield in Tonnes/ha |
|---|---|---|
| **206** | **20600** | **100.00** |

In Tamilnadu , the following varieties are considered as ruling varieties due their special features

| Sl. No | Variety name | Year of release | Parentage | Maturit group | Cane yield (t/ha) | Sucrose % juice | Resistance to diseases and pests | Reaction to abiotic stresses | Other characteristics | Recommended area of cultivation |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Co8371 (Bhima) | 2000 | Co 740 x Co 6806 | Midlate | 117.7 | 18.6 | Resistant to smut | Tolerant to waterlogging, drought and salinity | Thick cane. High cane yield | Gujarat, Maharashtra, Madhya Pradesh, Karnataka, Interior Andhra Pradesh, Tamil Nadu, Kerala |
| 2 | Co 85004 (Prabha) | 2000 | Co 6304 x Co 740 | Early | 90.5 | 19.5 | Resistant to smut | | Good ratooner | Gujarat, Maharashtra, Madhya Pradesh, Karnataka, Interior Andhra Pradesh, Tamil Nadu, Kerala |
| 3 | Co 86032 (Nayana) | 2000 | Co 62198 x CoC 671 | Midlate | 102.0 | 20.1 | Resistant to smut, field resistant to red rot | Tolerant to drought | Good ratooner. Retains quality up to 14-16 months. Suitable for wide row planting | Gujarat, Maharashtra, Madhya Pradesh, Karnataka, Interior Andhra Pradesh Tamil Nadu, Kerala |
| 4 | Co86249 (Bhavani) | 2000 | CoJ 64 x CoA 7601 | Midlate | 104.2 | 18.7 | Resistant to red rot | | Good ratooner | Orissa, CoastalAndhra Pradesh,CoastalTamilNadu,Pondicherry |
| 5 | Co87025 (Kalyani) | 2000 | Co 7704 x Co 62198 | Midlate | 98.2 | 18.3 | Resistant to smut, susceptible to red rot. | Tolerant to drought | Erect cane, sparse flowering | Gujarat, Maharashtra, Madhya Pradesh, Karnataka, Interior Andhra Pradesh, Tamil Nadu, Kerala |
| 6 | Co 87044 (Uttara) | 2000 | Co 62198 x CoC 671 | Midlate | 101.0 | 18.3 | Moderately resistant to smut | Tolerant to drought | High cane yield | Gujarat, Maharashtra, Madhya Pradesh, Karnataka, Interior Andhra Pradesh, Tamil Nadu, Kerala |
| 7 | Co 91010 (Dhanush) | 2000 | Co 312 x Co 775 | Midlate | 116.0 | 19.1 | Resistant to smut | Tolerant to drought | Good ratooner, high cane yield | Gujarat, Maharashtra, Madhya Pradesh, Karnataka, Interior Andhra Pradesh, Tamil Nadu, Kerala |

| Sl. No | Variety name | Year of release | Parentage | Maturity group | Cane yield (t/ha) | Sucrose %juice | Resistance to diseases and pests | Reaction to abiotic stresses | Other characteristics | Recommended area of cultivation |
|---|---|---|---|---|---|---|---|---|---|---|
| 8 | Co94008 (Shyama) | 2004 | Co 7201 x Co 775 | Early | 119.8 | 18.3 | Resistant to red rot and smut | Tolerant to drought and salinity | | Gujarat, Maharashtra, Madhya Pradesh, Karnataka, Interior Andhra Pradesh, Tamil Nadu, Kerala |
| 9 | Co 99004 (Damodar) | 2007 | Co 62175 x Co 86250 | Midlate | 115.5 | 19.5 | Moderately resistant to red rot | Tolerant to drought and salinity | Erect canes, non flowering | Gujarat, Maharashtra, Madhya Pradesh, Karnataka, Interior Andhra Pradesh, Tamil Nadu, Kerala |
| 10 | Co 2001-13 (Sulabh) | 2009 | Co 7806 GC | Midlate | 108.6 | 19.0 | Resistant to red rot and moderately resistant to smut. | Tolerant to drought | Good ratoonability | Gujarat, Maharashtra, Madhya Pradesh, Karnataka, Interior Andhra Pradesh, Tamil Nadu, Kerala |
| 11 | Co 2001-15 | 2009 | Co 85002 x Co 775 | Midlate | 108.2 | 18.9 | Moderately resistant to red rot. | Tolerant to drought | Good ratoonability | Gujarat, Maharashtra, Madhya Pradesh, Karnataka, Interior Andhra Pradesh, Tamil Nadu, Kerala |
| 12 | Co 0218 | 2010 | Co 8353 x Co 86011 | Midlate | 104.5 | 20.6 | Resistant to red rot and smut. Susceptible to rust. | Tolerant to drought | Erect, tall cane. Good ratoonability | Gujarat, Maharashtra, Madhya Pradesh, Karnataka, Interior Andhra Pradesh, Tamil Nadu, Kerala |
| 13 | Co 92005 | 2011 | CoC 671 x CoT 8201 | Early | 120.0 | 18.0 | Susceptible to red rot. | | Erect yellowish canes. High quality jaggery | Maharashtra |
| 14 | Co 05011 | 2012 | CoS 8436 x Co 89003 | Midlate | 82.5 | 18.0 | Resistant to red rot | | Non lodging, non flowering. Suitable for winter harvesting | Punjab, Haryana, Rajasthan, Uttarakhand, Western and Central UP |

| S. No | Variety name | Year of release | Parentage | Maturity group | Cane yield (t/ha) | Sucrose %juice | Resistance to diseases and pests | Reaction to abiotic stresses | Other characteristics | Recommended area of cultivation |
|---|---|---|---|---|---|---|---|---|---|---|
| 15 | Co 0237 | 2012 | Co 93016 GC | Early | 71.3 | 18.8 | Resistant to red rot | Tolerant to low temperature, water stress and water logging | Non lodging and non flowering | Punjab, Haryana, Rajasthan, Uttarakhand, Western and Central UP |
| 16 | Co 0403 | 2012 | Co 8371 x Co 86011 | Early | 101.5 | 18.2 | Resistant to red rot and smut | Tolerant to drought | High cane population | Gujarat, Maharashtra, Madhya Pradesh, Karnataka, Interior Andhra Pradesh, Tamil Nadu, Kerala |
| 17 | Karan-10 (Co 05009) | 2013 | Co 8353 x Co 62198 | Early | 75.89 | 17.44 | Resistant to red rot | | Non-lodging, non-flowering | Punjab, Haryana, Rajasthan, Uttarakhand, Uttar Pradesh |
| 18 | Co 06027 | 2013 | CoC 671 x IG 91-1100 | Midlate | 110 | 19.32 | Resistant to red rot | Tolerant to drought and salinity | | Gujarat, Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu, Kerala |
| 19 | Co 06030 | 2013 | CoC 671 x IG 91-1100 | Midlate | 104 | 16.6 | Resistant to red rot | | | Tamil Nadu, Andhra Pradesh and Odisha. |

| Varieties | Year | Parentage | Cane yield (t/ha) | CCS (%) | Traits |
|---|---|---|---|---|---|
| CoC (Sc) 23 | 2006 | 69 A 591 GC | 133.0 | 12.9 | Early, High yielder and high quality, erect and lodging cane and hence suitable for machine harvest, long internode, non flowering. |
| CoC (Sc) 24 | 2009 | Co 8371 x MS 68/47 | 135.0 | 12.55 | Early, High yielder and high quality. |
| CoC 25 | 2017 | Co 85002 x HR83-144 | 145.0 | 12.77 | Early, High yielding, fast growing, good ratooner, moderately resistant to red rot and less susceptible to shoot borer, suitable for early and special season |

| Variety | Year of release | Parentage | Age (days) | Season | Cane yield (t/ha) | CCS (%) | Sugar yield (t/ha) |
|---|---|---|---|---|---|---|---|
| CoG (SC) 5 | 2005 | CoC 8201 X CoT671 | 330 –360 | Mid-late | 120.9 | 13.0 | 15.6 |
| CoSi (SC) 6 | 2005 | Co 8213X CoA7602 | 360 | Early | 148.0 | **12.3** | **18.1** |
| TNAU Sugarcane SI 7 | 2010 | Co 99043X CoG93076 | 300-330 | Early | 154.0 | 13.04 | 20.21 |
| TNAU Sugarcane SI 8 | 2012 | CoC 90063 X Co 8213 | 330 | Mid-late | 146.0 | 12.9 | 18 |

## Special varieties

| Parameters | Co 0212 | Co 06022 |
|---|---|---|
| Parentage | Co 7201 X ISH 106 | GU 92-275 X Co 86249 |
| Maturity group | Mid-late | Early |
| Year of release | 2016 | 2018 |
| Institute name | ICAR- Sugarcane Breeding Institute, Coimbatore | ICAR-Sugarcane Breeding Institute, Coimbatore |
| Cane yield (t/ha) | 150.56 | 135.8 |
| CCS % | 12.80 | 13.10 |
| Sugar yield (t/ha) | 19.27 | 17.68 |
| Reaction to red rot | Moderately resistant | Moderately resistance |
| Special features | Tolerant to drought and salinity, A1 quality jaggery, Good ratooner, Erect and medium thick cane | A1 quality jaggery of golden yellow colour Non lodging, erect, thick cane Tolerant to water deficit stress |
| **Parameters** | **Co 09004 (Amritha)** | **Co 11015 (Atulya)** |
| Parentage | CoC 671 X CoT 8201 | CoC 671 X Co 86011 |
| Maturity group | Early | Early |
| Year of release | - | 2019 |
| Institute name | ICAR-Sugarcane Breeding Institute, Coimbatore | ICAR-Sugarcane Breeding Institute, Coimbatore |
| Cane yield (t/ha) | 109.85 | 142.72 |
| CCS % | 18.94 (Sucrose %) | 20.22 (Sucrose %) |
| Sugar yield (t/ha) | 14.56 | 20.16 |
| Reaction to red rot | Moderately resistance | Moderately susceptible |
| Special features | Resistant to smut, Less susceptible to borer, Tall cane, early fast growth, high tillering, medium thick cane, non- flowering, non lodging, good ratooner | Short duration (8 month) High sugar content Tall (>250 cm) and erect plant, Medium thick cane, A1 quality jaggery of golden yellow colour |

**What are the currently available drought tolerant sugarcane varieties?**

Varieties Co 86032, Co 88006, CoTl 88322, Co 95014, Co97008, Co 99004, Co 95003, Co 95006, Co 94012, Co 96009, CoJn 86-600, VSI 9/20, Co99012, Co 97001 and Co 96023 are some drought tolerant varieties.

**What are the varieties that are tolerant to water logging?**

Varieties like Co 8231, Co 8232, Co8145, CoSi 86071, Co Si 776, Co 8371, Co 99006, 93A4, 93A11, 93A145 and 93A21 are tolerant to drought

**What are the varieties that are tolerant to salinity conditions?**

Varieties like Co 95003, Co 93005, Co 97008, Co 85019, Co 99004, Co 2001-13 grow luxuriantly even in saline soils. Other varieties like Co 94012, Co 94008, Co 2000-10, Co 2001-15 and Co 97001 are tolerant to saline conditions.

**Name a few sugarcane varieties tolerant to iron deficiency?**

Varieties like Co 8021, Co 86032, Co 86249, Co 88025, Co 94005 and Co 94012 are tolerant to iron deficiency.

**What are the varieties tolerant to post harvest deterioration?**

Varieties CoC 671, Co 7314 and Co 775 were found to be comparatively resistant than CoJ 64, CoS 510, Co 7240, CoC 8001, Co 6907 and Co 62175. Studies at Coimbatore indicated that CoC 671 is comparatively less prone to post harvest inversion than Co 6304. CoC 671 stales less and is less inclined to inversion or dextran formation, even after 14-16 months.

**What are the varieties good for jaggery making?**

Tamilnadu: CoC 671, Co 62175, Co 7704, Co 6304, Co 8021, Co 86032, **CoC 92061**

**What are the varieties that have good juice quality for beverage purposes?**

Varieties like CoC 671, Co 62175, Co 7717, Co 86032, Co 86249 and Co 94012 have high sugar content in juice, light colored and less fibre and are suitable for making sugarcane juice.

## AGRONOMIC INTERVENTIONS TO ENHANCE THE PRODUCTION OF LATEST VARIETIES OF IMPORTANT AGRICULTURAL CROPS

**Dr.S.Marimuthu** and **Dr.M.Gunasekaran**
**National Pulses Research Centre,**
**Tamil Nadu Agricultural University, Vamban – 622 303, Pudukkottai District**

---

**Rice**

Rice (*Oryza Sativa L.*) being a staple crop is widely consumed by Indian community. Its production needs to be increased by another 40 % to provide food security to the growing population by 2030. The area of rice grown in India (44 million hectares) is the largest among all the rice growing countries with an annual production of around 104 million tonnes.

**Green manure**

- Sunhemp or dhaincha or Kolingi may be raised and incorporated at 50 per cent flowering stages i.e 40 to 45 DAS before cultivation of rice crop for improving soil fertility and higher productivity.

**System of Rice Intensification**

a. **Nursery Management**

- Use high yielding rice CR 1009 *Sub*1, TNAU Rice ADT 50, ADT 51, CR 1009, TRY3, TKM 13 and ADT54.

**Seed rate** 7.5 kg/ha

- **Preparation of mat nursery** is most appropriate for growing short duration varieties, as seedlings experience less transplanting shock. Compared to other methods, this requires less labor, and has minimal root damage.
- Prepare dapog nurseries where a flat firm surface is available and water supply is very reliable. Allot 100 $m^2$/ha or 1% of the field for the seedbed, and prepare 40–50 kg of seed per ha. Mark out 1 m wide and 10–20 m long plots. Cover the surface with banana leaves, plastic sheets, or any flexible material from penetrating the bottom layer of the soil. Cemented floors may also be used as base. Form the boundary with bamboo splits or banana sheath. Cover the seedbed with about 1 cm of burned paddy husk or compost. Sow pre-germinated seeds on the seedbed. Maintain a thickness of 5–6 seeds (1 kg per 1.5 $m^2$). Sprinkle water to the seeds after sowing, and then press down by hand or with a wooden flat board. Prevent water stress by irrigation. Transplant 9–15 days old seedlings.

- Pre-sprouted seeds are sown on raised nursery bed
- Prepare nursery bed similar to that of garden crops
- Apply a layer of fine manure, Spread sprouted seed sparsely
- Cover with another layer of manure, Mulch with paddy straw
- Watering carefully
- Banana leaf sheath may be used for easy lifting and transport of seedlings.

**b. Transplanting**

- 14 days old seedlings are transplanted with square planting of 25 x 25 cm
- A metal sheet is inserted 4-5 inches below the seed bed and the seedlings along with soil lifted without any disturbance to the root.
- Seedlings are transplanted shallow and therefore establish quickly. Single seedling with seed and soil are transplanted by using index finger and thumb and gently placing them at the intersection of markings.
- develops hair line cracks.
- Alternate wetting and drying of soil results in increased microbial activity in the soil and easy availability of nutrients to the plants

**c. Weed management**

- Absence of standing water leads to more weed growth in SRI.
- Use of conoweeder from 10, 20, 30 & 40 DAP
- Incorporate the weeds in the soil by moving the weeder between the rows
- Weeds close to the hills/tillers have to be removed by hand
- Soil health improves through biological activity
- Nitrogen application through Leaf Colour Chart
- Take observations from 14 DAT in transplanted rice or 21 DAS in direct seeded rice. Repeat the observations at 7 days intervals up to heading stages. To select fully opened third leaf from the top as index leaf for observation. Match the leaf color with the colours in the chart during morning hours (8-10am). Totally take observation in 10 places.
- LCC critical value is 3.0 in low N response cultures like White Ponni and 4.0 in other cultivars and hybrids. When 6/10 observations show less than the critical colour value, N can be applied as per the following recommendation : Application of 25 kg N ha$^{-1}$i.e50 kg of urea) at 7 DAT followed by N @ 40 kg ha$^{-1}$each time for kuruvai/ short duration rice / 30 kg ha-1 each time for medium & long duration rice as and when the leaf colour value falls below the critical value of 4 for varieties and hybrids and critical value of 3 for white ponni, monitored from 14 DAT.

**Maize**

Maize (*Zea mays*) is one of the most important cereal crops in the World grown over an area of 132 m.ha with a production of 570 m.t. It is the crop with the highest per day productivity. In India, maize is next in important only to rice and has an acreage around 6 m.ha with a production of 10.5 m.t. Maize is the World's third most important crop after rice and wheat. About half of this is grown in developing countries, where maize flour is a staple food for poor people and maize stalks provide dry season feed for farm animals. Maize can be classified on the basis of its protein content and hardness of the kernel. These include popcorn, flint, flour, Indian and sweet corn.

**Formation of ridges and furrows**

- Form ridges and furrows, 6 m long and 60 cm apart.
- If ridges and furrows are not made, form beds of size 10 $m^2$ or 20 $m^2$ depending on the availability of water.
- Use a bund former or ridge plough to economise cost of production.
- Use high yielding maize hybrid viz., Hybrid CO 6 and COH(M) 8 for higher yield.

**Seed rate:** Select good quality seeds and adopt the seed rate of 20 kg/ha for CO 1 and TNAU Maize Hybrid CO 6 and 25 kg /ha for COBC 1.

**Spacing:** Adopt a spacing of 20 cm between plants in the rows, which are 60 cm apart. Population: 80,600/ha

**Sowing:** Dibble the seeds at a depth of 4 cm along the furrow in which fertilizers are placed and covered with soil. Put one seed per hole in the case of CO H (M)6& 8 and two seeds per hole in the case of K1.

**Gap filling :** Take up gap filling on the 10$^{th}$ day of sowing

**Thinning:** should be done between 15-20 days if there is excess plant population (i.e., there are two or more seedlings in a hill). Generally, thinning is done at the time of first hoeing. The plant-to-plant distance should be maintained at 20-25 cms.

**Rectification of ridges and furrows :** Reform the ridges and furrows after first top dressing in such way that the plants are on the top of the ridges and well supported by soil.

**Irrigation requirements:** About 60 cm of well-distributed rainfall during the growing season is quite sufficient for the crop. There are certain critical growth stages of maize for irrigation in new plant types at which moisture stress results in considerable reduction of grain yield. The most pronounced critical stages for irrigation are Seedling stage ,Knee- height stage , Tasseling stage, Silking stage and Grain filling stage. Of these moisture stress at early growth stages results in a delayed tasseling and silking by 3-5 and 5-8 days respectively, while stress at later stages results in drastic reduction in yield.

- Any reduction in soil moisture at this stage will markedly reduce the yield.
- Proper drainage measures will protect the crop from salinity and waterlogging specially during the early stages.
- It has been estimated that the maize crop requires about 50 per cent of its total water requirement in a short period of 30-35 days after tasselling.
- If there is any water stress during this period the principle of source link relationship will come in effect i.e. there will be seed formation proportionate to the availability of water and nutritional resources.
- The rest of embryos will die on that particular stage where fertilization of ovaries over. From a harvested cob we can find out the stress faced by crop during the period by observing the grain-filling pattern.

**Methods of Irrigation**

Various methods of irrigation can be used

The flat bed method is used when the crop is planted evenly on a flat bed without any furrows.

**Scheduling of Irrigation**

- Water requirement of Kharif maize is 400-550 mm while that of Rabi maize is 450-600 mm.
- Even though maize roots can penetrate upto 120 cm., the density of roots is high only at 60 cm.
- After every crop of maize, ploughing with disc plough and working sub soil after every three years, raising of green manure crops like Sunhemp and their incorporation into soils make the soils loose and friable upto 120 cm.
- Hence roots of subsequent maize crop penetrate to deeper layers and efficiently use water. Presowing irrigation to Field capacity is very important as Maize seed will not germinate unless it absorbs moisture to double its weight.
- First irrigation should be given upto 120 Cm, depth. Second irrigation after 10 to 15 days depending upon soil, temperature and wind velocity. Schedule irrigations at more frequent intervals in dry weather and less frequent intervals in humid weather.
- Maize is susceptible to moisture stress throughout its life cycle. Since flowering and grain-filling stages are most critical, the crop should be irrigated at these stages, if rains fail.
- Where soils are generally light, it is desirable to schedule the irrigations at 70% soil-moisture availability throughout the period of crop growth and development.
- In heavy soils, a moisture level of 30% during the vegetative stage and 70% during the reproductive and grain-filling period is desirable for obtaining optimum yield.
- Four to six irrigations are needed during the Rabi crop season. If six irrigations are given, they should be applied at the following crop growth stages
    1. Two irrigations up to flowering at an interval of 20-25 days
    2. One (essential) at the time of flowering
    3. Two after flowering
    4. One at the early grain-filling stage.

If only five irrigations are given, one irrigation at the vegetative stage may be avoided and if only four irrigations are given, irrigation after the dough stage may be avoided. The irrigation schedule may, however be charged suitably if adequate rains are received.

**Fertilizer Management**

Soil Test Crop Response based Integrated Plant Nutrition System (STCR- IPNS). If soil test recommendation is not available adopt a blanket recommendation of 135:62.5:50 Kg/NPK ha-1 for varieties and 250:75:75 kg NPK ha-1 for hybrid maize. The recommended dose of fertilizer apply quarter of the dose of N; full dose of $P_2O_5$ and $K_2O$ basally before sowing.The remaining dose of N on the 25$^{th}$ day of sowing along the furrows evenly and cover it with soil. Place the remaining quarter of N on the 45$^{th}$ day of sowing. Drip fertigation with Water Soluble Fertilizer (WSF), N : Poly feed 19-19-19, P : MAP 12-61-00 and K : $KNO_3$ 13-00-45.

**Application of micronutrient**

- Apply TNAU MN mixture @ 30 kg ha $^{-1}$ as enriched FYM (Prepare enriched FYM at 1:10ratio MN mixture and FYM; mix at friable moisture and incubate for one month in shade.

- Apply zinc sulphate @ 37.5 kg $ha^{-1}$ for hybrid maize and 25 kg $ha^{-1}$ for varieties can be followed in Zn deficient soils.
- Apply 50 kg $FeSO_4$ + 12.5 t FYM $ha^{-1}$ along with 40 kg S as elemental sulphur for calcareous soils. Apply the mixture over the furrows and two thirds in the top of ridges, if ridge planting is followed. If bed system of sowing is followed, apply the micronutrient mixture over the beds.
- Foliar spray of TNAU Maize Maxim @ 7.5 kg/ha in 500 litres of water at tassel initiation and at grain filling stages improves grain filling, grain yield and drought tolerance.
- Apply 40 kg S, 10 kg borax and 50 kg $FeSO_4$ + 12.5 t FYM for specific respective nutrient deficiency in soils.
- For zinc and iron deficiencies in plants foliar spraying 0.5% $ZnSO_4$, 1% $FeSO_4$ +0.1% citric acid thrice on 30, 40 and 50 days after sowing can be followed.

**Weed management**

- Apply Atrazine @ 0.50 kg/ha as pre-emergence on 3-5 DAS followed by 2,4-D @ 1 kg/ha on 20-25 DAS, using Backpack/Knapsack/Rocker sprayer fitted with a flat fan nozzle using 500 litres of water/ha.
- In line sown crop, apply Pre Emergence herbicide Atrazine @ 0.50 kg/ha on 3-5 DAS followed by Twin Wheel hoe weeder weeding on 30-35 DAS.

**Pulses**

Pulses constitute the major source of protein for majority of population in India that is predominantly vegetarian in dietary habits. India contributes 25-28% of the total global pulse production and it is the largest producer and consumer of pulses in the World. Pulses are known to have higher protein content and other essential nutrients and considered as important component in nutrition for poor in developing countries. Pulses are not only important sources of proteins, but also offer vitamins and minerals, popularly known as 'Poor man's meat' and 'rich man's vegetable'.

- Use high yielding blackgram VBN6, VBN8,VBN10 and VBN11, for greengramCO(Gg) 7, VBN(Gg) 2, VBN(Gg) 3, CO8, VBN 4 and for redgramCo (Rg) 7 and VBN(Rg) 3.
- Sowing at correct time i.e July and December
- Optimum plant population (33/sq.m)
- Seed treatment T.*viride* or *Pseudomonas* and *Rhizobium* and *Phosphobacteria*
- DAP 2% + 1%KCl twice / TNAU pulse wonder once @ 5 kg/ha + 40ppm NAA foliar sprays.

Dibble the blackgram and greengram seeds adopting a spacing of 30 x 10 cm. for redgram short duration varieties 60 cm x 30 cm and long duration varieties 90 cm x 30 cm or 120 -150 x 30 cm. For bund crop dibble the seeds at 30 cm spacing.

**Season**

- Long duration redgram varieties (CO 6, CO 8, Vamban 2, LRG 41) : Second fortnight of
- July and First fortnight of August months.
- Short duration varieties : January - May and September first fort night.

**Weed management**

i) Pre emergence application of Pendimethalin 30% EC + Imazethapyr 2% EC (Valor 32% EC; Readymix herbicide) @ 1.0 kg a.i. ha-1 at 3 DAS.

**Water management**

Irrigate immediately after sowing, followed by life irrigation on third day. Irrigate at intervals of 7 to 10 days depending upon soil and climatic conditions. Flowering and podformation stages are critical periods when irrigation is a must. Avoid water stagnationat all stages. Apply KCl at 0.5 per cent as foliar spray during vegetative stage if there ismoisture stress.

**Foliar application**

a.Foliar spry of 2% DAP on30 and 45 DAS to increase the nos. of flowering and quality of grains.

b. Foliar spray of NAA 40 mg/litre once at pre-flowering and another at 15 days thereafter to reduce flower shedding.

c. i) For rice fallow crops foliar spray of TNAU Pulse wonder @ 5 kg/ha once at flowering to decreases flower shedding.

ii) For irrigated and rainfed crops, foliar spray of TNAU Pulse wonder @ 5 kg/ha once at flowering

d. Foliar spray of salicylic acid 100 mg/litre once at preflowering and another at 15 days there after to improve translocation efficiency and seed yield.

**Foliar spraying to mitigate moisture stress**

Foliar spraying of 2% KCl + 100 ppm Boric acid during dry spell as mid season management practice in black gram during *Rabi* season is recommended to increase the yield over KCl spray alone .

**Multi bloom technology**

A special technology being practiced in Pattukottai block of Tanjore district for blackgram and greengram. The soil is alluvial and rich in organic matter and nutrients. The crop is sown during early summer (Jan.-Feb.) as normal crop and fertilizer is applied as per the recommendation for irrigated crop. In addition to that, top dressing of Nitrogen is done with an extra dose of 25 to 30 kg through urea. Since pulses are indeterminate growth habit and continue to produce new flashes, the top dressing will be done on 40-45 days after sowing. The crops complete its first flesh of matured pods during 60-65$^{th}$ day, further their second new flesh within 20-25 days. Therefore two fleshes of pods can be harvested at a time within the duration of 100 days.

**Rice fallow pulses**

- Use the suitable variety for rice fallow condition in Black ram VBN 6, VBN9, ADT3 and Greengram ADT1
- Selection of quality seeds
- Proper leveling of field during Samba season
- Sowing at correct time (15$^{th}$ December – last week of January )
- Optimum plant population (33/sq.m)
- Gap filling with sprouted seeds
- Seed treatment – *Pseudomonas*, Bio-fertilizers
- DAP 2% + 1%KCl twice / TNAU Pulse wonder once + 40ppm NAA foliar spray.

**Redgram Transplanting**

- Select only long duration redgram varieties
- Transplant within the month of August either under rainfed condition or under irrigated condition
- Select poly bag with a size of 6x4 inches and 200 micron thickness. Fill the poly bag with native soil: Sand: FYM @1:1:1 and put 3-4 holes in thebottom to avoid water stagnation
- Soak the seeds in 0.2% Calcium chloride for one hour and dry it under shade for7 hours to harden the seeds
- Treat the hardened seeds with *T. viride* @ 4g/kg and 100 g *Rhizobium* and 100 g *Phosphobacteria*. Sow the seeds @ 2/poly bag at 1 cm depth.
- Sow the seeds in polybags 30-45 days prior to transplanting
- Plough the field deeply to get fine tilth followed by 2-3 harrowings at 3 weeks prior to transplanting
- In medium to deep soils for raising long duration varieties, dig 15 sqcm pits at 5' x 3' for pure crops and 6' x 3' for intercropping under irrigated condition. In rainfed condition dig the pits at a spacing of 5'x3'. For short duration varieties dig 15 sq cm pits at 3' x 2' spacing.
- Under water logging condition, form furrows before digging pits
- Apply inorganic fertilizers @ 25:50:25 kg NPK /ha at 20-30 days after planting as urea, DAP and potash around the seedlings
- Apply $ZnSO_4$ @ 25 kg/ ha as basal along with FYM or sand Nip (removal of top 5 cm) the plants at 20 – 30 days after planting to arrest the terminal growth
- Foliar Spray of Napthalene Acetic Acid (NAA) @ 0.5 ml/litre to control flower dropping in red gram.

**Oilseeds: Groundnut**

Groundnut (*Arachis hypogaea* L.), the king of oil seeds is one of the important legume crops cultivated predominantly under rainfed conditions in the tropical and semi-arid tropical countries including India. It provides food and feed and a major source of oil, carbohydrates and proteins. Its kernel is rich in both oil (43 - 55%) and protein (25 - 28%).

Use the following high yield groundnut varieties

Bunch varieties: TMV Gn13, TMV 14, VRI Gn 6, VRI 8, CO7.

Semi spreading varieties: :VRIGn 7, CO6

Suitable varieties for irrigated: VRI 8, BSR 2, CO 7

Suitable varieties for rainfed:TMV Gn13, TMV 14, BSR 2, CO 6, CO7 and VRI 7

Bold variety (Gujarat) : GG 7

TMV 14 and BSR 2 are alternate varieties for TMV 7

**Seed rate**

Use 120 kg/ha of kernels, 175 kg/ha of kernels for bold seeded varieties.

**Spacing**

Adopt a spacing of 30 cm between rows and 10 cm between plants. Wherever groundnut ring mosaic (bud necrosis) is prevalent, adopt a spacing of 15cm x 15 cm.

**Seed treatment**

i. Treat the seeds with talc formulation of *Trichoderma viride* @ 4 g/kg seed or *Pseudomonas fluorescens* @ 10 g/kg seed. Biocontrol agents are compatible with biofertilizers. Treat the seeds with biocontrol agents first and then with *Rhizobium*. Fungicides and biocontrol agents are incompatible.

ii. Treat the seeds with *Trichoderma*@ 4g/kg. This can be done just before sowing. It is compatible with biofertilizers.

iii. Treat the seeds with Thiram or Mancozeb @ 4 g/kg of seed or Carboxin or Carbendazim at 2 g/kg of seed.

iv. Treat one hectare of seeds with 125 ml of *Rhizobium* (TNAU 14) and 125 ml of *Phosphobacteria*, shade dry it for 30 minutes before sowing

**Weed management**

- **Pre-emergence**: Pendimethalin @ 1.0 litre/ha applied through flat fan nozzle with 500 l of water/ha. After 35 - 40 days one hand weeding may be given.
- If no herbicide is applied two hand weeding may be given on $20^{th}$and $40^{th}$ DAS.

**Earthingup** during second hand weeding/late hand weeding (in herbicide application).

NOTE: i) Earthing up provides medium for the peg development ii) Use the improved hoe with long handle which can be worked more efficiently in a standing position. iii) Do not disturb the soil after $45^{th}$ day of sowing as it will affect pod formation adversely.

**Application of gypusm**

- Apply gypsum @ 400 kg/ha by the side of the plants on $40^{th}$ to $70^{th}$ day depending upon soil moisture.
- Apply gypsum, hoe and incorporate it in the soil and then earth up.
- Avoid gypsum in calciferous soils.
- Gypsum is effective in soils deficient in calcium and sulphur.

**APPLICATION OF FERTILIZERS**

- Apply NPK fertilizers as per soil test recommendation. If soil test is not done, followthe blanket recommendation.
- For rainfed groundnut, apply the recommended dose of 10:10: 45 kg NPK $ha^{-1}$to the main crop of groundnut. For irrigated condition, follow the blanket recommendation of NPK 25: 50: 75 kg/ha respectively, 80 kg S as gypsum on 45 DAS.
- For sulphur deficient calcareous soil, application of 60 kg S/ha elemental sulphur as basal application is recommended. Growing CO7, ALR3 and CO2 can be recommended in calcareous soils tolerate lime induced iron chlorosis while CO4, TMV2 and ALG320 were highly sensitive to iron deficiency.

**Application of micronutrients**

Apply TNAU MN mixture @ 7.5 kg /ha as Enriched FYM (Prepare enriched FYM at1:10 ratio of MN mixture & FYM ; mix at friable moisture &incubate for one month inshade). Broadcast evenly on the soil surface immediately after sowing. Do not incorporate micronutrient mixture in to the soil.

**5. NUTRITIONAL DISORDER**

**Zinc deficiency**: Apply 25 kg $ZnSO_4$/ha as basal.If soil analysis shows less than 1.2 ppm of zinc, soil application of 25 kg $ZnSO_4$ isrecommended. Reduce $ZnSO_4$ application from 25.0 kg ha-1 to 12.5 kg ha-1 if FYM isapplied @ 12.5 t ha-1. For the standing crop, less than 39.4 ppm of zinc in leaves, foliar spray of 0.5% $ZnSo_4$ is recommended.

**Iron deficiency**: Foliar of spray 1% $FeSO_4$ + 0.1% citric acid thrice on 30, 40 and 50 DAS.

**Boron deficiency**: Application of Borax 10 kg

**Sulphur deficiency:** Gypsum 400 kg/ha as soil application at 45$^{th}$ day after sowing.

**Spray of TNAU groundnut rich**

To increase flower retention, pod filling and to induce drought tolerance apart from yield improvement, 2 sprays of TNAU groundnut rich @ 5.0 kg/ha (for each spray) at 35 DAS ( 50 per cent flowering) and 45 DAS (Pod developing stage) in 500 litres of water is recommended.

**Combined nutrient spray**

Pod filling is a major problem especially in the bold seed varieties. To improvepod filling spraying of nutrient solution is to be given. This can be prepared by soaking DAP 2.5 kg, Ammonium sulphate 1 kg and borax 0.5 kg in 37 lit of water overnight. The next day morning it can be filtered and about 32 litre of mixture can be obtained and it may be diluted with 468 lit of water so as to made up to 500 litre to spray for one ha. Planofix at the rate of 350 ml. can also be mixed while spraying. This can be sprayed on 25$^{th}$ and 35$^{th}$ day after sowing.

**SUGARCANE** (*Saccharum officinarum* )

In 62% World's sugar is met from cane. Sugar requirement is projected at 150 million tonnes for the World. India alone requires 16-20 million tons. Sugar industry is the largest agro-based industry next only to textiles in India. At present there are 450 sugar factories and average productivity is 14.2 million t on and average sugar recovery of 11%.

**Season**

Sugarcane is grown chiefly in the main season (December - May) in the entire State. In parts of Tiruchirapalli, Perambalur, Karur, Salem, Namakkal and Coimbatore districts, it is also raised during the special season (June - September). The particulars in respect of each season are given below:

**Season, period of planting**

1. Main season i) Early : Dec - Jan, ii) Mid : Feb - March iii) Late: April - May 2. Special season : June - July Early season varieties are suitable for special season.

Suitable high yielding variety viz., CoG 94077, Co 86032, CoSi (SC) 6, TNAU SC Si 7, TNAU SC Si 8 , CoC 25, CoG 6, Co 11015 (Atulya) and Co 09004 (Amritha)

**1. Preparation of setts for planting**

a. Take seed material from short crop (6 to 7 months age) free from pests and diseases incidence.

i. Detrash the cane with hand before setts preparation.
ii. Use sharp knife or sett cutting machine developed by TNAU to prepare setts without splits.
iii. Discard setts with damaged buds, sprouted buds, splits etc.
iv. Sett treatment with biofertilizers: Prepare slurry with 2 kg of *Azospirillum / Gluconacetobacter*, 2 kg of *Phosphobacteria*, 2 kg of SSB and dip the setts required for one ha for 30 minutes and plant. (or) sett treatment with powder formulation of *Gluconacetobacter diazotrophicus* and AM fungi each @ 67.5 g/ha along with 75% of recommended dose of N & P.

**2. Sett treatment**

**Select healthy setts for planting.**

- The setts should be soaked in 100 litres of water dissolved with 50g Carbendazim, 200ml malathion and 1 kg urea for 15 minutes.
- Treat setts with Aerated steam at 50°C for one hour to control primary infection of grassy shoot disease.

**3. Seed rate:** 75000 two-budded setts/ha.

**4. Planting**

Different systems of planting is not found to influence the millable cane population, commercial cane sugar percent, cane and sugar yield.

a) Irrigate the furrows to form a slurry in wet land condition (Heavy soil)
b) Place the setts along the centre of the furrows, accommodating 12 buds/metre length. Keep the buds in the lateral position and press gently beneath the soil in the furrow.
c) Next day cover the exposed setts with soil to avoid exposure of setts to sunlight.
d) Plant more setts near the channel or double row planting at every $10^{th}$ row for gap filling, at later stage.
e) In dry/ garden land dry method of planting may be followed. First arrange the setts along the furrows, cover the setts with soil and then irrigate. Improved technologies on cane planting systems

**Mechanization of planting**

- TNAU mechanical planter is useful for cost effective planting with saving of Rs.3750 / ha and it can cover an area of 1.5 ha/day
- Reduces the human labour drudgery and seed rate up to 5 tones/ha.
- Paired row system of planting double side planting of sugarcane setts with 150 + 30 cm spacing for Astraf 8000 series (Mechanical harvester) operated areas and 150 + 30 cm spacing for New Holland 4000 series operated areas may be 293 adopted with single row of cane planting.
- Sugarcane cultivates under subsurface drip system the laterals may be placed 20cm depth in the furrows and setts are placed 5cm above the laterals.

- For sustainable sugarcane initiative system (SSI) transplanting young chip bud seedling raised in portray (25-35 days old) in wide spacing (5x2 feet) in the main field with drip fertigation system.

**5. Filling up gaps**

i. Fill the gaps, if any, within 30 days after planting with sprouted setts.

ii. Gap filling with two budded setts/ poly bag seedlings within 15 to 20 days after planting to maintain optimum plant stand.

iii. Maintain adequate moisture for 3 weeks for proper establishment of the sprouted setts.

**6. Trash Mulching**

Mulch the ridges uniformly with cane trash to a thickness of 10 cm within a week after planting. It helps to tide over drought, conserves moisture, reduce weed population and minimise shoot borer incidence. Mulch the field with trash after 21 days of planting in heavy soil and wetland conditions. Avoid trash mulching in areas where incidence of termites is noticed.

**7. Raising Inter Crops**

In areas of adequate irrigation, sow one row of soybean or blackgram or greengram along the centre of the ridge on the 3rd day of planting. Intercropping of *daincha* or sunhemp along ridges and incorporation of the same on the 45th day during partial earthing up helps to increase the soil fertility and also the cane yield.

**8. Weed Management, Weed Management in pure crop of Sugarcane**

i. Wherever weed menace is higher, one line weeding along the crop row and spade digging of ridges have to be done on 30, 60 and 90 DAP

ii. Spray Atrazine 1 kg or Oxyflurofen 750 ml/ha mixed in 500 liters of water as pre emergence herbicide on the 3rd day of planting, using deflector or fan type nozzle fitted with knapsack sprayer.

iii. Pre emergence application of atrazine @ 1.0 kg $ha^{-1}$ on 3 DAP followed by post emergence application of glyphosate @ 10 ml / litre of water on 45 DAP with hood+ one hand weeding on 90 DAP registered the maximum cane yield.

iv. If the parasitic weed Striga is a problem, Pre-emergence application of Atrazine 1.0 kg/ha on 3 DAP + hand weeding on 45 DAP with an earthing up on 60 DAP combined with post-emergence sparaying of 2,4-D @ 6 g (0.6%) + Urea @ 20 g (2%) / litre of water on 90 DAP + Trash mulching 5 t/ha on 120 DAP.

v. If herbicide is not applied work the junior-hoe along the ridges on 25, 55 and 85 days after planting for removal of weeds and proper stirring. Remove the weeds along the furrows with hand hoe. Otherwise operate power tiller fitted with tynes for intercultivation.

vi. Control of creeper weeds post emergence directed application of fernoxone (2, 4 –D sodium salt) @ 2 gm + 10 gm of urea per liter of water may be sprayed over the creeper weeds. Weed management in Sugarcane intercropping system Pre emergence application of Thiobencarb @ 1.25 kg ai/ha under intercropping system in Sugarcane with Soybean, blackgram or groundnut gives effective weed control. Raising intercrops is not found to affect the cane yield and quality.

**9. Earthing up**

After application of 3rd dose fertilizer (90 days), work victory plough along the ridges for efficient and economical earthing up. At 150 days after planting, earthing up may be done with spade.

**10. Detrasing:** Remove the dry cane leaves on 150th and 210th day to avoid borer infestation.

**11. Propping :** Do double line propping with trash twist at the age of 210 days of the crop.

**12. Top dressing with fertilizers**

Apply 275 kg of nitrogen and 112.5 kg of $K_2O$/ha in three equal splits at 30, 60 and 90 days a. Soil application Coastal and flow irrigated belts (assured water supply areas). In the case of lift irrigation belt, apply 225 kg of nitrogen and 112.5 kg of $K_2O$/ha in three equal splits at 30, 60 and 90 days (water scarcity areas). For jaggery areas, apply 175 kg of nitrogen and 112.5 kg of $K_2O$/ha in three equal splits on 30, 60 and 90 days.

Foliar spray of TNAU Sugarcane Booster @ 1.0, 1.5 and 2 kg/acre in 200 litres of water at 45, 60 and 75 days after planting enhances cane growth and weight, internodal length, cane yield, sugar content and offers drought tolerance.

**Micro nutrient fertilizers**

1. (a) Zinc deficient soils : Basal application of 37.5 kg/ha of zinc sulphate. (b) For zinc deficiency symptoms: foliar spray of 0.5% zinc sulphate with 1% urea at 15 days internal till deficiency symptoms disappear.
2. (a) Iron deficient soils: Basal application of 100 kg/ha of ferrous sulphate + 12.5t FYM. (b) For Iron deficiency symptoms: Foliar spray of 1% ferrous sulphate + 0.1% citric acid with 1% urea at 15 days interval till deficiency symptoms disappear.

Common Micronutrient mixture : To provide all micronutrients to sugarcane, 50 kg /ha of micronutrient mixture containing 20 kg Ferrous sulphate,10 kg Manganese sulphate, 10 kg Zinc sulphate, 5 kg of Copper sulphate, 5 kg of Borax mixed with 100 kg of well decomposed FYM, can be recommended as soil application prior to planting. (or) Application of TNAU MN mixture @ 50 kg/ha as EFYM for higher cane yield. Recommended dosage of macro and micronutrients.

a. Sugarcane – plant crop (meant for sugar mills) 300:100:200 kg N, $P_2O_5$ and $K_2O$ per ha
b. Sugarcane – Ratoon crop (meant for sugar mills) 300 + 25% extra N : 100 : 200 kg N, $P_2O_5$ and $K_2O$ per ha
c. Sugarcane for jaggery manufacture (plant as well as ratoon crop) 225 : 62.5 : 112.5 kg N, $P_2O_5$ and $K_2O$ per ha

**Biofertilizer for Sugarcane**

*Azospirillum* is the common biofertilizer recommended for N nutrition which could colonize the roots of sugarcane and fix atmospheric nitrogen to the tune of about 50 to 75 kg nitrogen per ha per year. Recently, another endophytic nitrogen fixing bacterium, *Gluconacetobacter diazotrophicus* isolated from sugarcane can able to fix more nitrogen than *Azospirillum*. It colonizes throughout the sugarcane and increases the total N content. In soil, it can also colonize the roots and able to solubilize the phosphate, iron and Zn. This new organism was test-verified in various centres and released as new biofertilizer *Gluconacetobacter diazotrophicus* TNAU Biofert-I. *Phosphobacteria* as P solubiliser are recommended for sugarcane crop. 297 Sett treatment with *Gluconacetobacter diazotrophicus*. Before planting the sugarcane setts can be treated with ten packets (2 kg) per ha of *Gluconacetobacter diazotrophicus* prepared as slurry with

250 L of water. Soil application *Gluconacetobacter diazotrophicus* Twelve packets (2.4 kg) per ha is recommended for soil application each at $30^{th}$, $60^{th}$ and $90^{th}$ day after planting under irrigated condition. Same method of application can be followed for *Phosphobacteria.*

- If basal application is not followed apply the same with $30^{th}$ day, $60^{th}$ day and $90^{th}$ day after planting and copiously irrigate the field.
- Biofertilizer treatment should be done just before planting.
- Immediately plant/ Irrigate after biofertilizer application
- Do not mix biofertilizer along with chemical fertilizer.
- Reduces 25% of the recommended N to reap the benefits of biofertilizer application

**Water management**

Irrigate the crop depending upon the need during different phases of the crop.

Germination phase (0 - 35 days): Provide shallow wetting with 2 to 3 cm depth of water at shorter intervals especially for sandy soil for enhancing the germination. Sprinkler irrigation is the suitable method to satisfy the requirement, during initial stages.

Later, irrigation can be provided at 0.75, 0.75 and 0.50 IW/CPE ratio during tillering, grand growth and maturity phases respectively. The irrigation intervals in each phase are given below:

**Days of irrigation interval**

**Stages**

- Tillering phase (36 to 100 days) : once in 8 to 10 days
- Grand growth phase (101 - 270 days) : once in 8 to 10 days
- Maturity phase (271 - harvest) : once in 10 to 14 days

**Drip Irrigation**

- Planting setts obtained from 6-7 months old healthy nursery and planted in paired row planting system with the spacing of 30x30x30 / 150 cm. for manual harvest and 30/150 cm for machine harvest.
- Eight setts per metre per row have to be planted on either sides of the ridge thus making it as four row planting system.
- 12 mm drip laterals have to be placed in the middle ridge of each furrow with the lateral spacing of 240 cm & 8 'Lph' clog free drippers should be placed with a spacing of 75 cm on the lateral lines. The lateral length should not exceed more than 30-40 m.
- Phosphorus @ 62.5 kg $ha^{-1}$ has to be applied as basal at the time of planting.
- Nitrogen and Potassium @ 275 : 112.5 kg $ha^{-1}$ have to be injected into the system as urea and muriate of potash by using "Ventury" assembly in 10-12 (298 equal splits) starting from 150 - 180 days after planting.
- Low or medium in nutrient status soil to be given with 50 per cent additional dose of Nitrogen and Potassium.
- Irrigation is given once in three days based on the evapo-transpiration demand of the crop.
- The double side planting of sugarcane with lateral spacing of 120 + 40 cm under subsurface drip fertigation system improves the yield.
- Application of 125 % recommended NPK (Rec NPK-275 :63:112.5 kg /ha ) through fertigation under pit system of planting inprove the yield and yield attributes.

**Concept of fertigation**

Fertigation is the judicious application of fertilizers by combining with irrigation water. - Fertigation can be achieved through fertilizer tank, venturi System, Injector Pump, Non- Electric Proportional Liquid Dispenser (NEPLD) and Automated system. - Recommended N & K @ of 275 and 112.5 kg. $ha^{-1}$ may be applied in 14 equal splits with 15 days interval from 15 DAP. - 25 kg N and 8 kg $K_2O$ per ha per split. - Urea and MOP (white potash) fertilisers can be used as N and K sources respectively - Fertigation up to 210 DAP can also be recommended.

**Ratoon crop**

**i. Management of the field after harvest of the plant crop**

Complete the following operations within 10 days of harvest of plant crop to obtain better establishment and uniform sprouting of shoots.

1. Remove the trash from the field. Do not burn it. Irrigate the field copiously.
2. Follow stubble shaving with sharp spades to a depth of 4 - 6 cm along the ridges at proper moisture.
3. Work with cooper plough along with sides of the ridges to break the compaction.
4. The gappy areas in the ratoon sugarcane crop should be filled within 30 days of stubble shaving. The sprouted cane stubbles taken from the same field is the best material for full establishment. The next best method is gap filling with seedlings raised in polybags.
5. Apply basal dose of organic manure and super phosphate as recommended for plant crop

**Management of the crop**

1. 25% additional N application on 5-7 days after ratooning.
2. Foliar spray of Ferrous sulphate at 2.5 kg/ha on the 15$^{th}$ day. If chlorotic condition persists, repeat the spray twice further at 15 days interval. Add urea 2.5 kg/ha in the last spray.
3. Hoeing and weeding on 20$^{th}$ day and 40$^{th}$ to 50$^{th}$ day.
4. First top dressing on 25$^{th}$ day, 2$^{nd}$ on 45$^{th}$ to 50$^{th}$ day.
5. Final manuring on 70$^{th}$ to 75$^{th}$ day.
6. Partial earthing up on 50$^{th}$ day. If junior-hoe is worked two or three times upto 90$^{th}$ day, partial earthing up is not necessary.
7. Final earthing up on 90$^{th}$ day.
8. Detrashing on 120$^{th}$ and 180$^{th}$ day.
9. Trash twist propping on 180$^{th}$ day.
10. Harvest after 11 months.

**Sustainable sugarcane initiative**

**Varieties**

- COC 779- 205 t/ha, COC 22 - 135.9 t/ha , COC 23 & COC 24 -133 t/ha
- TNAU SC Si 7- 156 t/ha and TNAU SC Si 8- 156 t/ha

**Nursery management**

- Select healthy canes of 7-9 months old cane
- Which have good internode length 7-8 inches and girth
- Healthy setts has to be selected
- Protrays required 100 Nos/acre
- Composted coir pith requirement 150 kg /acre

**Principles of SSI**

- Raising nursery using single budded chips.
- Transplanting young seedlings (25-35days old).
- Maintaining wide spacing (5 x 2 feet) in the main field
- Providing sufficient moisture through efficient water management technology viz., Drip irrigation (sub or sub surface) and avoiding inundation of water.

Practicing intercropping with effective utilization of land

**TNAU sugarcane sett cutting machine**

- Operated by 0.5 hp electric motor , Used for cutting single budded sett
- Consists of a circular saw directly coupled to the motor
- 3600 setts / hour and Cost of the unit is Rs.5000/-

**Transplanting and cultural operations**

- Transplanting of 25- 35 days old seedlings
- Water can be stopped 1day before transplanting
- Optimum plant spacing 150 cm x 60 cm
- To moist the soil, irrigate the field 1 or 2 days before transplanting. Irrigation should be given immediately after planting.
- After establishment of 2- 3 tillers, the mother shoot may be removed 1 inch above the ground
- Intercropping : Groundnut, pulses, water melon, cucumber and Green manure crops
- Intercroping facilitates weed control, soil enrichment & additional income
- Weeding has to be done on 30, 60 and 90 DAP
- Earthing up : $45^{th}$ and $90^{th}$ DAP – aeration &root growth
- For effective photosynthesis 8-10 leaves are sufficient
- Remove the older leaves on $5^{th}$ and $7^{th}$ month and apply as mulch in the interspaces
- Apply FYM / Compost during field preparation
- Inorganic fertilizers
- For Coastal and flow irrigated areas : 275 : 62.5 : 112.5 N: $P_2O_5$: $K_2O$ kg /ha. N & K applied in 3 equal quantities at 30, 60 7 90 DAP, N may be coated with neem cake @ 20%
- For Lift irrigated areas: 225 : 62.5 : 112.5 N: $P_2O_5$: $K_2O$ kg /ha
- For Jaggery producing areas: 175 : 62.5 : 112.5 N: $P_2O_5$: $K_2O$ kg /ha
- For those soils deficient in iron : apply 100 kg ferrous sulphate /ha
- In Zinc : apply 37.5 kg Zinc sulphate / ha.
- Sugarcane consumes 250-300 liters of water to produce 1kg of cane and 1500 -3000 liters of water to produce 1kg of sugar
- More production with less water
- Cane can be cultivated in marginal soil
- Reduce ploughing
- More ratoon crop
- Cost of drip irrigation Rs. 65000/ha

**Fertigation schedule for sugarcane (kg $ha^{-1}$)**

| Crop stage (DAP) | Nitrogen | Phosphorus | Potassium |
|---|---|---|---|
| 0-30 | 39.4 | 0 | 0.00 |
| 31 - 60 | 50.6 | 26.25 | 9.00 |
| 61 - 90 | 56.5 | 20.50 | 14.50 |
| 91 - 120 | 61.2 | 16.25 | 16.00 |
| 121 - 180 | 57.8 | 0 | 40.50 |
| 181 - 220 | 10.5 | 0 | 35.00 |
| **Total** | **275** | **63** | **115.00** |

**Cotton**

Cotton is one of the important fibre crop and which is called white gold and it is also backbone of textile industry and it Contributes 7% of GDP. Cotton industries providing employment to 1 million people. Totally 45% World's fibre need is fulfilled and 10% of World's edible oil. It is cultivated primarily for lint. Linters are used cushions, pillows etc., also used for high grade paper, rayon, films, explosives , Stalk is a fuel, Seed crushed for edible oil and Cakes and meals are excellent cattle feed.

| **Season and district** | | **Suitable varieties** |
|---|---|---|
| **Winter Irrigated (Aug – Sep)** | : | |
| Coimbatore, Erode, Madurai, Dindigul, Theni, Salem,Namakkal | | MCU 5, MCU 5VT, Suraj, MCU 13, Surabhi, Suvin, CO 14 |
| Dharmapuri | : | MCU 5, MCU 5VT, Suraj, MCU 13, Surabhi, CO 14 |
| Cuddalore, Villupuram | : | LRA 5166, SVPR 2, SVPR 4, Surabhi, CO14 |
| Madurai, Virudhunagar, Tirunelveli, Trichy, Salem, Erode, Dindigul | : | SVPR5 |
| **Summer – Irrigated (Feb – Mar)** Erode | : | MCU 5, MCU 12, MCU 13, Surabhi |
| Madurai, Virudhunagar, Dindigul, Tirunelveli, Thoothukudi, Theni, Ramanathapuram, Sivagangai. | : | MCU 5, SVPR 2, SVPR 4, Surabhi, SVPR5, SVPR 6 |
| **Rice Fallow** Thanjavur, Tiruvarur, Nagapattinam, Karur, Cuddalore and Villupuram | : | MCU 7, SVPR 3 |

**Pre-treatment of acid delinted seeds with biofertilizer**

Treat one hectare of seeds with 600g of *Azospirillum,* 600g of *Phosphobacteria* (or) 600 g of Azophos + 600 g of Silicate Solubilizing Bacteria.

**Liquid formulation** Treat one hectare of seeds with 125 ml of *Azospirillum,* 125 ml of *Phosphobacteria* and Silicate Solubilizing Bacteria (SSB) shade dry for 30 minutes before sowing.

**Varieties/Hybrids Spacing between ridges**

MCU 5, SVPR 2, LRA 5166, MCU 12, MCU 13 : 75 x30cm

Suvin : 90x30cm

MCU 7 : 60 x 30cm

**Application of Inorganic Fertilizers**

i) If soil test recommendations are not available, follow the blanket recommendation for the different varieties MCU 7, SVPR 3 : 60:30:30 kg NPK/ha

ii) MCU 5, MCU 12, MCU 13,Suvin, SVPR 2:80:40:40 kg NPK/ha if basal application could not be done, apply on the 25$^{th}$ day after sowing.

iii) Apply 50 percent of N and K full dose of $P_2O_5$ as basal and remaining ½ N and K at 40 – 45 DAS for varieties. For hybrids apply N in three splits *viz.*, basal, 45 and 65 DAS.

**Application of Micronutrient Mixture**

TNAU MN mixture 12.5 kg/ha for variety and 15 kg/ha for hybrid apply as enriched FYM. Enriched FYM is prepared at 1.10 ratio of MN mixture and FYM, mixed at friable moisture and for one month in shade. Need based foliar spray of 2% Mgso4 + 1% urea during boll formation stage.

**Seed rate:**

MCU 5, MCU 7, MCU 12, MCU 13, SVPR2: 15 kg/ha offuzz seed and 7.50 kg/ha of delinted seed. KC 2:20 kg/ ha of fuzz seed and Suvin 6 kg/ ha of delinted seed.

**Spacing**:

| Variety/hybrid | | Spacing (cm) |
|---|---|---|
| MCU 5, MCU 12, MCU 13 | : | 75 x 30 |
| KC 2 | : | 45x 15 |
| SUVIN | : | 90x45 |

**ACID-DELINTING OF COTTON SEEDS**

- Choose plastic bucket bucket for acid delinting of seeds.Do not use earthen wares, metal vessels, porcelain wares or wooden drum for acid delinting as concentrated sulphuric acid will corrode them.
- Put the required quantity of seeds in the container and add commercial concentrated sulphuric acid at the rate of 100 ml per kg of fuzzy seed.Stir vigorously and continuously with a wooden stick for 2 to 3 minutes till the fuzz sticking to the seeds is completely digested and the seed coat attains a dark brown colour of coffee powder.
- Add water to fill the container. Drain the acid water and repeat the washing 4 or 5 times to remove any trace of acid.
- Remove the floating, ill-filled and damaged seeds while retaining the healthy and good seeds which remain at the bottom.Drain the water and dry the delinted seeds in shade.

**Advantages of Acid delinting**

- Eliminates some externally seed borne pathogenic organisms.
- Kills eggs, larvae and pupae of pink boll worm.
- Helps to remove immature, ill-filled, cut and damaged seeds.
- Makes seed dressing more effective and easy
- Facilitates easy sowing and good germination.

**Pre-Treatment of Acid Delinted Seeds with fungicides**

i) Treat the delinted seeds with talc formulation of *Trichoderma viride* @ 4g/kg of seed or with Carbendazim (or) Thiram @ 2g/kg of seed.

ii) Treat the delinted fungicide treated seeds with 3 packets (600 g) of *Azospirillum* and 3 packets of *Phosphobacteria* 600g (or) 6 packets of Azophos (1200 g) and sow immediately.

**Seed Hardening**

Soak the seeds in equal volume of Pungam leaf extract (1%) for 8 hours and dry back to original moisture to increase germination and vigour. Dry the seeds in shade.

Seed pelleting: Seeds coated with arappu leaf powder (100 g/kg) along with DAP (40 g/kg), micronutrient mixture (15 g/kg) and *Azospirillum* (200 g/kg) *Phosphobacteria* (200 g/ha) or Azophos (400 g/ha) using 5% maida solution or gruel as adhesive (300 ml/kg) to increase the germination and vigour.

**Sowing**

i) Dibble the seeds at a depth of 3-5 cm on the side of the ridge 2/3 height from the top and above the band where fertilizers and insecticides are applied, maintaining the correct spacing and then cover seeds with soil.

ii) In the case of intercropping, sow the seeds of the intercrop in between the paired rows of cotton in a row of 5 cm apart and cover the seeds.

**Cotton growth stages**

1. Seedling stage (sowing - 45' days) , 2.Square formation stage (45-60 days)
3. Flower initiation stage (60-70 days), 4. Peak flowering stage (90-100 days)
5. Boll formation stage (100-120 days) 6. Boll bursting stage (120-165 days)

**Weed management**

- Apply Pendimethalin @ 1.0 litre/ha three DAS or Fluchloralin 1.0 kg a.i /ha on 3DAS + power weeding on 45 DAS followed by earthing up or Trifloxysalfuron @ 10 g/ha on 15 DAS for broad leave weeds and sedges. Sufficient moisture should be present in the soil at the time of herbicide application. This will ensure weed free condition upto 40 days.

**Gap filling**

a. Take up gap filling on the $10^{th}$ day of sowing.

- In the case of TCHB 213, raise seedlings in polythene bags of size 15 x 10 cm.
- Fill the polythene bags with a mixture of FYM and soil in the ratio of 1:3.
- On the $10^{th}$ day of sowing, plant seedlings maintained in the polythene bags, one in each of the gaps in the field by cutting open the polythene bag and planting the seedling along

**Thinning**

Thin out the seedlings on the $15^{th}$ day of sowing. In the case of fertile soils, allow only one seedling per hole, whereas in poor soil allow two seedlings per hole.

**Top dressing**

- Top dress 50% of the recommended dose of N and K on 40 – 45 DAS for varieties.
- Top dress $1/3^{rd}$ of recommended dose of N on 40-45 DAS and the remaining $1/3^{rd}$ on 60- $65^{th}$ DAS for hybrids.

**Rectification of ridges and furrows**

Reform the ridges and furrows after first top dressing in such a way that the plants are on the top of the ridges and well supported by soil.

**Spraying of Napthalene Acetic Acid (NAA)**

Spray 40 ppm NAA at 60 and 90 days after sowing on the crop to prevent early shedding of buds and squares and to increase the yield.

NOTE: 40 mg of NAA dissolved in one litre of water will give 40 ppm.

**Management strategies for delayed summer irrigated cotton sowing**

KCI 1% spray, twice on 50 and 70 DAS for delayed sowing (first fortnight of March) of summer irrigated cotton in rice-cotton cropping system for Srivilliputhur region.

**Arresting Terminal Growth**

Nip the terminal portion of the main stem as indicated below: For varieties having less than 160 days duration nip the terminal portion of the main stem beyond the 15$^{th}$ node (75 to 80 DAS) and for varieties and hybrids having more than 160 days duration beyond the 20th node (85 - 90 DAS).

**Skip furrow irrigation**

a) Suited to heavy soils like clay and loam
b) Alternate furrows should be skipped and may be converted to ridges having a wide bed formation.
c) Short term crops like pulses may be raised in wider bed without exclusive irrigation.
d) Water saving is 50% when compared to control.

**Alternate furrow irrigation**

a) During any one run of irrigation a particular set of alternate furrows is irrigated.
b) The interval of irrigation should be shortened when compared to the conventional furrows.
c) During the next run, the left over furrows be irrigated.
d) Suited to heavy soils like clay and loam.

Foliar spray of TNAU Cotton Plus @ 2.5 kg/acre in 200 litres of water at flowering and at boll formation stages reduces flower and square shedding, improves boll bursting, increases seed cotton yield and imparts drought tolerance.

**Rice fallow cotton**

- It is cotton cultivated in rice fields immediately after the harvest of rice when the field is in waxy condition when the season is optimum. No field preparation is needed to sow the crop.

**Season:** January 15$^{th}$ –Feb 15$^{th}$

**Sowing**

- Immediately after the harvest of rice
- Sowing at waxy soil condition
- Immediately after the harvest of rice  cotton seeds are sowing at waxy soil condition
- Varieties: MCU 7, SVPR 1, ADT 1 LRA 5166
- Spacing:60 x 30 and (75 X 30 for LRA)
- Fertilizers: 60:30:30  kg NPK/ha

**Gap filling and thinning**

- Gap filling from 7$^{th}$ day onwards
- Thinning on 15$^{th}$ day
- Hand weeding around the plant
- From 15$^{th}$ day
- Digging the rows and earthing up from 21$^{st}$ day

**Irrigation**

- After drying of the soil dug between the rows
- Fertilizer application: Around 35$^{th}$ day and followed by 1st irrigation

**Earthing up**

- Around 40$^{th}$ day after the moisture dried and soil loosened for second time
- 2$^{nd}$ irrigation may be around 50-60 DAS

## NEW GENERATION PESTICIDES AND ITS FIELD USAGE IN AGRICULTURE

**Mr.C.Janakiraman, Senior Agricultural Officer, Fertilizer Control Laboratory, Trichy.**

---

**This Chapter consist the detailed information about the following things**

- RECENTLY INTRODUCED INSECTICIDES, FUNGICIDES WITH BRAND NAMES
- FORMULATIONS & MODE OF ACTION
- EFFICACY OF NEWER PESTICIDES IN FIELD
- RECOMMENDED DOSAGE FOR CROPS
- RESIDUAL EFFECTS & WAITING PERIOD.
- ERA OF INSECTICIDES AND INSECTICIDES OF CURRENT SCENARIO.
- EFFECTIVE NEW GENERATION INSECTICIDES AVAILABLE IN THE MARKET.
- MODE OF ACTION OF THE INSECTICIDES AND VARIOUS GROUP OF INSECTICIDES.

### INSECT CONTROL ERAS

| 1940-50 | 1970s | 1990s | 2010 |
|---|---|---|---|
| Organochlorines, Organophosphates & Carbamates | Pyrethroids | Neonicotinoids | Diamides |

- ❖ **High Bio-efficacy**
- ❖ **High Selectivity**
- ❖ **Safer to Environment and Beneficial Insects**

### THE ACTUAL PROBLEM

- The agrochemical industry has developed a broad range of very effective insecticides for the control of pests.
- Unfortunately, as a consequence of the misuse or overuse of these insecticides, many insect species have developed resistance.
- American Boll worm *Helicoverpa armigera* which infests cotton, Pulses, and Vegetable crops has developed resistance to almost all groups of insectices like Organo Chlorines, Organo Phosphorus, Carbamates and Synthetic Pyrethroids leading to resurgence of pests.

### ANTI-RESISTANCE STRATEGY

- It is hard to develop new types of insecticides with novel modes of action, but this process is becoming ever harder and more costly.
- It is vital that effective Insecticide Resistance Management (IRM) strategies are implemented, to ensure that resistance does not develop to these new compounds, or to older chemistries that are still effective.

- In order to help prevent or delay the incidence of resistance, Insecticides Resistance Action Committee (IRAC) promotes the use of a Mode of Action (MoA) classification.
- Chlorantraniliprole features a new mode of action (group 28 in the IRAC MoA scheme). Although it has no cross-resistance with other insecticidal modes of action, the risk of resistance development has been considered from the beginning.
- Pro-active, anti-resistance management is an essential part of the marketing strategy of Chlorantraniliprole.

**PESTICIDE FORMULATIONS**

- It is the form in which pesticide is stored & transported to the user in a cost effective manner.
- Like Dusts, W.P., E.C.,G., Aerosol, Fumigant.
- Newer Formulations : WDG, Concentrated Emulsions and Micro emulsions, suspension concentrates, Micro encapsulations.

**CRITERIA**

- Effective at low dosage
- Safe to handle
- Easy to apply
- Long shelf-life
- Non – persistant in the environment (Very short half-life period)

**CHANGING SCENARIO IN PESTICIDE INDUSTRY**

- To keep environment safe
- To keep ecosystem in harmony
- To lessen the user exposure while application
- Use of new generation formulation

**OBJECTIVE**

- To have maximum efficiency with minimum active ingredient.
- To reduce the exposure hazard to minimum.
- To minimize the use of flammable, toxic, costly petroleum solvents.

**HOW TO ACHIEVE THIS?**

Replacement of older pesticides with

- Newer Pesticides
- More Toxic
- Short lived
- Negatively correlated.

**EVOLVING SOPHISTICATED FORMULATIONS WITH**

- Reduced Application Rate
- Less Critical Timing
- More Control on Placement
- More safety in hangling.

**Classification Based on Mode of Action**

- Physical Poison – Physical effect like tar, Abrasiveness like Aluminium Oxide.
- Protoplasmic Poison – Destroy cellular protoplasm of midgut epithelium like mercury, copper & arsenic compounds.
- Respiratory Poison – block respiration like HCN
- Nerve Poison – blocks acetylcholine esterase like Organo Phosphorus, Carbamates, Pyrethrum.
- General Poison – induce neurotoxicity after latent period like Toxaphene, Chlordane. The very stable physical and chemical properties of the Pesticides made them the most persistent of environmental pollutants. Some pesticide inhibit nitrification bacteria. Negative effects on growth and reproduction of earthworm (soil invertebrate) by many pesticides – Chlorpyrifos.
- Misuse of pesticides – killed valuable pollinators e.g bees.
- Some pest becomes resistant to pesticides
- Decline of bees after repeated application of insecticide Fenitrothion
- Negative effects on amphibians and fishes have been reported. Malathion , Carbaryl
- Clothianidin & Imidacloprid are play an important role in CCD.
- Colony Collapse Disorder (CCD) is a phenomenon in which worker bees from beehive or European honey bee colony abruptly disappear.

**The Pre-Harvest Interval (PHI)**

- It is the wait time between a pesticide application and when a crop can be harvested.

**VARIOUS NEWER FORMULATIONS AVAILABLE**

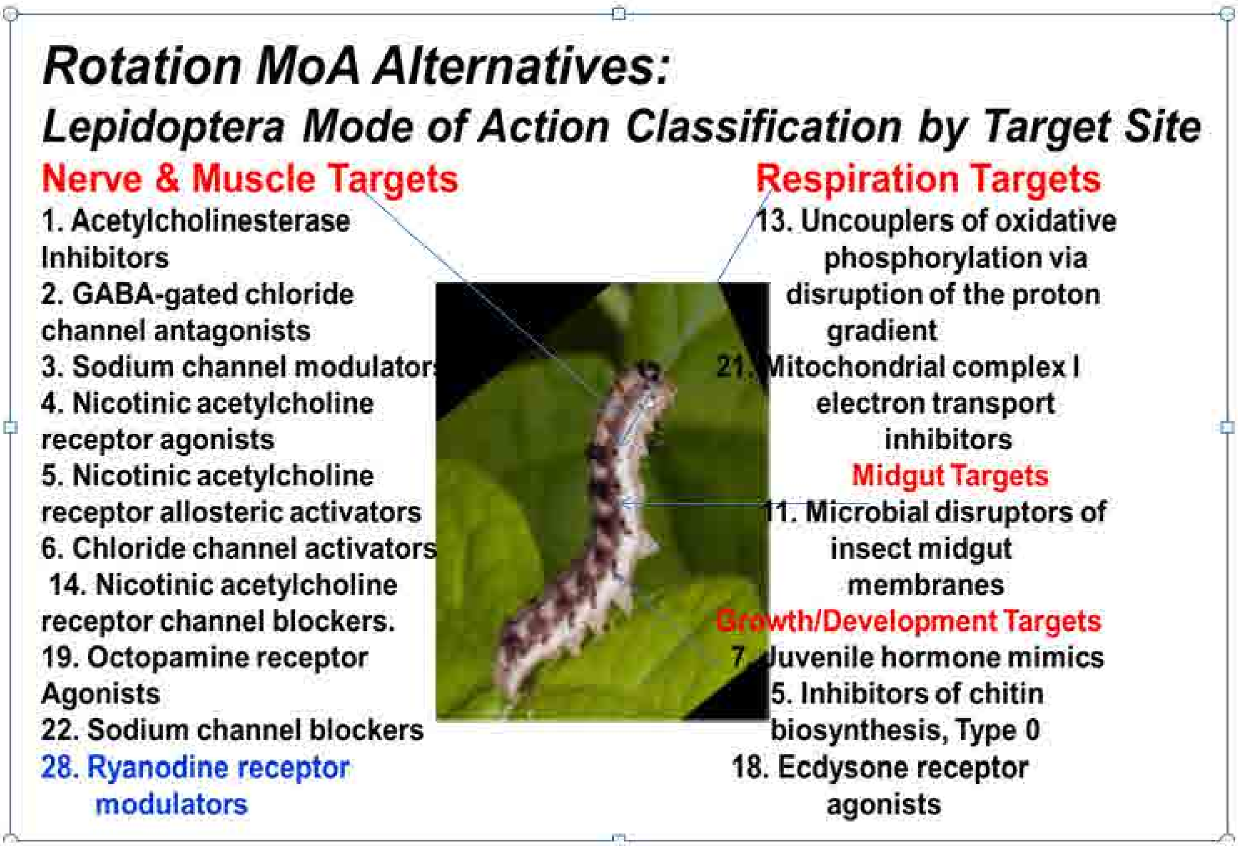
*Table 4.1 Abbreviations for Formulations*

| | | | | | |
|---|---|---|---|---|---|
| A | = | Aerosol | M | = | Microencapsulated |
| AF | = | Aqueous flowable | MTF | = | Multiple temperature formulation |
| AS | = | Aqueous solution or aqueous suspension | P | = | Pellets |
| B | = | Bait | PS | = | Pellets |
| C | = | Concentrate | RTU | = | Ready-to-use |
| CM | = | Concentrate mixture | S | = | Solution |
| CG | = | Concentrate granules | SD | = | Soluble dust |
| D | = | Dust | SG | = | Soluble granule |
| DF | = | Dry flowables | SP | = | Soluble powder or soluble packet |
| DS | = | Soluble dust | ULV | = | Ultra low volume |
| E | = | Emulsifiable concentrate | ULW | = | Ultra low weight or ultra low wettable |
| EC | = | Emulsifiable concentrate | W | = | Wettable powder |
| F | = | Flowable (liquid) | WDG | = | Water-dispersible granules |
| G | = | Granules | WP | = | Wettable powder |
| GL | = | Gel | WS | = | Water soluble |
| L | = | Liquid (flowable) | WSG | = | Water-soluble granules |
| LC | = | Liquid concentrate or low concentrate | WSL | = | Water-soluble liquid |
| LV | = | Low volatile | WSP | = | Water-soluble powder or water-soluble packet |

**Combination (New Type)**

- ZC - A mixed formulation of CS and SC
- ZE -A mixed heterogeneous formulation of CS and SE
- ZW A mixed heterogeneous formulation CS and EW
- SC - Soluble concentrate
- CS - Capsule Suspension
- SE - Suspo-emulsion
- EW - Emulsion (Oil in Water)

Available insecticides are allocated to specific groups, based on their target site, as described by using sequences or alternations of insecticides from different MoA classes




**NERVE AND MUSCLE TARGETS**

**Group 1 Acetylcholinesterase (AChE) inhibitors**

- Inhibit AChE, causing hyperexcitation. AChE is the enzyme that terminates the action of the excitatory neurotransmitter acetylcholine at nerve synapses.
- Carbamates (e.g. Methomyl, Thiodicarb)
- Organophosphates (e.g.Chlorpyrifos)

**Group 2 GABA-gated chloride channel antagonists**

- Block the GABA-activated chloride channel, causing hyperexcitation and convulsions.
- GABA is the major inhibitory neurotransmitter in insects.
- Cyclodiene Organochlorines (e.g. Endosulfan)
- Phenylpyrazoles (e.g. Fipronil)

**Group 3 Sodium channel modulators**

- Keep sodium channels open, causing hyperexcitation and, in some cases, nerve block.
- Sodium channels are involved in the propagation of action potentials along nerve axons. Pyrethrins, Pyrethroids (e.g. Cypermethrin, Lambda-Cyhalothrin

**Group 4 Nicotinic acetylcholine receptor (nAChR) agonists**

- Mimic the agonist action of acetylcholine at nAChRs, causing hyperexcitation.
- Acetylcholine is the major excitatory neurotransmitter in the insect central nervous system.
- Neonicotinoids (e.g. Acetamiprid, Thiacloprid, Thiamethoxam)

**Group 5 Nicotinic acetylcholine receptor (nAChR) allosteric modulators**

- Allosterically activate nAChRs, causing hyperexcitation of the nervous system.
- Acetylcholine is the major excitatory neurotransmitter in the insect central nervous system.
- Spinosyns (e.g. Spinosad, Spinetoram)

**Group 6 Chloride channel activators**

- Allosterically activate glutamate-gated chloride channels (GluCls), causing paralysis.
- Glutamate is an important inhibitory neurotransmitter in insects.
- Avermectins, Milbemycins (e.g. Abamectin, Emamectin Benzoate)

**Group 7 Juvenile hormone mimics**

- Applied in the pre-metamorphic instar, these compounds disrupt and prevent metamorphosis
- Juvenile hormone analogues (e.g. Fenoxycarb)

**Group 14 Nicotinic acetylcholine receptor (nAChR) blockers**

- Block the nAChR ion channel, resulting in nervous system block and paralysis.
- Acetylcholine is the major excitatory neurotransmitter in the insect central nervous system. E.G.Bensultap, Cartap

**Group 15 Inhibitors of chitin biosynthesis**

- Incompletely defined mode of action leading to inhibition of chitin biosynthesis.
- Benzoyl ureas (eg. Flufenoxuron, Lufenuron, Novaluron)

**Anthranilic Diamides**

- Chlorantraniliprole is a new compound belonging to a new class of selective insecticides (Anthranilic diamides) featuring a novel mode of action (group 28 in the IRAC classification).
- Extensively tested in the field since 2002, it is registered or next to market introduction in the majority of agricultural countries Worldwide.
- In India it was first introduced in September 2008 at Hyderabad

**Chlorantraniliprole a Novel Insecticide - Acts At The Ryanodine Receptor (Belonging to group 28 MoA)**

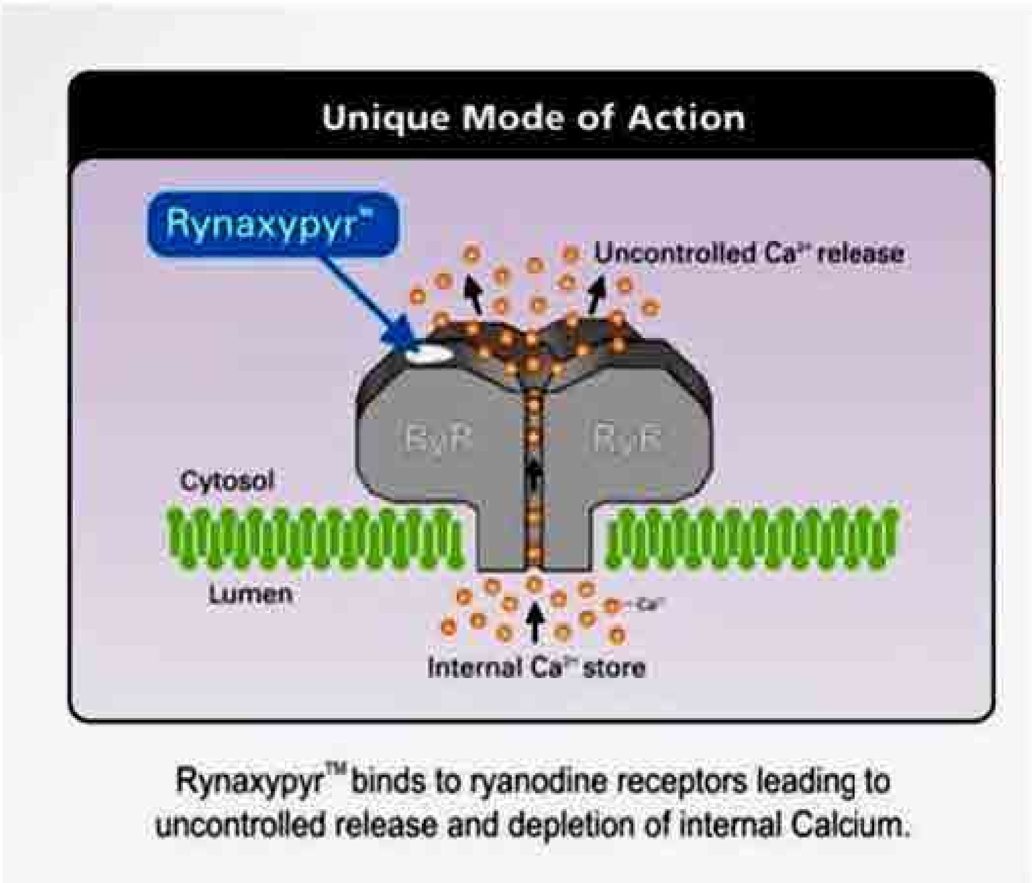
**Ryanodine Receptors**

- **Ryanodine receptors (RyRs)** form a class of intracellular calcium channels in various forms of excitable animal tissue like muscles and neurons.
- **Ryanodine receptors** mediate the release of calcium ions from the sarcoplasmic reticulum, an essential step in muscle contraction.

  **Ryanodine** is an alkaloid found in the South American plant (*Flacourtiaceae*) originally used as an insecticide.

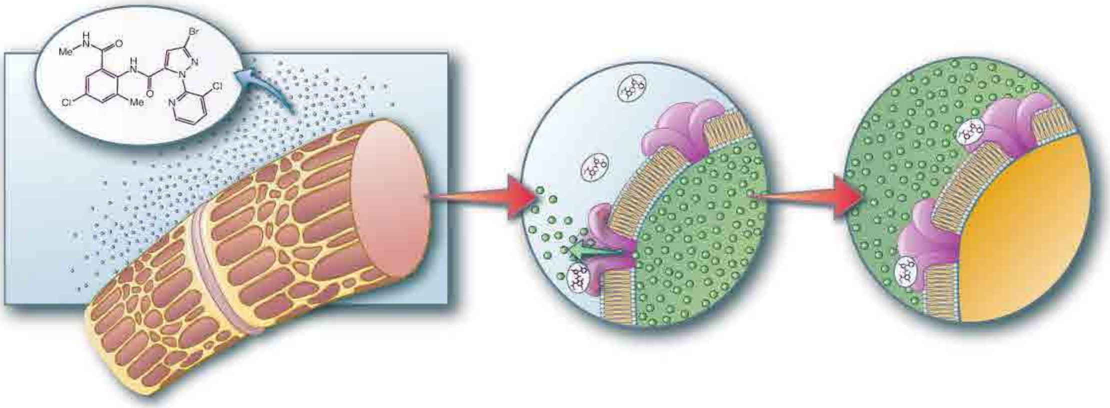
**Ryanodine Receptors**

- Calcium channel
- Regulates release of stored calcium.
- Ryanodine locks the RyR partially open (like a doorstop)
- Critical for muscle contraction
- Diamides are inactive against cells that don't express RyRs
- Activate muscle ryanodine receptors, leading to contraction and paralysis. Ryanodine receptors mediate calcium release into the cytoplasm from intracellular stores.
- Diamides (e.g. Chlorantraniliprole, Flubendiamide)




Rynaxypyr™ binds to ryanodine receptors leading to uncontrolled release and depletion of internal Calcium.

| Phase 1 | Phase 2 | Phase 3 |
|---|---|---|
| Insect comes in contact or ingests diamide. | Chlorantraniliprole binds to the ryanodine receptors located in the insect's muscle, and activates them. | Calcium floods out of the open receptors. As stored calcium is needed for contraction, muscles become paralyzed. |



**Chlorantraniliprole - Behaviour on Field**

- **Chlorantraniliprole** - is a Broad Spectrum Insecticde
- Excellent activity against wide range of insects belonging to different orders covering 80 genera and more than 100 species across wide range of crops
- Long Duration of Lepidopteran Pest Control
- Excellent Translaminar and Systemic Action
- Excellent Rainfastness

**Effect of Chlorantraniliprole on Beneficial organisms**

- Chlorantraniliprole has an excellent profile of safety to beneficial arthropods, pollinators and non-target organisms such as earthworms and soil microorganisms.
- The product effects on honeybees have been studied extensively, demonstrating low intrinsic toxicity of chlorantraniliprole
- This is an important differentiating feature compared to most synthetic pyrethroid, organo-phosphate and neonicotinoid insecticides that are currently used.
- Earthworm acute LC50; >1000 mg a.i./kg
- Honeybee acute (48-h) LD50 (oral) :>114 µga.i./bee

**Novaluron**

- Novaluron is a new pesticide chemical belonging to the class of insecticides called insect growth regulators (IGR).
- IGRs slowly kill the insects over a period of few days by disrupting the normal growth and development of immature insects.
- Novaluron acts as an insecticide mainly by ingestion, but has some contact activity.
- IGR insecticides are comparatively safer to beneficial insects and environment and is compatible for use in an integrated pest management system.

**Spinetoram**

- Fermentation product of *Saccharopolyspora spinosa,* and an analogue of spinosad, a spinosyn
- Spinetoram controls or suppresses Lepidoptera larvae (e.g., worms, caterpillars)
- Foliar spray applications can be made by aerial, ground or chemigation application on all crops as needed for insect control.
- Its mode of action is disruption of nicotinic/Gamma Amino Butyric Acid (GABA)-gated chloride channels.

**Emamectin benzoate**

- Stomach Poison ingested by larvae to be most effective. To be sprayed. This molecule acts if swallowed and has some contact action. It penetrates leaf tissues (translaminar activity) and forms a reservoir within the leaf.
- The mechanism of action is unique in the panorama of insecticides. In fact, it inhibits muscle contraction, causing a continuous flow of chlorine ions in the GABA and H-Glutamate receptor sites.
- Emamectin is widely used in the US and Canada as an insecticide because of its chloride channel activation propertiesEmamectin, produced by the bacterium *Streptomyces avermitilis,* belongs to the avermectin family of compounds all of which exhibit toxicity for nematodes, arthropods, and several other pests.
- The benzoate salt of emamectin in particular has found widespread use as an insecticide.
- The low-application rate of the active ingredient needed (~6 g/acre) and broad-spectrum applicability as an insecticide has gained emamectin significant popularity among farmers

**Flubendiamide**

- Flubendiamide is the first representative of a new chemical insecticide classes - the diamides.
- In contrast to other insecticide classes targeting the insect nervous system, Flubendiamide acts at receptors in insect muscles causing an immediate cessation of feeding and thus avoids crop damage.
- It is well suited for the control of a broad range of Lepidoptera pests.
- The unique mode of action makes the compound well suited as a tool in insect resistance management programmes.
- In contrast to most commercially successful insecticides which act on the nervous system, Flubendiamide disrupts proper muscle function in insects and therefore represents a novel, unique mode of action.

- These characteristic symptoms are induced by Flubendiamide through the activation of ryanodine sensitive intracellular calcium release channels (ryanodine receptors, RyR) as shown by $Ca^{2+}$ fluorescence measurements in insect neurons as well as in recombinant cells expressing the cloned ryanodine receptor from Drosophila melanogaster.
- Insecticide Resistance Action Committee (IRAC) Classification No. 28

**Cyantraniliprole 19.8% + Thiamethoxam 19.8% F.S.**

- It delivers superior results in a variety of climatic conditions – even under high pest pressure.
- It is designed to optimize the grower's pest control experience, offering best-in-class early season insect protection while promoting improved crop establishment, leading to better yields.
- Applied as a seed treatment, is quickly taken up by the roots and moves upward in the plant through the xylem system, controlling a broad range of above ground insects.
- The product is also distributed into the soil around the root zone forming a bulb of protection against below ground insects.
- It is a soil systemic product. Insects are controlled mainly by ingestion but some contact activity is also observed. It provides excellent crop protection resulting from a rapid feeding inhibition and long lasting residual effect
- Best-in-class early-season insect control, both above and below the ground.
- Long-lasting residual effect.
- Dual mode of action with no known cross-resistance.
- Strong root uptake and highly systemic in the xylem.
- Help manage insect resistance to chemicals and GM traits.
- Robust database of more than 1,000 seed treatment field trials across the globe.
- Liquid formulations that are specifically designed for seed treatment.
- Safe to seeds, rhizobium, selective for beneficial arthropods.
- Efficient movement around and within the plant.
- Maximizes return on investment via excellent crop establishment, resulting in greater yield potential.

# NEW GENERATION HERBICIDES AND THEIR FIELD USAGE IN AGRICULTURE

**Dr. G. Prabukumar, Assistant Professor (Agronomy), Krishi Vigyan Kendra, Vamban – 622 303.**

---

Weed management in crop lands was almost entirely a manual farm operation. The use of herbicides or weed control was limited to some major crops. Due to labour scarcity and increase in cost of weeding, herbicides become popular. Low dose high potency herbicides are now available for broad spectrum weed control in food grain, horticulture and plantation crops.

**Merits**

- Herbicide can be recommended for adverse soil and climatic conditions, as manual weeding is highly impossible during monsoon season.
- Herbicide can control weeds even before they emerge from the soil so that crops can germinate and grow in completely weed-free environment at early stages. It is usually not possible with physical weed control.
- Weeds, which resemble like crop in vegetative phase, may escape in manual weeding. However, these weeds are controlled by herbicides.
- Herbicide is highly suitable for broadcasted and closely spaced crops.
- Controls the weeds without any injury to the root system of the associated standing crop especially in plantation crops like Tea and Coffee.
- Reduces the need for pre- planting tillage
- Controls many perennial weed species
- Herbicides control the weed in the field itself or in-situ controlling whereas mechanical method may lead to dispersal of weed species through seed
- It is profitable where labour is scarce and expensive
- Suited for minimum tillage concept
- Highly economical

**Demerits**

- Pollutes the environment
- Affects the soil microbes if the dose exceeds
- Herbicide causes drift effect to the adjoining field
- It requires certain amount of minimum technical knowledge for calibration
- Leaves residual effects
- Some herbicide is highly costlier
- Suitable herbicides are not available for mixed and inter-cropping system.

**Recommendations**

**Rice**

| Herbicide | Weed species | Dosage /ha | | Dilution in water (L) | Waiting period (days) |
|---|---|---|---|---|---|
| | | a.i. (g,kg) | Formulation (g,kg,ml,L) | | |
| Anilofos 30% EC (transplanted rice) (pre-em, early (pre-em, early post-em, 3-5 DAT) | *Echinochloa crus-galli, Echinochloa colonum, Cyperus difformis, Cyperus iria, Eclipta alba, Ischaemum rugosum, Fimbristylis* sp., *Marsilea quadrifolia* | 0.3-0.45 kg | 1.5 l | 375-500 | 30 |
| Anilophos 2% Gr (transplanted rice) (pre-em, early post-em,) | *Echinochloa crus-galli, Echinochloa colonum, Ischaemum rugosum, Cyperus iria, Cyperus difformis, Fimbristylis* s p. | 0.4-0.5 kg | 20-25 kg | - | 30 |
| Azimsulfuron 50% DF (transplanted rice) (20 DAT) | *Echinochloa colonum, E. crus-galli, Cyperus* s pp., *Fimbristylis miliacea, Ludwigia parviflora, Eclipta alba, Bergia capensis, Marsilea quadrifolia, Ammannia baccifera, Sphenoclea zeylanica* | 35 g | 70 g | 300 | 59 |
| Bensulfuronmethyl 60% DF (transplanted rice) (pre-em 3 DAT) | *Marsilea quadrifolia, Eclipta alba, Ammannia baccifera, Ludwigia parviflora, Sphenoclea zeylanica, Monochoria vaginalis, Alternanthera sessilis, Cyperus iria, Cyperus difformis, Fimbristylis miliacea, Scirpus roylei* | 60 g | 100 g | 300 | 88 |
| Bensulfuronmethyl 60% DF (transplanted rice) (post-em 20 DAT) | *Marsilea quadrifolia, Eclipta alba, Ammannia baccifera, Ludwigia parviflora, Sphenoclea zeylanica, Monochoria vaginalis, Alternanthera sessilis, Cyperus iria, Cyperus differmis, Fimbristylis miliacea, Scirpus roylei* | 60 g | 100 g | 300 | 71 |
| Bispyribac-sodium 10% SC rice (nursery) | *Echinochloa crus-galli, Echinochloa colonum* | 20 g | 200 ml | 300 | - |

| | | | | | |
|---|---|---|---|---|---|
| Bispyribac-sodium 10% SC (transplanted rice) | *Ischaemum rugosum, Cyperus difformis, Cyperus iria* | 20 g | 200 ml | 300 | 78 |
| Bispyribac-sodium 10 % SC (direct seeded rice) 20 DAS | *Fimbristylis miliacea, Eclipta alba, Ludwigia parviflora, Monochoria vaginalis, Alternanthera philoxeroides, Sphenoclcea zeylani ca* | 20 g | 200 ml | 300 | 78 |
| Butachlor 50% EC (tra nsplanted rice) (pre-em, 1-3 DAT) | *Cyperus difformis, Cyperus iria, Echinochlo a crus-galli, Echinochloa colona, Eleusine indica, Eclipta alba, Fimbristylis miliacea, Ludwigia parviflora, Sphenoclea zeylanica* | 1.25-2.0kg | 2.5-4 l | 250-500 | 90-120 |
| Butachlor 5% Gr | *Cyperus difformis, Cyperus iria, Echinochloa crus-galli, Echinochloa colona, Eleusine indica, Eclipta alba, Fimbristylis miliacea, Ludwigia purviflora, Sphenoclea zeylanica* | 1.25-2.0 kg | 25-40 kg | - | 90-120 |
| Butachlor 50% EW (transplanted rice) Pre-em, 3-4 DAT | *Echinochloa colonum, Echinochloa crus-galli, Cyperus difformis, Cyperus iria, Eclipta alba, Fimbristylis miliacea Ludwigia parviflora, Sphenoclea zeylanica Monochoria vaginalis* | 1.25-1.5 kg | 2.5-3.0 l | 250-500 | - |
| Chlorimuron-ethyl 25% WP (transplanted rice) (post-em, 2-6 leaf stage of weed) | *Echinochloa crus-galli, Eclipta alba, Commelina benghalensis, Chenopodium album, Cyperus rotundus, Echinochloa colona* | 6 g | 24 g | 500-600 | 60 |
| Cinmethylin 10% EC (transplanted rice) | *Cyperus ir ia, Fimbristylis milac ea, Monochoria vaginalis, Commelina benghalens is, Echinocloa crus-g a lli, Marsilea minut a* | 75-100 g | 0.75-1.0 l | 500-700 | 110 |
| Clomazone 5 0%EC (transplanted rice) | *Echinochloa crus-gall i, Echinochloa colonum , Cyperus difformi s, Cyperus iria, Ludwigia parviflora, Eclipta alb a* | 0.4 - 0.5 kg | 0.8-1.0 l | 500-750 | 90 |
| Cyhalofop-butyl 10% EC (direct seeded rice) | *Echinochloa* spp. | 75-80 g | 0.75-0.80 l | 500-600 | 90 |
| 2,4-D ethyl ester 38% EC (having 2,4-D acid 34% w/w) (transplanted rice) | *Echinochloa colona, Echinochloa crus-galli* | 0.85 kg | 2.5 l | 400 | - |

| | | | | | |
|---|---|---|---|---|---|
| 2,4-D ethyl ester 4.5% Gr (having 2,4-D acid 4% w/w) (transplanted rice) | *Echinochloa Colona, Echinochloa crus-galli, Panicum ischaemum, Cynodon dactylon* (germinating), *Cyperus rotundus* (germinating), *Cyperus iria, Cyperus difformis, Ludwigia parviflora, Monochoria vaginalis, Marsilea quadrifolia Cyanotis cucullata, Eclipta alba, Ammannia baccifera* | 1.0 kg | 25 kg | - | - |
| Ethoxysulfuron 15% WDG (transplanted rice) (10-15 DAT) | *Fimbristylis miliacea, Cyperus iria, Cyperus difformis, Scirpus* sp., *Eclipta alba, Marsilea quadrifolia, Ammannia baccifera, Monochoria vaginalis* | 12.5-15 g | 83.3-100 g | 500 | 110 |
| Fenoxaprop-Pethyl 9.3% w/w EC (9% w/v) (transplanted rice) (25-30 DAT) | *Echinochloa crus-galli, Echinochloa colona* | 56.25 g | 625 mL (10-15 DAT) | 300-375 | 70 |
| Fenoxaprop-P-ethyl 6.7% w/w EC (transplanted and direct-seeded rice) (25-30 DAT) | *Echinochloa* sp | 56.6-60.38 g | 812.5-875 mL | 375-500 | 61 |
| MCPA, amine salt 40% WSC (transplanted rice) (post-em) | *Cyperus rotundus, Ipomoea reptans , Ammannia baccife ra, Lippia nodiflor a, Alternanthera* sp ., *Ludwigia parviflor a , Marsilea quadrifolia* | 0.8-2.0 kg | 2-5 kg | 400-600 | - |
| Metsulfuronmethyl 20% WP (transplanted rice) (post-em, 25-35 DAT) | *Cyperus rotundus, Sphenochlea* spp ., *Fimbristylis* sp., *Ludwigia parviflora, Marsilea quadrifolia* | 4 g | 20 g | 500-600 | 60 |
| Metsulfuronmethyl 20% WG (transplanted rice) (post-em, 25-35 DAT) | *Monochoria vaginalis, Ludwigia parviflora, Ludwigia adscenden s, Marsilea quadrifolia, Eclipta alba, Oxalis minima, Dopatrium junceum, Commelina benghalensis, Ammannia baccifera, Sphenoclea zeylanica, Caesulia axillaris* | 4 g | 20 g | 500-600 + surfactant (Iso-octyl phenoxyl poloxet hanol 12.5%) @ 0.2% | 71 |

| | | | | | |
|---|---|---|---|---|---|
| Orthosulfamuron 50% WG (transplanted rice) (pre-em, post-em, 3 DAT) | *Echinochloa* spp., *Cyperus* spp., *Scirpus* spp., *Ludwigia parviflora, Fimbristylis Rotala* spp. spp | 60-75 g | 120-150 g | 500 | 65 |
| Oxadiargyl 80% WP (transplanted rice) (pre-em, 0-5 DAS) | *Echinochloa crus-galli, Echinochloa Colona, Cyperus iria, Cyperus difformis, Eclipta alba, Ludwigia quadrifolia* | 100 g | 0.125 kg | 500 | 97 |
| Oxadiargyl 6% EC (transplanted rice) (pre-em, 0-5 DAT) | *Echinochloa crus-galli, Echinochloa colona* | 100 g | 1.66 L | 500 | 97 |
| Oxadiazon 25% EC (transplanted rice) (pre-em) | *Echinochloa crus-gal li, Echinochloa colona, Cyperus iria, Cyperus difformis, Marsilea quadrifolia, Eclipta alba, Ludwigia* sp | 0.5 kg | 2.0 L | 500 | - |
| Oxyflourfen 0.35% Gr (direct-sown puddled or transplanted rice) | *Echinochloa* sp. *Cyperus difformis, Cyperus iria, Eclipta alba, Ludwigia parviflora, Fimbristlylis miliacea, Marsilea* spp. | 100-150 g | 30-40 kg | - | - |
| Oxyflourfen 23.5% E (direct-sown rice as pre-em) | *Echinochloa* sp., *Cyperus iria, Eclipta alba* | 150-240 g | 650-1000 mL | 500 | - |
| Pendimethalin 30% EC (transplanted and direct-sown upland rice (pre-em, 6-7 DAT) | *Echinochloa colona, Echinochloa crus-galli, Fimbristylis miliace, Marsilea quadrifolia, Alternanthera sessilis, Ammannia baccifera, Ludwigia parviflora, Eclipta alba, Cyperus difformis* | light to heavy soil: 1.0-1.5 kg | 3.3 –5.0 L | 500-700 | - |
| Pendimethalin 5% Gr (direct sown puddled or transplanted rice) | *Echinochloa colona, Fimbristylis miliacea, Marsilea quadrifolia, Alternanthera sessili s, Ammannia baccife ra, Ludwigia parviflora , Eclipta al ba, Cyperus difformis* | 1.0-1.5 kg | 20-30 kg | - | - |
| Pretilachlor 37% EW (tr ansplanted rice) (pre-em, 3-7 DAT) | *Echinochloa crus-galli, Echinochloa colona, Cyperus difformis, Cyperus iria, Digitaria sa n guinalis, Fimbristylis miliacea , LEucldipwtiag aial b paa,rviflora, Monochoria vaginalis* | 0.60-0.75 kg | 1.5-1.875 L | 500 | 90 |
| Pretilachlor 30.7% EC (direct-sown puddled rice) | *Echinochloa crus-galli, Echinochloa colona, Cyperus difformis, Cyperus iria* | 0.45-0.60 kg | 1.5-2.0 L | 500 | 110 |

| | | | | | |
|---|---|---|---|---|---|
| Pretilachlor 50% EC (transplanted rice) (pre-em, 3-7 DAT) | *Echinochloa crus-galli, Echinochloa colona, Cyperus difformis, Cyperus iria, Fimbristylis miliacea, Eclipta alba, Ludwigia parviflora, Monochoria vaginalis, Leptochloa chinensis, Panicum repens* | 0.50-0.75 kg | 1.0 -1.5 L | 500- 700 | 75-90 |
| Paraquat dichloride 24% SL [pre-plant (minimum tillage) before sowing/ transplanting rice for controlling standing weeds] | *Echinochloa crus-galli, Cyperus iria, Ageratum conyzoides, Commelina benghalensis, Marsilea quadrifolia, Brachiaria muti ca* | 0.3-0.8 kg | 1.25-3.5 L | 500 | - |
| Pyrazosulfuronethyl 10% WP (transplanted rice) (8-10 DAT) | *Cyperus ir ia, Cyperus difformi s, Fimbristylis miliacea , LMuodnwoicghioar piaa rvvaigflionraali s,* | 10-15 g | 100-150 g | 500-600 | 95 |
| Anilofos 24% +2,4-D ethyl ester 32% EC (transplanted rice) | *Echinochloa crus-galli, Echinochloa colona, Ischaemum rugosum, Fimbristylis miliacea* | (0.24+ 0.32) to (0.36 + 0.48) kg | 1-1.5 L | 300 | 90 |
| Bensulfuronmethyl 0.6% + Pretilachl or 6% Gr (transplanted rice) (0-3 DAT) | *Echinochloa crus-galli, Echinochloa colona, Cynodon dactylon, Cyperus iria, Cyperus difformis, Cyperus rotundus, Fimbristylis miliacea, Ludwigia parviflora, Marselia quadrifolia, Enhydra fluctuans, Sphenoclea zeylanica, Eclipta alba, Ammannia baccifera* | 60 + 600 g | 10 kg | - | 88 |
| Clomazone 20% + 2,4-D ethyl ester 30% EC (transplanted rice) | *Echinochloa colona, Echinochloa crus-galli, Cyperus iria, Cyperus difformis, Eclipta alba, Leptochloa chinensis, Panicum repens, Fimbristylis miliacea, Marsilea quadrifolia, Ludwigia parviflor a* | 0.250 kg -0.375 | 1.25 L | 500 | 100-110 |
| Metsulfuronmethyl 10% + Chlorimuron-ethyl 10% WP (transplanted rice) | *Cyperus ir ia, Cyperus difform is, Fimbristlylis miliace a, Eclipta alba, Ludwigia parviflor a, CMyoannoocthiso raixai lvlaagriisn ,alis, Marsilea quadrifolia* | 4 g | 20 g | 300 | 90 |

**Maize**

| Herbicide | Weed species | Dosage /ha | | Dilution in water(L) | Waiting period (days) |
|---|---|---|---|---|---|
| | | a.i. (g,kg) | Formulation (g,kg,ml,L) | | |
| Alachlor 50% EC (0-3 DAS) | *Echinochloa colona, Euphorbia hirta, Eleusine indica, Amaranths viridis, Digitaria* spp., *Echinochloa*spp., *Euphorbia hirta, Phyllanthus niruri, Portulaca oleracea, Trianthema portulacastrum* | 2.5 kg | 5 L | 250 -500 | 120-1 50 |
| Alachlor 10% Gr | *Digitaria* spp., *Echinochloa* spp., *Chenopodium album* | 1.5-2.5 kg | 15-25 kg | - | - |
| Atrazine 50% WP (early post-em, (0-3 DAS) | *TDriigaenrtah aarmvaen msi osn, ogyna,* *Echinochloa* spp ., *Eleusine* spp ., *Xanthium strumarium, Brachiaria* sp., *Digitaria* sp., *Amaranthus viridis , Cleome viscosa, Polygonum* spp. | 0.5-1.0 kg | 1-2 kg | 500-700 | - |
| 2,4-D dimethyl a mine salt 58% SL (pre-em, post-em) | *Trianthema monogyna, Amaranthus* sp., *Tribulus terristris, Boerhavia diffusa, Euphorbia hirta, Portulaca oleracea, Cyperus* sp. | 0. 5 kg | 0.86 L | 400-500 | 50-60 |
| 2,4-D sodium salt technical (having 2,4-D a cid 80% w/w)Earlier registered as 80 % WP) (pre-em, post-em) | *Amaranthus viridis, Trianthema portulacastrum Phyllanthus niruri, Euphobia geniculata, Amaranthus spinosus, Cleome chelidonii, Lagascea mollis* | 1.00 kg | 1.25 kg | 500 | 120<br>90 (post-em)<br>(pre-em) |

| | | | | | |
|---|---|---|---|---|---|
| 2,4-D ethyl ester 38% EC (having 2,4-D acid 34% w/w) (pre-em, post-em) | *Trianthema monogyna, Amaranthus* sp., *Portulaca oleracea, Tribulus terrestris, Boerhavia diffusa, Euphorbia hirta, Cyperus* sp. | 0.9 kg | 2.65 L | 400-450 | 50-60 |
| Diuron 80% WP (pre-em, post-em) | *Cyperus iria, Echinochloa* spp, *Digitaria* spp., *Chenopodium album, Eleusine* sp., *Amaranthus* sp., *Phyllanthus niruri* | 0.8 kg | 1.0 kg | 600 | - |
| Paraquat dichloride 24% SL [pre-plant (minimum tillage) before sow ing] | *Cyperus rotundus, Commelina benghalensis, Trianthema monogyna , Amaranthus* sp., *E chinochloa* sp., | 0.2-0.5 kg | 0.8-2.0 L | 500 | 90-120 |
| Paraq uat (post-em directed inter row application at 2-3 leaf stage of weeds) | *Cyperus iria, Cyperus rotundu s, Commelina benghalensi s, Amaranthus* s p., *Echinochloa* sp ., *Trianthema monogyna* | 0.2-0.5 kg | 0.8-2.0 L | 500 | 90-120 |

**Sugarcane**

| Herbicide | Weed species | Dosage /ha | | Dilution in water(L) | Waiting period (days) |
|---|---|---|---|---|---|
| | | a.i. (g,kg) | Formulation (g,kg,ml,L) | | |
| 2,4-D dimethyl amine salt 58% SL (pre-em, post-em) | *Cyperus iria, Digitaria* sp., *Dactyloctenium aegyptium, Digera arvensis, Portulaca oleracea, Commelina benghalensis, Convolvulus arvensis* | 3.5 kg | 6.3 L | 500 | - |

| | | | | | |
|---|---|---|---|---|---|
| 2,4-D sodium salt technical (having 2,4-D acid 80% w/w) (earlier registered as 80%WP) (pre-em, post-em) | *Boerhavia diffusa, Chenopodium album, Tribulus terrestris, Portulaca oleracea, Xanthium* spp., *Convolvulus arvensis, Amaranthus spinosus, Digera arvensis, Celosia argentea* | 2.0-2.6 kg | 2. 5-3.25 kg | 600 -900 | 300 |
| 2,4-D ethyl ester 38% EC (having 2,4-D acid 34% w/w) (pre-em, post-em) | *Cyperus iria, Digitaria* sp., *Dactyloctenium aegyptium, Digera arvensis, Portulaca oleracea, Commelina benghalensis, Amaranthus* sp., *Convolvulus arvensis* | 1.2 to 1.8 kg | 3.53- 5. 29 L | 500 | 300-330 |
| Diuron 80% WP (pre-em) | *Cyperus iria, Portulaca oleracea, E*sp*ch*pi*.n*, *oAcmhloaara cnrtuhsu-gsa* s *lpli*,p *C.,yanotis Convolvulus* spp., *Digitaria* spp. | 1.6-3.2 kg | 2.0-4.0 kg | 600 | - |
| Metribuzin 70% W P (early post-em 3-5 DAP or postem, 20-25 Days after planting) | *Cyperus esculentus, Amaranthus viridis, Portulaca oleracea, Parthenium hysterophorus, Trianthema* sp., *Cleome viscosa, Solanum* sp., *Com melina benghalensis, Euphorbia* sp., *Digera* sp. | 6 kg | 30 kg | 500-600 + (non-ionic surfactant Iso-octyl phenoxylpo loxeth anol 12.5% @ 2mL per liter of spray volume (0.2%) | 346 |

**Groundnut**

| Herbicide | Weed species | Dosage /ha | | Dilution in water(L) | Waiting period (days) |
|---|---|---|---|---|---|
| | | a.i. (g,kg) | Formulation (g,kg,ml,L) | | |
| Alachlor 50% EC (Pre emer) | *Ac Flaveria australasica anthosermum hispidum* | 1.5-2.5 kg | 3-5 L | 250-500 | 20-150 |
| Alachlor 10% Gr (Pre em) | *Digitaria* spp., *Echinochloa* spp., *Chenopodium album* | 1.5-2.5 kg | 15-25 kg | - | - |
| Imazethapyr 10% SL | *Cyperus difformis, Commelina benghalensis, Trianthema portulacastrum, Eragrostis pilosa* | 100-150 g | 1.0-1.5 L | 500-700 | 90 |
| Oxyfluorfen 23.5% E C | *Echinochloa colona, Digitaria marginata* | 100-200 g | 42 5-850 mL | 500 -750 | - |
| Quizalofop-ethyl 5% EC (Post em) | *Echinochloa colona, Dinebra retroflexa, Dactyloctenium* sp. | 37.5-50.0 g | 750-1000 mL | 500 | 89 |

**Sesamum**

| Herbicide | Weed species | Dosage /ha | | Dilution in water(L) | Waiting period (days) |
|---|---|---|---|---|---|
| | | a.i. (g,kg) | Formulation (g,kg,mL,L) | | |
| **Pendimethalin 30% EC** (0-3 DAS) | *Digiteria sanguinalis, Echinochola crus-galli, Chenopodium* sp., *Argemone mexicana, Amaranthus spinosus, Portulaca* sp. | 0.75-1.00 kg | 2.5-3.0 L | 400-600 | - |

**Blackgram**

| Herbicide | Weed species | Dosage /ha a.i. (g,kg) | Dosage /ha Formulation (g,kg,ml,L) | Dilution in water (L) | Waiting period (days) |
|---|---|---|---|---|---|
| **Alachlor 50% EC** (0-3 DAS) | *Cynodon dactylon*, *Echinochloa* spp., *Digitaria* spp., *Cyperus rotundus*, | 2.0-2.5 kg | 4-5 L | 250-500 | - |
| **Fenoxaprop-P-ethyl 9.3% w/w EC (9% w/v)** (post-em) (15-20 DAS) | *Echinochloa crus-galli*, *Echinochloa colona*, *Digitaria* sp., *Dactyloctenium aegyptium* | 56.25-67.5 g | 625-750 mL (15-20 DAS) | 375-500 | 43 |
| **Pendimethalin 30% EC** (0-3 DAS) | *Digiteria sanguinalis*, *Echinochola crus-galli*, *Chenopodium* sp., *Argemone mexicana*, *Amaranthus spinosus*, *Portulaca* sp. | 0.75-1.00 kg | 2.5-3.0 L | 400-600 | - |
| **Propaquizafop 10% EC** (post-em) | *Echinochloa colona*, *Echinochola crus-galli*, *Digitaria sanguinalis*, *Dactyloctenium aegyptium*, *Eleusine indica* | 75-100 g | 750-1000 mL | 500-750 | 21 |
| **Quizalofop-ethyl 5% EC** (post-em) | *Eleusine indica*, *Dactyloctenium aegyptium*, *Digitaria sanguinalis*, *Eragrostis* sp., *Paspalidium* sp., *Echinochloa* sp., *Dinebra retroflexa* | 37.5-50.0 g | 750-1000 mL | 500 | 52 |

# NEW GENERATION FUNGICIDES AND THEIR FIELD USAGE IN AGRICULTURE

**Vijayasamundeeswari, A.[1], N. Revathy[2] and A. Subbiah[3]**

[1] Assistant Professor (Plant Pathology), Department of Crop Protection, Agricultural College & Research Institute, Kudumiyanmalai
[2]Associate Professor (Plant Pathology), Department of Crop Protection, Agricultural College & Research Institute, Kudumiyanmalai
[3] Assistant Professor (Horticulture), Grapes Research Station, Anaimalayanpatty, Theni dt

---

Diseases are biotic agents which commonly occur in plants impairing the growth and development resulting in a significant economic impact on yield and quality. Plants are affected by a number of plant pathogenic (disease-causing) organisms including fungi, bacteria, virus, viroids and phytoplasma. In this fungi are considered the number one cause of crop loss Worldwide. Hence, disease management becomes an essential component of crop production. Fungicides play a vital role in disease management as (a) satisfactory control can be visualized by the stakeholder (b) cultural practices often do not provide adequate disease control when the climatic conditions are conducive and if the pathogen is virulent causing severe disease (c) resistant cultivars are not available for all the diseases or many instances the stakeholders are reluctant to accept the genuineness of the product and (d) certain high value crops have an extremely low tolerance for disease incidence. Broadly, there are three main reasons for the success of the fungicides amongst other methods of disease management

a) Control a disease during the establishment and development of a crop.
b) Increases productivity of a crop and to reduce the symptoms like spots, lesions and blemishes which affect photosynthesis in the leaves, the edible part of the crop, the appeal and attractiveness in ornamentals, etc. In all the cases, affect the market value of the crop.
c) To improve the storage life and quality of harvested plants and produce. Some of the greatest disease losses occur post-harvest

**Fungicides are of two types based on the mobility in a plant**

**Systemic fungicide**

A systemic fungicide is defined as fungitoxic compound that controls a fungal pathogen remote from the point of application, and that can be detected and identified at that point. Any compound capable of absorbed and freely translocated after penetrating the plant is called systemic or penetrants or mobile fungicides.

**Contact fungicide**

Contact fungicides (also called protectants) remain on the surface of plants and are suited for preventive or prophylactic use as they work by mere contact action when applied on the surface of the plant. Repeated applications are needed to protect new growth of the plant and to replace material that has been washed off by rain or irrigation, or degraded by environmental factors such as sunlight. Many contacts are potentially phytotoxic if absorbed by the plant tissues.

**Overview of Fungicide Development and Usage**

The first fungicide usage was the result of keen and continuous observations where in the use of salt water for brining of grain followed by liming was done practiced to control bunt that took place in the middle of the 17$^{th}$ century. This had occurred long before Tillet (1755) established that seed-borne fungi (*Tilletia tritici, T. laevis*) caused bunt of wheat and that it could be controlled by seed treatments of lime, or lime and salt. Another important discovery was made in France in 1882 by Millardet, who noticed that grape vines that had been sprayed with a bluish-white mixture of Copper sulphate and lime to deter pilferers retained their leaves through the season, whereas the unsprayed vines lost their leaves. Thereafter, until the 1940s chemical disease control relied upon inorganic chemical preparations, frequently prepared by the user from basic recipes. Prior to the introduction of the dithiocarbamates, most of the products used as fungicides were applied at high rates, e.g., 10 to 20 kg a.i./ha (~9 to 18 lbs/acre) for Sulfur against powdery mildew on grapes. The products did not always give good control, could be phytotoxic and had to be applied frequently. Also the concerns for the fungicides' impact on the environment were minimal.

The fungicides introduced between 1940 and 1970 were proprietary brand products used by farmers who did not want to take the time and trouble to make their own. Further beyond 1970, more important modern fungicides listed in Table 4 according to their mode of action or chemical class were manufactured by different chemical industries. Hence, over time there was a drastic reduction in usage rates per ha (acre) as more effective and selective fungicides were introduced. For example, the current use rates of well below 100 g/ha for many triazoles against the same pathogen is a 200 fold reduction.

The inclination towards more intensive cropping, the introduction of high yielding varieties, the neglect of proper crop rotation and minimum tillage or direct seeding without any plouging have led to new diseases in major crops cultivated. Such changes in crop varieties and in cultivation methods keep the disease status very dynamic, constantly warranting new methods and active ingredients to deploy successful disease management.

**Table 1. Major fungicide groups introduced since 1970 with their most important representatives**

| Group | Year | Common name of compounds | Main spectrum / uses |
|---|---|---|---|
| Inhibitors of sterol biosynthesis (triazoles if not indicated otherwise) | 1973 | Triadimefon imazalil (imidazole) | broad post harvest & seed |
| | 1975 | Fenarimol (pyrimidine) | powdery mildew |
| | 1977 | Triadimenol prochloraz (imidazole) | seed treatment cereal fungicide |
| | 1979 | Propiconazole, bitertanol fenpropimorph (morpholine) | broad broad / cereals |
| | 1982 | triflumizole | broad |
| | 1983 | Flutriafol, diniconazole, fluzilazole, penconazole | broad |
| | 1986 | Fenpropidin (morpholine) hexaconazole, cyproconazole, myclobutanil, pyrifenox (pyridine) tebuconazole | broad / cereals<br>broad<br>broad / leaf crops<br>broad, foliar & seed |
| | 1988 | Difenoconazole tetraconazole, fenbuconazole | broad, foliar & seed broad |
| | 1990 | Epoxiconazole | broad / cereals |
| | 1992 | Metconazole, fluquinconazole triticonazole | broad<br>broad, foliar & seed |
| | 2002 | Prothioconazole | broad |
| Inhibitors of cytochrome bc1 (Qo site & strobilurin analogues if not indicated otherwise) | 1992 | Azoxystrobin kresoxim-methyl | broad cereal fungicide |
| | 1996 | Famoxadone (azolone) | oomycetes |
| | 1998 | Fenamidone (azolone) trifloxystrobin | oomycetes<br>broad |
| | 2000 | Picoxstrobin pyraclostrobin, fluoxastrobin | cereal fungicide<br>broad |
| | 2001 | Cyazofamid (Qi site of action, cyanoimidazole) | Oomycetes |

| Other classes, various fungicides and plant activators | Common names with year of introduction | Uses uses |
|---|---|---|
| Dicarboximides | Iprodione 1974, vinclozolin 1975, procymidione 1976 | Botrytis, Monilinia |
| Phenylamides | Metalaxyl 1977, Benalaxyl 1981, Oxadixyl 1983, Mefenoxam 1996 | Oomycetes |
| Phenylpyrroles | Fenpiclonil 1990, Fludioxonil 1990 | broad foliar and seed |
| Anilinopyrimidies | Pyrimethanil 1992, Cyprodinil 1994 | broad |
| Melanin synthesis | Tricyclazole 1975, Pyroquilone 1985, Carpropamide 1997 | rice / water and foliar |
| CAA fungidices* | Dimethomorph 1988, Iprovalicarb 1998, Benthiavalicarb 2003, Mandipropamid 2005 | Oomycetes |
| Defense activators | Probenazole 1979, Acibenzolar-S.methyl 1996 | Fungi, bacteria, viruses |
| Various | Cymoxanil 1976, Fosetyl-Al 1977, Propamocarb 1978, | Oomycetes |
| | Carbendazim 1976, Fluazinam 1992 | broad |
| | Quinoxyfen 1997 | powdery mildew |

* carboxylic acid amides

**Brief notes on the key classes of modern fungicides are as follows:**

i) **Benzimidazole** fungicides: were introduced for plant disease control in the 1960s and early 1970s as foliar fungicides, seed treatments and for use in post harvest applications. They possessed unique properties not seen before in the protectants. These included low use rates, broad spectrum and systemicity with post-infection action that allowed for extended spray interval. The reason for the rapid development of resistance was that these fungicides were single site inhibitors of fungal microtubule assembly during mitosis, via tubulin-benzimidazole-interactions. The current ranking of global sales is: Carbendazim, Thiophanate, Thiabendazole.

ii) **Morpholine** fungicides are best known for their excellent control of cereal diseases, powdery mildew on vegetables and grapes, and sigatoka of banana. These fungicides are referred to as Sterol Biosynthesis Inhibitors (SBI). During the 1980s key patents were held by BASF for Calixin (tridemorph) and Corbel (fenpropimorph) and Dr. R. Maag for Corbel (tridemorph). Dimethomorph, though a morpholine, is quite distinct from the morpholines above with its activity against Oomycetes via the inhibition of cell wall formation (FRAC group 40 in Table 5). The current ranking of global sales is: dimethomorph, fenpropidin, fenpropimorph, sprioxamine.

iii) **Triazoles** are the largest class of fungicides and Bayer was the first to launch a triazole, namely triadimefon (Bayleton) in 1973 followed by triadimenol (Baytan) and bitertanol (Baycor). Propiconazole (Tilt) was launched in 1979 by Ciba-Geigy. Numerous other triazoles have been launched since, with Bayer's most recent entrée being prothiaconazole (Proline) in 2004. The reason for the longevity of this class of fungicides is that while being highly efficient broad spectrum products, resistance has occurred over time as a slow shift resulting in a decreased sensitivity to their mode of action as De-Methylation Inhibitors (DMI). The current ranking of global sales is: tebuconazole, epoxiconazole, propiconazole, difenoconazole, flusilazole, tetraconazole, fluquinconazole, flutriafol.

iv) **Anilides** are a diverse group of fungicides for example the earliest seed treatment chemical carboxin (Vitavax) is highly effective on bunts, smuts and assorted Basidiomycetes such as *Rhizoctonia spp.* This was followed by the dicarboximides iprodione (Rovral) from Rhone-Poulenc, vinclozolin (Ronilan) from BASF and procymidone (Sumisclex) from Sumitomo. These fungicides all had exceptional protectant activity on the genera *Botrytis, Monilinia* and *Sclerotinia.* Combating resistance became an issue with the wide scale use of these fungicides.

Unquestionably the greatest of this group of anilides were the **phenylamide fungicides** metalaxyl (Apron/ Ridomil) from Ciba–Geigy and benalaxyl (Galben) from Isagro. These, along with phosphonate fosetyl-Al (Aliette) from Rhone-Poulenc, which was also introduced in 1977, brought a completely new level of control to the Oomycetes through their systemic properties by offering protection to the plants as seed treatments, and soil or foliar applications. Syngenta in 1996 with mefenoxam (Apron XL and Ridomil Gold) and Isagro (2005) with kiralaxyl have introduced the resolved isomers of metalaxyl and benalaxyl. Again, what has limited the use of the phenylamide fungicides has been the development of resistance, even though the manufacturers tried introducing combinations with protectant fungicides such as mancozeb and chlorothalonil.

The anilide to be registered in 2003 is boscalid (Emerald, Endura, Pristine) from BASF. Boscalid is registered for foliar use on a wide range of vegetables, fruits and nut crops, either alone or in a mixture with pyraclostrobin as Pristine.

**v) Star Fungicides – a Fascinating Group of Fungicides**

- STAR **(Strobilurin Type Action and Resistance) are** fungicides which include the **Strobilurins** – azoxystrobin, dimoxystrobin, enestroburin, fluoxastrobin, kresoxim-methyl, metaminostrobin, orysastrobin, picostrobin, pyraclostrobin, and trifloxystrobin
- **Non-strobilurin** – famoxadone, fenamidone and pyribencarb with similar mode of action

**Strobilurins** group of fungicides are extracted from the fungus *Strobilurus tenacellus* (mushroom) and were launched in 1996 represents a novel group of fungicides. They are now the second largest chemistry group of fungicides as a result of widespread use on cereals. They acts as QoIs (Quinol oxidation inhibitor) and inhibit the respiratory chain at the level of Complex III. They are highly active against a broad range of fungi belonging to Oomycetes, Ascomycetes, Basidiomycetes and Deuteromycetes.

Zeneca began researching this chemistry in the early 1980s, first synthesizing azoxystrobin (Amistar, Abound, Quadris) in 1988; it is now the largest selling member of this group. However, kresoxim-methyl (Cygnus, Sovran) from BASF was the first member to be commercialized in 1996. BASF has since entered the market (2002) with a broader spectrum strobilurin pyraclostrobin (Cabrio, Headline, Insignia) also sold in combination with kresoxim-methyl as Opera and with boscalid as Pristine. Other strobilurin fungicides include, trifloxystrobin (Flint) sold by Bayer, and fluoxastrobin (Disarm, Evito) sold by Arysta. The current ranking of global sales is: azoxystrobin, pyraclostrobin, trifloxystrobin, kresoxim-methyl, picoxystrobin.

**Main advantages of the strobilurins are**

- Novel mode of action with broad spectrum activity
- High activity against the major groups of fungal disease
- Activity on a wide range of crops
- Systemic action with outstanding preventive activity
- Excellent safety and environmental profile

Disease resistance have been reported in these fungicides due to extensive usage as a result, companies are developing mixtures and other uses, including seed treatments with these fungicides.

**Table 2. Fungicides with strobilurins type of action**

| Trade name | Active ingredient | Manufacturer/ Marketer |
|---|---|---|
| ***Solo Products*** | | |
| Abound™ 2.08F | Azoxystrobin | Syngenta |
| Amistar™ 80WG | Azoxystrobin | Syngenta |
| Heritage™ 50WG | Azoxystrobin | Syngenta |
| Quadris™2.08SC | Azoxystrobin | Syngenta |
| Reason™ 500SC | Fenamidone | Bayer |

| | | |
|---|---|---|
| Disarm™ 480SC<br>Evito™ 480SC | Fluoxastrobin | Arysta |
| Cygnus™ 50WG | Kresoxim methyl | BASF |
| Sovran™ 50WG | Kresoxim methyl | BASF |
| Cabrio™ 20EG | Pyraclostrobin | BASF |
| Headline™ 2.08EC | Pyraclostrobin | BASF |
| Insignia™ 20WG | Pyraclostrobin | BASF |
| Compass™ 50WG | Trifloxystrobin | Bayer |
| Flint™ 50WG | Trifloxystrobin | Bayer |
| Gem™ 500SC | Trifloxystrobin | Bayer |
| ***Premixes*** | | |
| Tanos™ 50DF | Famoxadone ($Q_oI$) + cymoxanil | Dupont |
| Pristine™ 38WDG | Pyraclostrobin ($Q_oI$) + boscalid | BASF |
| Stratego™ 2.08EC | Trifloxystrobin ($Q_oI$) + propiconazole | Bayer |
| Uniform™ 2.09EC | Azoxystrobin ($Q_oI$) + mefanoxam | Syngenta |
| Quilt™ 1.67SC | Azoxystrobin ($Q_oI$) + propiconazole | Syngenta |
| Quadris Opti™ | Azoxystrobin ($Q_oI$) + chlorothalonil | Syngenta |

**Other Systemic Fungicides** include a diverse group of products, such as: tricyclazole (Beam) launched in 1975 by Eli Lily/Dow and still widely used for control of rice blast; cymoxanil (Curzate), a downy mildewcide from DuPont; the cereal and fruit fungicide cyprodinil (Vanguard, Unix) from Syngenta; fludioxonil (Saphire, Switch, Maxim) from Syngenta; and quinoxyfen (Fortress, Quintec), a powdery mildewcide from Dow.

**Table 3. Mode of action of major fungicides classes, their Fungicide Resistance Action Committee (FRAC) code and resistance risk.**

| FRAC Code | Chemical Class | Mode of action / inhibition | Resistance risk |
|---|---|---|---|
| 1 | Benzimidazoles | Beta-tubulin biosynthesis | high |
| 2 | Dicarboximides | NADH cytochrome c reductase in lipids | high |
| 3 | Azoles, Pyrimidines | C-14 demethylation in sterol biosynthesis | medium |
| 4 | Phenylamides | RNA polymerase | high |
| 5 | Morpholines | ^8 and ^7 isomerase and ^14 reductase in sterol biosynthesis | low-medium |
| 7 | Carboxamides | Succinic acid oxidation | medium |
| 9 | Anilinopyrimidine | Methionine biosynthesis | medium |
| 11 | Strobilurins | Mitochondrial synthesis in cytochrome bc1 | high |
| 16 | Various chemistry | Melanin biosynthesis (two sites) | medium |
| 40 | Carboxylic acid amides | Cell wall formation in Oomycetes | low-medium |
| M1 | Inorganics | Multisite contact | low |
| M3 | Dithiocarbamates | Multisite contact | low |
| M5 | Phthalimides | Multisite contact | low |

**Table 4. New generation fungicides- FRAC classification (Leadbeater, 2012)**

| Mode of action | Group | Examples | Disease/Pathogen controlled |
|---|---|---|---|
| Complex III inhibitors | Strobilurins and Other complex III inhibitors | Azoxystrobin, Pyraclostrobin, Famaxadone | Downy mildew, Powdery mildew, Rust, Scab, blight, Blast |
| Succinate dehydrogenase (complex II) inhibitors | Anilides and Pyridinyl-Ethyl Benzamide | Boscalids, Penthiopyrad | *Rhizoctonia* spp |
| NADH inhibitors (complex I) | Aminoalkylpyrimidines | Diflumetorim | Rose Powdery mildew, Chrysanthemum white rust |
| Uncouplers of Oxidative Phosphorylation | Dinitro phenol, Arylhydrazins, Diarylamines | Meptyldinocap, Drazoxolin, Fluazinam | Powdery mildew, *Pyricularia oryzae* |
| Signal transduction inhibitors | Phenylpyrroles and Dicarboximides | Fludioxinil | Botrytis cinerea |
| Cell division inhibitors | Benzamides | Zoxamide and Pencycuron | Late blight, Downy mildew, *Rhizoctonia* spp |
| SBI | SBI class I, II, III | class I -Triazoles (Tetraconazole, Epoxiconazole, Triticonazole, Simeconazole) class II- Amines (Spiroxamine) class III- Hydroxyanilides (Fenhexamide) | class I and II - Powdery mildew and rust Fenhexamide - Botrytis, Monilinia and Sclerotinia |
| Nucleic acid inhibitors | Phenylamide | Metalaxyl - M | Oomycetes |

Other newer active ingredients introduced are benthiavalicarb (Valbon from Kumiai) and mandipropamid (Revus from Syngenta), from the Carboxylic Acid Amide (CAA) fungicide group, and fluopicolide (Infinito from Bayer), metrafenone (Flexity from BASF), proquinazid (Talius from DuPont), and zoxamide (Electis from Dow). For a more detailed technical description of modern fungicides, including chemistry, we refer to the treatise edited by Krämer and Schirmer (2007).

One of the most novel new products introduced by Ciba-Geigy is acibenzolar-S-methyl (Actigard, Bion). At use rates of 30 g/ha or less, it activates the host's Systemic Acquired Resistance (SAR) process in many crop plants. It offers broad protection against fungi, bacteria and viruses without having any direct activity on these pathogens (Leadbeater and Staub, 2007). Actigard has performed best when incorporated into a program of chemical sprays, as the inherent level of disease control has seldom been sufficient when applied alone. This product has initiated a whole new field of research into utilizing peptides for controlling diseases, and other means of stimulating SAR and the Jasmonic Acid pathway (JA) with chemicals and biological agents in plants.

# IMPORTANCE OF BIO-PESTICIDES USAGE AND LIST OF BIO PESTICIDES AVAILABLE IN MARKET AVAILABILITY

**Dr.Raja. Ramesh** and **Dr. M.Gunasekaran**
**National Pulses Research Centre,**
**Tamil Nadu Agricultural University, Vamban – 622 303, Pudukkottai District**

---

The global population is projected to reach 8.5 billion by 2030, 9.7 billion by 2050 and exceed 11 billion in 2100 (UN World Population Prospects, 2011). In order to feed the growing population with limited land, getting higher yield is of paramount importance in agriculture. But pest comprises of invertebrates, pathogens and weeds are estimated to cause losses between 27 and 42 per cent in production for major crops around the World, if crop protection is not properly followed it would rise to 48–83%. Therefore, in order to meet the growing food demand, about 15 –20 times increase in the use of synthetic pesticides will be required to contain pest damage (Oerke, 2006). For over a century, chemical control of insect pests is a common practice in Indian Agriculture. The farmers have relied heavily on the use of chemical pesticides to protect their crop to increase crop production, which is now causing negative impact on the human health and environment. Though the chemical pesticides are effective, what concerns over the use of synthetic pesticides is their effect on soil and water and presence of residue in food products and also responsible for causing resistance development in pathogens and insects as well as adverse impacts on natural enemies and humans (Birch *et al.*, 2011).

Biopesticides are derived from microorganisms and other natural sources, that control pests by nontoxic mechanisms and are an eco-friendly alternative to the synthetic pesticides. The problem in using biopesticides is the mindset of farmers, who reluctant to use because of high cost, no practical knowledge and doubt in effectiveness of bio-pesticides. The first widely used biopesticide included spores of the bacteria *Bacillus thuringiensis* (Bt) isolated from a diseased silkworm by Japanese biologist Shigetane Ishiwata in 1901. Presently, biopesticides cover only 2% of the plant protectants used globally; however, its growth rate shows an increasing trend in past two decades.

As of 2017, over 200 products based on entomopathogenic fungi (*Beauveria bassiana, B.brongniartii, Metarhizium anisopliae, Lecanicillium lecanii* and *Hirsutella thompsonii*) and nematicidal fungi (*Purpureocillium lilacinum* and *Pochonia chlamydosporia*) are registered for use against various arthropods and plant parasitic nematodes. As far as bacteria is concerned, over 30 products based on *Bacillus thuringiensis* (*Bt*) subsp. *kurstaki* are registered against bollworms, loopers and other lepidopterans. Two viruses are registered, namely *Helicoverpa armigera* nucleopolyhedrovirus (22 products) and *Spodoptera litura* nucleopolyhedrovirus (5 products) for use against bollworms and armyworms.

**Area under Cultivation and under Use of Chemical & Bio- Pesticides**

**Area in '000 hectare**

| Year | Cultivation Area | Pesticides | | | |
|---|---|---|---|---|---|
| | | Chemical | Bio. | Both chem & bio. | Total |
| 2014-15 | 96628 | 53141 | **5405** | 9836 | **68382** |
| 2015-16 | 126957 | 69058 | **6478** | 10180 | **85717** |
| 2016-17 | 120798 | 71645 | **7267** | 25125 | **104037** |
| 2017-18 | 132011 | 82189 | **7738** | 10268 | **100195** |
| 2018-19 | 167499 | 87957 | **14636** | 31799 | **134391** |

**Source:** States/UTs Zonal Conferences on Inputs (Plant Protection).

Due to increase in demands of consumer for residue free agricultural produce has resulted in the lesser use of synthetic pesticides. Hence, there is need to switch for more environmentally safe and ecologically sound pest control methods such as bioagents or biopesticides. In India, as on 2005 biopesticides accounted 2.89 percent, up from the merely 0.2 percent during 2000 of the overall pesticide markets and it increased every year. It is clearly seen from the above table that area under biopesticides comprise 5.59 per cent in 2014-15 and in 2018-19 it was as high as 8.74 percent of cultivated area India.

Botanicals play important role in plant protection in Indian agriculture from time immemorial. Among the botanicals, neem is regarded as the most effective, ecofriendly and widely used plant products for the management of pests. Neem products are effective against more than 350 species of arthropods, 12 species of nematodes, 15 species of fungi, three viruses, two species of snails and one crustace and species. The other plants extract like garlic, onion, chillies, turmeric, ginger, tobacco, papaya, pongam, tulasi, aloe, custard apple, vitex, sweetflag, calotropis *etc* are also used in India.

**Advantages of biopesticides**

- Safety: Harmless and environmental safety.
- Target specificity: It affects only one specific pest or, in some cases, a few target organisms.
- Biodegradability: Decompose quickly, thereby resulting in lower exposures and largely avoiding the pollution problems
- Suitability: Highly suitable for Integrated Pest Management (IPM) programs.

| Sl. No. | Crop | Insects | Dosage (ml/lit/g/kg) (ha) |
|---|---|---|---|
| **Azadirachtin 0.030% (300 ppm)** | | | |
| 1. | Cotton | Aphids, Bollworms | 2.5 – 5 |
| 2. | Rice | Leaf roller, Stem borer, Brown plant hopper | 2 |
| 3. | Bhendi | Fruit borer, White flies, Leaf hopper | 2.5 – 5 |
| 4. | Brinjal | Shoot & fruit borer, Beetles | 2.5 – 5 |
| **Azadirachtin 0.15% (1500 ppm)** | | | |
| 1. | Rice | Thrips, Stem borer, Leaf folder,Brown plant opper, | 1.5-2.5 |
| 2. | Cotton | White fly, Bollworms | 2.5 |
| **Azadirachtin 0.3% (3000 ppm)** | | | |
| 1. | Cotton | American Bollworms | 4 |
| **Azadirachtin 1% (10000 ppm)** | | | |
| 1. | Tomato | Fruit borer *(Helicoverpa armigera)* | 1-1.5 |
| 2. | Brinjal | Shoot & fruit borer *(Leucinodes orbonalis)* | 1-1.5 |
| **Azadirachtin 5% (50000 ppm)** | | | |
| 1. | Rice | Brown plant hopper, Leaf folder, Stem borer | 200 |
| 2. | Cotton | White fly, Leaf hoppers, Aphid,*Helicoverpa armigera*, | 375 |
| 3. | Bhindi | Leafhopper, whitefly, Aphid, Pod borer | 200 |
| 4. | Tomato | Aphids, Whitefly, Fruit borer | 200 |
| ***Bacillus thuringiensis* var. *kurstaki* 0.5% WP** | | | |
| 1. | Pigeon pea | Bollworm *(Helicoverpa armigera)* | 1-1.25 |
| 2. | Caster | Semilooper *(Achaea janata)* | 0.25-0.375 |
| ***Bacillus thuringiensis* var. *kurstaki* 2.5% AS** | | | |
| 1. | Gram | Gram pod borer *(Helicoverpa armigera)* | 1-1.5 |
| 2. | Rice | Stem borer & Leaf folder | 1.5 |
| 3. | Pigeon Pea | *Helicoverpa armigera* | 0.75 |
| 4. | Cabbage, Cauliflower | Diamond back moth | 0.5 |
| ***Beauveria bassiana* 1.0% WP** | | | |
| 1. | Gram | Gram pod borer *(Helicoverpa armigera)* | 3 |
| 2. | Okra | Fruit borer, Spotted bollworm | 3.75-5 |
| ***Beauveria bassiana* 1.15% WP** | | | |
| 1. | Rice | Leaf folder *(Cnaphalocrosis medinalis)* | 2.5 |
| 2. | Cotton | Bollworms | 400 |
| 3. | Cabbage | Diamond back moth *(Plutella xylostella)* | 1-1.5 |

| | | | |
|---|---|---|---|
| ***Beauveria bassiana* 5% WP** | | | |
| 1. | Cabbage | Diamond back moth *(Plutella xylostella)* | 2 |
| ***Beauveria bassiana* 5% SC** | | | |
| 2. | Tomato | Fruit borer *(Helicoverpa armigera)* | 500 |
| ***Metarhizium anisopliae* 1.15% WP** | | | |
| 1. | Rice | Brown plant hopper *(Nilapavata lungens)* | 2.5 |
| 2. | Coconut | Rhinoceros beetle | 2.5 |
| ***Metarhizium anisopliae* 1% WP** | | | |
| 1. | Brinjal | Shoot & Fruit borer *(Leucinodes orbonalis)* | 2.5-5 |
| ***Verticillium lecanii* 1.15%WP** | | | |
| 1. | Cotton | White flies | 2.5 |
| 2. | Citrus | Mealybug (*Planococcus citri*) | 2.5 |
| ***Verticillium lecanii* 1.50% Liquid Formulation** | | | |
| 1. | Tomato | White fly (*Bemisia tabaci*) | 2.0 |
| ***Verticillium lecanii* 3.0% AS** | | | |
| 1. | Onion | Thrips (*Thrips tabaci*) | 2.0-2.5 |
| ***Verticillium lecanii* 5.0% SC** | | | |
| 1. | Rice | White backed plant hopper *(Sogotella furcifera)* | 3.125 |
| 2. | Cabbage | Diamond Back Moth *(Plutella xylostella)* | 500 |
| **Nuclear Polyhedrosis Virus of *Helicoverpa armigera* 0.43% AS** | | | |
| 1. | Cotton | *Helicoverpa armigera* | 2.7 |
| 2. | Tomato | *Helicoverpa armigera* | 1.5 |
| **Nuclear Polyhedrosis Virus of *Helicoverpa armigera* 2.0% AS** | | | |
| 1. | Pigeon pea | Pod borer (*Helicoverpa armigera*) | 500 |
| 2. | Gram | Pod borer (*Helicoverpa armigera*) | 250-500 |
| 3. | Tomato | Fruit borer (*Helicoverpa armigera)* | 250-500 |

# LIST OF FERTILIZERS OF MACRO, MICRO AND SECONDARY NUTRIENTS AND MIXTURES AVAILABLE IN SOLID AND LIQUID FORMS IN MARKETS

**Mr.M.Uthayakumar, Assistant Director of Agriculture, Kilapavoor, Tenkasi**

---

Fertilizers play a pivotal role in getting higher yield in both Agriculture and Horticulture crops. Looking back at the use of fertilizers in India, it started gaining momentum after green revolution in later part of 1960s and subsequent commissioning of several fertilizer manufacturing plants in 1970s. Fertilizer productivity increased rapidly in the initial period of its usage and started declining in the 21$^{st}$ century due to unbalanced use of fertilizers by farmers. Fertilizers manufacturing started in India in the year 1906 with establishment of SSP plant in Ranipet. Though phosphatic fertilizers were hugely manufactured in pre-independent period, nitrogenous fertilizers took a predominant role in post independent period.

**Market share of macro nutrient fertilizers**

| Sl. No | Type of fertilizers | Share of market in India |
|---|---|---|
| 1 | Urea | 50% |
| 2 | DAP | 19% |
| 3 | NP/NPK | 16% |
| 4 | MOP | 9% |
| 5 | SSP | 5% |
| 6 | Ammonium sulphate / CAN | 1% |

**Market share of all macro nutrient fertilizers in 2017-18 & 2018-19**

**(Lakh Tonnes)**

| Sl.No | Fertilizers | 2017-18 | 2018-19 |
|---|---|---|---|
| A | **Straight N** | | |
| 1 | Ammonium sulphate | 5.73 | 5.6 |
| 2 | Urea | 298.9 | 314.2 |
| 3 | CAN | 100 Kg | 2000 Kg |
| 4 | Ammonium chloride | 0.193 | 0.235 |
| B | **Straight $P_2O_5$** | | |
| 1 | Single Super Phosphate | 34.39 | 35.79 |
| 2 | Rock phosphate | 0.31 | 0.273 |

| | | | |
|---|---|---|---|
| **C** | **Straight $K_2O$** | | |
| 1 | Muriate of Potash | 31.58 | 29.56 |
| 2 | Sulphate of Potash | 0.05 | - |
| **D** | **NP/NPK complexes** | | |
| 1 | 16:20:0:13 | 1.19 | 2.08 |
| 2 | 20:20:0:13 | 32.63 | 34.51 |
| 3 | 20:20:0: | 2.16 | 1.97 |
| 4 | 15:15:15 | 5.10 | 5.69 |
| 5. | 14:35:14 | 3.03 | 3.26 |
| 6 | 18:46:0 | 92.94 | 92.11 |
| 7 | 24:24:0 | 1.97 | 1.98 |
| 8 | 24:24:0:8 | 0.29 | 0.515 |
| 9 | 28:28:0 | 4.85 | 4.97 |
| 10 | 14:28:14 | 0.062 | 0.104 |
| 11 | 19:19:19 | 0.614 | 0.818 |
| 12 | 17:17:17 | 0.786 | 0.410 |
| 13 | 13:33:0:6 | 0.02 | 0.01 |
| 14 | 16:16:16 | 0.783 | 0.143 |
| 15 | 12:32:16 | 12.21 | 13.61 |
| 16 | 10:26:26 | 19.70 | 18.74 |

**Fertilizer Mixtures Notified by Central Government and available in the market**

1. Sufla (15 : 15 : 15)

2. Sufla (20 : 20 : 20)

3. Lakshmi (12 : 12 : 12)

4. Lakshmi (8 : 8 : 8)

5. IFFCCO-1 (10 : 26 : 26)

6. IFFCCO-2 (12 : 32 : 16).

**List of fertilizer mixtures notified by Government of Tamilnadu**

| Mixture No | Analysis | Crop for which recommended |
|---|---|---|
| 2 | 12:6 | Paddy, Ragi, Cotton, Chillies, Tobacco & Vegetables. |
| 2a | 12:6:6 | Fruits |
| 3 | 8-8-16 | Coconut, Tapioca, Arecanut |
| 4 | 6-12-(2-4)-6 | Potato, Paddy, Hybrid Millets & Basal dressing Mixtures |
| 4a | 6-12(2-4)-6 | Potato |
| 5 | 9:9:9 | Paddy, Millets, Vegetables & Basal dressing mixtures. |
| 7 | 4-8(1-6)-12 | Groundnut |
| 9 | 10-0-30 | Banana |
| 10 | 15-5-5 | Sugarcane |
| 12 | 16-0-12 | Top dressing Mixtures |
| 14 | 12-4-12 | Coconut (Sandy loam) |
| 16 | 20-0-10 | Sugarcane (N and K at higher level) |
| 18 | 17:17:17 | Paddy |

## NITROGENOUS FERTILIZERS

**Ammonium sulphate 20.6 % N**

It is white crystalline salt, available as a by-product of caprolactam grey, yellow or red.Commercial form of this product has 20.6 % N, 24 % S. It possesses no problem in handling and storage. It contains powdered material which can cause caking under high humidity.It is suitable for application as basal, top dressing, side dressing. Under highly reduced conditions, it causessulphide injury.And it increases acidity and 110 Kg of Calcium Carbonate offset the acidity of 100 Kg Ammonium sulphate.

Ammonium ions released during hydrolysis of ammonium sulphate is absorbed in exchange complex, so loss is minimized upon application. Sulphate ions after hydrolysis is held in soil strongly than nitrate & chlorides, weakly than phosphates. It increases acidity, and not advocated for acidic soils. It should not mixed with urea or rock phosphate.

Ammonium sulphate is suited for onion, sunflower, safflower & tea and wetland paddy. It is used to increase herbicide efficacy, if water is of poor quality, high in Ca, Mg, and Na.

Application of ammonium sulphate makes more calcium available to plants.

**Ammonium chloride – 26% N**

It is highly soluble in water and has similar physical properties as Ammonium sulphate. But it is more acidic than Ammonium sulphate. 128 Kg $CaCO_3$ is needed to neutralize the acidity caused by 100 Kg Ammonium chloride. Substantial part of application of this fertilizer is lost due to the conversion into Calcium chloride that is highly volatile. This fertilizer is not recommended for Banana, Acid lime, Grapes, Mango, Onions, tobacco, potato and other chloride sensitive crops.

It is suitable for application in soils directly as basal and top dressing. Moreover, it is suitable for saline and alkali soil.

**Calcium Ammonium Nitrate (CAN)- 25% N or 26%N**

Ammonium nitrate diluted with limestone gives Calcium Ammonium Nitrate. Nitrogen is available in both Ammonium and Nitrate form 50% each. It is neutral in reaction. Ammonium nitrate dissolves much faster than calcium carbonate. Calcium carbonate releases calcium over a long time but has no effect on N efficiency. Calcium absorbed on exchange complex, Calcium can neutralize some acidity and also serve as a nutrient. It is suitable for application as basal and top dressing. It can also be used as a source of Calcium nutrition.

CAN is suitable for basal dressing for most upland crops. It is preferred for several fruit crops &mulberry. It is a good source of Nitrogen for moisture stress condition especially in dryland crops due to its better mobility and availability of nitrate component.

It is not suitable for basal dressing in rice.

## PHOSPHATIC FERTILIZERS

**Single Super Phosphate (SSP) – 16% $P_2O_5$**

It is available in the market both in granular and powdered form. Powdered product cakes in storage. It is produced by reacting Monocalcium phosphate and gypsum in equal proportions. 90% of phosphorus is water soluble P and also it has 16% Sulphur. It is suitable for all crops and soils except highly acidic soil. And it is best suited for pre-plant basal application.

It should be applied broadcasting followed by mixing in densely populated crops and drilling, band placement in wide placed crops. SSP,that has 11 % S, must be effective for high Sulphur requiring crops such as oilseeds, and in Sulphur deficient soils.

SSP is least mobile in soil, so it must be placed as close as possible so that plant roots can easily absorb P. It is immobile in fine textured soils, and in moisture stress conditions.

**Rock phosphate - 35% $P_2O_5$, Ca – 35%**

Finely ground rock phosphate is suitable for direct application. It is a slow acting phosphorus fertilizer. It gives best results in acid soil, not suitable for neutral and alkali soil. It is suitable for perennial crops like tea, rubber, coffee, but not suitable for cotton, paddy. It should be applied before sowing crops.

**Di-ammonium phosphate 46 % $P_2O_5$, 18% N**

It is the largest of source of Phosphorous and second largest source of nitrogen after urea. It is suitable for application in all types of soil & crops as pre-plant applications. It is suited for foliar spray as well.It is highly useful in calcareous soils.

**Bone meal – TCP- $Ca_3(PO_4)_2$**

**Raw bone meal**

- 20% total $P_2O_5$
- 8% is citrate soluble
- 3% Nitrogen

**Steamed bone meal**

- More soluble
- 22% $P_2O_5$
- 16% citrate soluble

Citrate soluble Phosphorous present in this fertilizer is slowly soluble in water. Once dissolved and converted to orthophosphate, this fertilizer is subject to same transformation as Single super phosphate. Non citrate soluble P dissolves very slowly as that of rock phosphate.

**Mono ammonium phosphate (MAP) $NH_4H_2PO_4$ - 12:61:0**

Ammonia & Phosphoric acid 1:1 ratio gives MAP. It is 100% water soluble fertilizer. 52% $P_2O_5$ is in citric acid soluble form. Water soluble form of $P_2O_5$ is 44.2%. Salt index of MAP is 30 It is suitable for basal application below soil surface to position phosphate within or near rootzone.

**Ammonium phosphate sulphate (APS)** $(NH_4)_2HPO_4.(NH4)_2\ SO_4$

A mixture of ammonium phosphate and ammonium sulphate. It is suitable for pre-plant application for most soils and crops especially for soils deficient in Sulphur.

1. **20:20:0:13**

20:20:0:13 is a chemical blend of 40 parts of ammonium phosphate and 60 parts of ammonium sulphate. It contains 20% N and 20% $P_2O_5$. The entire N is in ammoniacal form and P is completely water soluble. In addition, it contains 13% sulphur, a secondary plant nutrient which is now attaining great importance in the agricultural scene. It is suitable for application on all soils and all crops.

2. **10:26:26**

10:26:26 is a complex fertiliser containing all the three major plant nutrients viz. Nitrogen, Phosphorous and Potassium. Granular NPK complexes are free flowing and do not pose any problem during handling and storage.However, exposure of material for long period to very high humidity may cause caking.

3. **12:32:16**

This is one of the highest nutrient-containing NPK complex fertilisers with total nutrients of 60%. Nitrogen and Phosphate are available in the ratio 1:2.6 as in the case of DAP, but 12:32:16 also contains 16% additional Potash . Helps the young plants to grow faster, even under adverse soil or climatic conditions. It is suitable for crops that require high phosphorous during initial stage of crop growth.

4. **16:16:16**

It has N, P and K in 1:1:1 ratio and supplies 16% each of nitrogen, phosphate and potash. It ensures availability of N in two forms. It contains 5% of N in Ammoniacal form and 12% in Urea form. It contains 14.5% out of 16% phosphate in water soluble form, which is easily available to crops. All of potash is in water soluble form.

5. **28:28:0**

It is a complex with highest N & P in 1:1 ratio. 19% of Nitrogen is in Urea form and 9% is in Ammoniacal form. 25.2% out of 28% Phosphate is in water soluble form and easily available to plants.. It is an ideal complex fertiliser for all crops for basal application.It is most suitable fertiliser for crops like Paddy, Cotton, Chillies, Sugarcane and Vegetables etc.

6. **15:15:15:10**

A complex universal fertilizer for any soils and crops, most effective when applied for tilled and technical crops – before pre-sowing cultivation or during sowing. It is also a perfect starter fertilizer for spring cereals. The sulphur content ensures high intake of nitrogen and phosphorus by plants, and potassium facilitates faster transport of synthesis products (carbohydrates) to root vegetables and seeds.

7. **14:35:14**

Highest total nutrient content among NPK fertilizers (63%). N & P ratio same as DAP. In addition, 14-35-14 has extra 14% potash.High in Phosphorous content (35%). It is suitable for Cotton, Groundnut, Chilly, Soya bean, Potato. It is not suitable for Tobacco and Grapes.

## POTASSIC FERTILIZERS

**Muriate of potash- 58% $K_2O$**

The colour of this fertilizer varies from white to red color depending on theconcentration of impurities. It is completely soluble in water. As potassium ions are positively charged, it is adsorbed in to soil colloids and hence leaching loss is less. It must be avoided to chloride sensitive crops. Salt index of this fertilizer is 116 and so it contributes to soil salinity.

**Application aspects**

It is suitable for pre-plant basal dressing application. MOP is necessary to high K demanding crops like banana and fruit crops. Foliar application with KCl should generally be avoided. Other K sources are preferred for foliar spray.

**Potassium sulphate – 50% $K_2O$, 18% S**

Potassium sulphate is available as white crystalline salts. It is suitable for all soils and crops. It is preferably used for saline soils and for fruit crops and vegetable which are sensitive to chloride salt.

**Application aspects**

It is less soluble than KCl. Its salt index is 46. It is suitable for salt sensitive crops, flowering crops, ornamental crops, potato, tobacco.It is suited for Sulphur deficient soils.It is suitable for both soil and foliar application. Sulphate of potash contributes to 1% of total $K_2O$ consumption in India.

**Potassium shoenite – $K_2SO_4.MgSO_4\ 6H_2O$** - 23% $K_2O$, MgO – 10%, Sulphur 13.5%

Potassium, Magnesium and Sulphur are in ideal proportion. Sulphur is present in Sulphate form and so it is readily available to plants. It is neutral in reaction.On account of its low salt index, it is suitable for salt sensitive crops like fruits, vegetables, grapevines, Sunflower, Sugarcane, tobacco, forest trees. It improves fruit size, taste, firmness, colour, shine, grain fill, weight, shelf life and general appearance of the produce.

**Consumption of NPK in India**

**('000 tonnes)**

| Sl. No | Year | N | $P_2O_5$ | $K_2O$ |
|---|---|---|---|---|
| 1 | 1950-51 | 55 | 8.8 | 6 |
| 2 | 1970-71 | 1479 | 541 | 236 |
| 3 | 1990-91 | 7997 | 3221 | 1328 |
| 4` | 2000-2001 | 10920 | 4215 | 1568 |
| 5 | 2010-11 | 16558 | 8050 | 3514 |
| 6 | 2018-19 | 17637 | 6910 | 2680 |

## SECONDARY NUTRIENTS

1. **Elemental Sulphur (upto 92% S)**

Sulphur is in elemental Sulphur and it must be converted to sulphate by microbes before becoming available to plants. It is available as both powder and granular form. Granular form is popular. Dispersion and conversion of Sulphur is better than bentonite Sulphur. Conversion of Sulphur to Sulphate is a slow process &takes time. It must be applied well before planting . It is an acid forming and is suited for application in neutral & alkaline soils. If this fertilizer is applied just before planting, additional ready source of Sulphur is needed. Sulphur deficient soils and Sulphur demanding crops need special attention.

2. **Bentonite Sulphur 90% Sulphur**

Elemental Sulphur with some bentonite clay as binding agent gives bentonite sulphur fertilizer. It is easy to apply, dust free, can be used in bulk blends. Sulphur needs to be oxidized to sulphate form, and to be absorbed by plants.Oxidation of Sulphur is acid forming process, Suitable for alkaline soils with calcareousness. Oxidation isa slow process, and it should be applied a few weeks before planting. This fertilizer must be mixed. with surface soil. Soil must be neither too wet nor too dry for microbes to act. After Sulphate is formed, it is strongly held in soil particle than chloride and weaker than phosphate ions.

**Application aspects Elemental Sulphur & Bentonite Sulphur**

It must be applied 4-6 weeks before planting. It must be surface applied and mixed. It leaves residual effect in soil. One application lasts for more than one crop. It is treated as slow-release fertilizer.

3. **Phospho gypsum - $CaSO_4 . 2H_2O$; 20% sulphur**

High grade gypsum containing 96% Gypsum on dry basis.20% Sulphur. It is a by product of wet process of phosphoric acid production. The prefix phosphor indicates phosphoric acid. It does not mean that it is a carrier of phosphorus. When rock phosphate is treated with sulphuric acid, phospho gypsum is produced. For every ton of phosphoric acid, 5 ton ofphospho gypsum is produced

**4. Sulphur containing fertilizers**

| Sl.No | Name of fertilizers | S content (%) |
|---|---|---|
| 1 | Ammonium Sulphate | 24 |
| 2 | Single Super phosphate | 12 |
| 3 | Potassium Sulphate | 18 |
| 4 | Ammonium Phosphate sulphate | 15 |
| 5 | Elemental S products | 80-95 |
| 6 | S fortified Ammonium Phosphate | 15 |
| 7 | Gypsum | 22-23 |

**5. Sulphates of micronutrients**

- Zinc sulphate 15% Sulphur
- Manganese sulphate 17% Sulphur
- Copper sulphate 13% Sulphur
- Ferrous sulphate 19% Sulphur

**6. Calcium & Magnesium containing fertilisers**

| Sl.No | Calcium | Magnesium |
|---|---|---|
| 1 | Calcium sulphate - Gypsum – 22-23 % Ca | Magnesium sulfate (containing 10% Mg and 14% S, also known as Epsom salt) |
| 2 | Superphosphate-20.4% Ca | Sulphate of potash magnesia (containing 11.2% Mg, 22%S, and 22% $K_2O$. commercially sold as K-Mag) |
| 3 | Calcium nitrate-19.4% Ca | Magnesium oxide (containing 55% Mg, also known as magnesia) |
| 4 | Calcium Ammonium Nitrate – 8% Ca | Dolomitic lime-6-12% of Mg |
| 5 | Calcium chloride – 36 % Ca | Magnesium nitrate : 16 %. |

**Dosage of Calcium for important crops**

| Crop | Gypsum |
|---|---|
| Paddy | 400 Kg/Ha |
| Sugarcane | 500 Kg/Ha |
| Pulses | 110 Kg/Ha |
| Groundnut | 400 Kg/Ha |
| Sunflower | 50 Kg/Ha |
| Gingelly | 50 Kg/Ha |

**Dosage of Magnesium**

| Crop | Magnesium sulphate |
|---|---|
| Sugarcane | 25 Kg/Ha |
| Banana | 3 T Dolomite/Ha |
| Mango | 5-10 Kg $MgSO_4$ |
| Coconut | 500 g/tree/yr |
| Oilpalm | 200 g/tree/yr |

7. **Soil conditioners (Calcium, Magnesium and Sulphur)**

There are several fertilizer brands available in the market that contain Calcium, Magnesium and Sulphur. It is said to be sold as soil conditioners. Soil Conditioner Granule (Ca:Mg:S) is made of gypsum. Gypsum is calcium sulfate, a naturally occurring mineral, which is mined from the ground. Chemically it is about 22 - 23% available calcium and 15 - 20% sulfur and other compounds.

a) **20:5:20 (CMS) – Rs. 6.4 per Kg**

Good soil structure is one of the most fundamental ingredients necessary to produce vibrant, healthy plants and lush velvety lawns. The use of this soil conditioner is one of the ways of insuring good soil structure. It is a natural soil conditioner that aids plant and lawn growth by loosening heavy, dense and water impervious clay soils.

It loosens the soil, making it open and porous, water and other nutrients are able to penetrate deeper into the soil, quickly reaching the root systems. Fertilizers are more effective because they can migrate into the loosened soil quickly and can be utilized immediately because of the sulfur. It is suitable for onion crop.

b) **8:8:6 (CMS) –**

The soil strata has been unbalanced due to the extreme usage of chemical fertilizers containing only N, P and K. Farmers hardly make use of secondary and micro nutrients as fertilizers . This results in stunted growth and poor yields of crop as well as poor soil condition. Due to the presence of these elements, it acts as soil conditioner. Because it improves the soil strata by improving the soil structure, ion exchange capacity as well as regulates the pH. Use of this fertilizer gives more number of flowers and fruits. Crops become healthy and there is overall increase in yields.

**Recommendation: 100 Kg Per Ha**

## MICRONUTRIENTS

Green revolution was made possible, among other things, by extensive use of NPK fertilizers. Though NPK fertilizer consumption increased over years, We could not get matching increase in food production.No appreciable increase in food grain production is observed irrespective of increase in quantum of NPK fertilizers usage. Yield Response is almost static over years. Use of micronutrients will enhance NPK efficiency & improve overall yield in all crops.

**Micronutrient fertilizers under FCO**

| Materials | Element/Forms | Content (%) |
|---|---|---|
| Zinc sulphate. | Zn | 21.0 |
| Manganese Sulphate* | Mn | 30.5 |
| Ammonium Molybdate | Mo | 52.0 |
| Borax (For soil application) | B | 10.5 |
| Solubor (Foliar spray) | B | 19.0 |

| | | |
|---|---|---|
| Copper Sulphate* | Cu | 24.0 |
| Ferrous sulfate | Ferrous & Ferric | 19.0 & 0.50 |
| Zinc Sulphate mono-hydrate | Zn | 33.0 |
| ZincPhosphate $Zn_3(PO_4)_2.4H_2O$ | Zn + P | 19.5 |
| Chelated Zn (EDTA form) | Zn | 12.0 |
| Chelated Fe (EDTA form) | Fe | 12.0 |
| Boronated super phosphate | $B+P_2O_5$ | 0.18B +16.0 |
| Zincated urea | Zn+N | 2.0 Zn + 43.0 N |

1. **Borax – Sodium tetra borate – $Na_2B_4O_7$ 10.$H_2O$**

B – 10.5%

Consumption : 12000 M.T

Boron is adsorbed in soil organic matter, some other is available in soil solution. In acidic soils, Boron is more available as boric acid. Boron is not fixed under such condition. In alkaline soils, lime induced boron fixation can occur. Only a small fraction is water soluble and acid soluble Boron is plant available. Boron availability in soil depends upon soil pH, moisture, texture and free carbonates.

**Borax application**

Borax can be applied as foliar spray, and fertigation. Gap between optimum requirement and toxic level of boron is narrow. So, care must be taken to apply right quantum of boron based on requirement of plant. It should be applied once Boron deficiency is confirmed. For Boron deficient soils and crops, 10 - 15 Kg Borax / Ha can be applied as soil application. 0.2 to 0.3% of B is recommended as foliar application.

2. **Boric acid – $H_3BO_3$** Boron – 17%

Boron is available in both solutionand in adsorbed forms. It is the only fertilizer that can be absorbed directly by plant roots. It is sparingly soluble in water. Boric acid is suitable for foliar spray.

3. **Di-Sodium Octa borate tetra hydrate**–$Na_2B_8O_{13}$ 4$H_2O$–20% Boron,

This fertilizer is suited for both soil and foliar application.

It enhances flowering and fruit formation. Increases size, shape and sweetness of the fruits. It reduces fruit cracking, flower and fruit shedding. It improves quality of the produce and increases the yield.

**Dosage:** 0.1 % foliar spray, 2.5 Kg per Ha.

**Application:**

(1) Use during critical growth stage of crop.

(2) Use 2 to 3 times at 15 – 20 days interval before and after flowering and fruit setting stage.

4. **Copper sulphate – $CuSO_4$ 5.$H_2O$–**Cu – 24%, S – 12% Copper sulphate monohydrate – Cu 33%

It is highly water soluble, and it dissociates into $Cu^{2+}$ Cations and $SO_4^{2-}$anions. It is found in soil solution, exchangeable cation, bound to organic matter. It is easily leached from sandy soils. Soil pH, Clay content, organic matter and presence of carbonates affects the transformation of added Copper sulphate behaves like sulphur in Ammonium sulphate. It is suited for soil, foliar, andfertigation.

Copper sulphate is recommended for soil application @ of 3-6 Kg Cu/Ha and is recommended 0.025% as foliar spray.

5. **Ferrous sulphate heptahydrate :** Fe – 19%, S – 10.5%

It dissociates into ferrous ion, sulphate ions upon hydrolysis. Iron sulphate is converted to less soluble form like ferric ion in alkali soil, Calcareous soil. In acidic soils, flooded submerged soil, paddy soils, ferric ion is reduced to ferrous ions. Under highly reduced condition, it is present in toxic level.

**Application of Ferrous sulphate**

Soil application is less effective than foliar application. In soil application, it is easily converted to ferric form which is unavailable to plants. For soil application, 20 – 50 Kg Fe/Ha is recommended. It is recommended as 1 – 3% foliar spray, repeated application for 2 – 3 times.

6. **EDTA – Fe Chelate:** EDTA ($C_{10}$ $H_{16}O_8N_2$)

Fe – 12%

Metal organic complex bound in a ring like structure of EDTA. Fe chelate stays in soil as such. If Fe is released at the root surface, it enters the plant, EDTA stays in soil. Fe – EDTA is effective only in the acidic conditions. It is recommended as 1 – 5 Kg Fe as Fe EDTA for soil application. Fe – EDTA is recommended as 0.1 – 0.2% foliar spray through 500 litres of water for one Ha.

7. **FE EDDHA chelates (Not in FCO):** 6 % Fe with EDDHA, EDDHAS

This fertilizer is recommended as 1 – 2 Kg as Fe EDDHA per Ha. It is suitable for application in soils with all range of pH. It is effective both soil and foliar application

**13% Fe with HEDTA is also available in the market. Fe chelates with DTPA is also available**

8. **Manganese sulphate $MnSO_4$.$H_2O$:** Mn – 30.5%, S – 17%

It is easily water soluble and dissociates into $Mn^{2+}$ and $SO_4^{2-}$ ions. Manganese is available as water soluble, exchangeable, easily reducible (active), complexed/organically bound. It's availability increases with acidity anddecreases with increase in pH and calcareousness. Water soluble Manganese can increase with submergence in soil. When soil dries out after submergence, Manganese availability drops.

**Application of Manganese sulphate**

Manganese is suited for application for both soil and foliar. Foliar application is effective. In upland soils, Manganese is converted to less available form. Manganese sulphate is recommended at the rate of 40 – 50 Kg/Ha in soil and as 0.5 – 1% foliar spray four times.

9. **Ammonium molybdate – $(NH_4)_6 Mo_7O_{24}.4H_2O$ :** Molybdenum – 52%

It dissociates in to ammonium and molybdate ions – $MoO_4^{2-}$ in water. Molybdenum behaves like phosphorus in SSP. Its availability reduces in acidic condition. In such condition, Manganese is fixed as Iron and Aluminum insoluble compounds. But its availability increases with rise in pH.

**Application**

Soil application: 1 – 2 Kg per Ha

Foliar spray: 0.1%

10. **Sodium molybdate ($Na_2MoO_4$) – Mo 46%**

**Recommendation of Sodium molybdate**

| Crops | Quantity /acre |
|---|---|
| Groundnut | 150 g |
| Pulses | 150 g |
| Tomato | 200 g |
| Sunflower | 150 g |
| Banana | 100 g |
| Cabbage | 500 g |
| Guava | 2 g/tree |
| Acid lime | 1.5 g/tree |
| Pomegranate | 5 g/tree |

11. **Zinc sulphate – $ZnSO_4.H_2O$ or $ZnSO_4.7H_2O$**

Zinc sulphate is the first micronutrient fertilizer produced in India. Zinc sulphate heptahydrate – Zn 21%, S – 10%. It is present as water soluble, exchangeable and adsorbed, organically bound, acid soluble in soil.

Zinc is fixed as Zinc oxide/hydroxide/carbonate, Zinc ammonium phosphate depending upon soil pH, redox conditions and ionic environment.Under highly reduced condition, it is fixed as Zinc sulphide. Zinc availability is reduced soils with low organic matter, light texture, alkaline, perennially wet and in soils with heavily fertilized with phosphorus. Liming the soil reduces availability of Zinc.

Soil application is best than foliar spray. Foliar spray of 0.5% with 0.25% lime is recommended. Repeat bi-weekly until deficiency symptoms disappear.

**12. EDTA Zinc chelate:** Zn – 12%

It works well in soils with pH above 6.0, In Acidic soil, EDTA Zn breaks down, losses EDTA to Fe and Mn. Instead of correcting Zinc deficiency, its application in acidic soil aggravates it.

**Application**

Soil application: 1-2 Kg

Foliar application: 0.1 – 0.2%

**13. Combination of 2 Secondary and 6 Micronutrient Including Cobalt** – 250 g pack, Rs. 490

**14. MN mixtures Approved by the Govt of Tamilnadu**

| Mix No. | Crop | Content | | | | | | | Recommendation (Kg/acre) |
|---|---|---|---|---|---|---|---|---|---|
| | | Zn | Mg | Mn | B | Fe | Mo | Cu | |
| 1 | Groundnut | 4.20% | Nil | 1.46% | 1.57% | 3.80% | 0.07% | Nil | 5 |
| 2 | Millets | 2.31% | Nil | 9.15% | .52% | 5.70% | Nil | 1% | 5 |
| 3 | Cotton | 3.15% | Nil | 2.99% | 3.15% | 3.80% | 0.07% | 1.25% | 5 |
| 4 | Coconut | 5% | Nil | 4.80% | 1.6% | 3.80% | Nil | .5% | 1 kg per tree |
| 5 | Citrus | 7.06% | Nil | 4.2% | 0.60% | 2.60% | 0.05% | 2% | 1 kg per 10 trees |
| 6 | Vegetables | 1.68% | Nil | 1.22% | 2.48% | 7.6% | .14% | 1% | 2.5 kg |
| 7 | Pulses | 4% | Nil | 6.1% | 2.1% | 3.80% | .35% | Nil | 2 |
| 8 | Sugarcane | 5.5% | 1.30% | 1.30% | 0.80% | 3% | .1% | 0.10% | 1 (foliar) |
| 9 | Cotton | 2.5% | 4% | 3% | .1% | 2% | .01% | .1% | 1 (foliar) |
| 10 | Paddy | 5% | 6% | 0.50% | 0.05% | 1% | Nil | 0.35% | 1 (foliar) |
| 11 | Paddy | 3% | 4% | 0.30% | 0.20% | 1.60% | Nil | .4% | 5 |
| 12 | Sugarcane | 6% | 1.20% | 0.35% | .2% | 4.75% | Nil | .2% | 10 |
| 13 | Banana | 4.20% | Nil | 3.60% | 2.1% | 3.04% | Nil | 1% | 10 |
| 14 | Chilly | 7.35% | Nil | 4.58% | 2.1% | 3.81% | Nil | 2.50% | 1 (foliar) |

**16. Micronutrient recommendation as per mission soil health card scheme**

| Nutrient | Soil application | Foliar application |
|---|---|---|
| **Iron** | Ferrous sulphate – 25 – 50 Kg/Ha, | 1% spray of Ferrous sulphate +0.5 lime solution |
| **Copper** | Copper sulphate 5-10 Kg/Ha | 0.1% Copper sulphate + 0.05% Lime |
| **Zinc** | Zinc sulphate 15-25 Kg/Ha | 0.5 % Zinc sulphate + 0.25% lime |
| **Manganese** | Manganese sulphate – 10-25 Kg/Ha | 1 % Manganese sulphate + 0.25% lime or 0.5 % Manganese sulphate spray 3 times. |

**Liquid formulations available in the market**

1. Liquid micronutrient fertilizer - Various micronutrients such as Mg, Zn, Fe, Mn, Cu, Mo, B Dosage: 2.5 ml per litre of water.
2. Organic micronutrient liquid – 125 ml, Rs. 350
3. Liquid Boron Fertilizer – 5% B
4. Liquid Iron Fertilizer – 4% Fe
5. Liquid copper sulphate – 6% Cu
6. Liquid Manganese sulphate – 4% Mn
7. Liquid Zinc Sulphate – 4% Zn
8. Liquid Molybdenum fertilizer – 1% Mo
9. Multi micronutrient fertilizer – Rs. 210 per litre
10. All in one nutrients: all major, micro and secondary nutrients, 500 ml packing, Rs. 555.
11. Micro Nutrient Mixture Fertilizer containing Zinc, Boron and Calcium for foliar spray.

**Dosage – 3 ml per litre**

**Time of application :**

1$^{st}$ spray : At flowering stage.

2$^{nd}$ spray : At the time of fruit setting stage.

3$^{rd}$ spray : After fruit setting stage OR As per requirement.

# IMPORTANCE OF SPECIALTY FERTILIZERS AND CUSTOMIZED FERTILIZERS IN AGRICULTURE AND THEIR MARKET AVAILABILITY

**Mr.M.Ibramsa, Assistant Director of Agriculture, STAMIN, Kudumiyanmalai**

---

Specialty fertilizers are helpful to promote nutrient use efficiency and balanced fertilization of crops. Scientist suggest that best NPK ratio for soil health is 4:2:1 and but the present ratio of NPK all India level is 7:3:1 that is skewed highly in favour of nitrogen usage. The indiscriminate use of bulk fertilizers, especially the highly subsidized nitrogenous fertilizers is main cause for unhealthy NPK ratio. Non-judicious application of fertilizers without considering nutrient requirements and soil nutrient status by farmer also contributes to this ratio. In addition, unbalanced fertilizer usage leads to lower nutrient use efficiency. There are several ways in which unbalanced fertilization could be overcome. One such way is promoting speciality fertilizers among farmers.

**Specialty fertilizers**

In a broader sense, specialty fertilizers fall in to any one of the following type of fertilizers.

- Solid/liquid containing macro, secondary and micro nutrients intended for fertigation and other applications.
- NPK fertilizers with Calcium, Sulphur and micronutrients called specialty fertilizers
- Concentrated fertilizers with high efficiency used to enhance yields, improve crop quality, save water, protect the environment
- These are precision and specific fertilizers, which are required by high quality cash crops for precision application.

**Categories of specialty fertilizers**

1. Water soluble fertilizers
2. Customized fertilizers
3. Fortified fertilizers
4. Coated fertilizers
5. Controlled & Slow-release fertilizers
6. Liquid fertilizers

**1. Water soluble fertilizers**

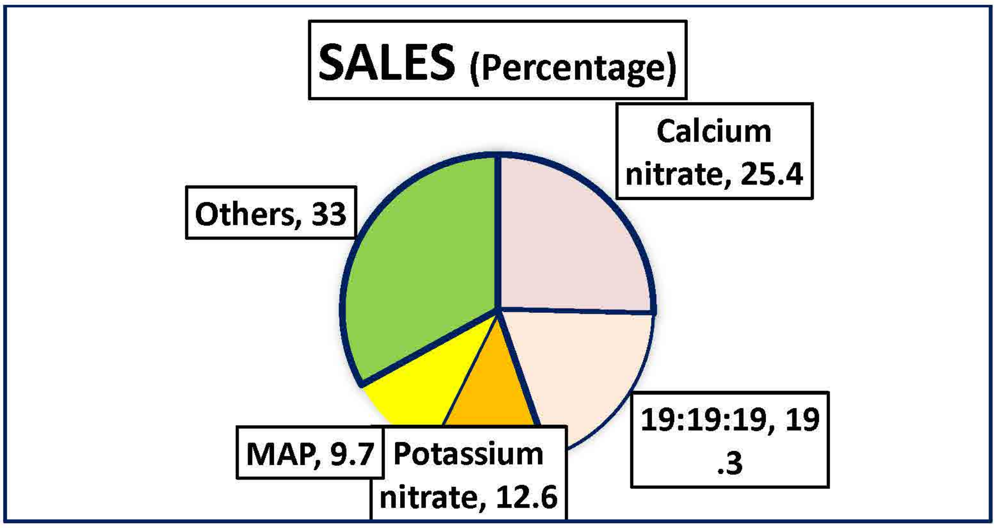
**Advantages**

- Completely soluble in irrigation water.
- Regular flow of both water and nutrients.
- Can be directly applied to the root zone.
- Save in nutrients by 35-40%

- Acidic in nature, no blocking of drip system
- Free from harmful salts.
- Versatile utility for fertigation, foliar and side dressing.
- Save in time and labour
- Ensure balanced nutrition.
- Improves yield and quality of crop.

**Market share of WSF & scope**

- Several grades of water soluble fertilisers in India
- The growth in hi-tech farming in the country.
- Drip and micro irrigation area
- Fertigation demand
- Improvement in the fertiliser use efficiency through the use of water soluble fertilisers




**NPK 19:19:19**

- Starter grade containing all the three forms of Nitrogen viz. Amide ($NH_2$), Ammoniacal ($NH_4$) and Nitrate ($NO_3$)
- Useful for the initial vegetative growth period of the crop for bud bursting and rejuvenation of vegetative growth.
- Gives the crop early boost. Increases vigour of the crop and makes the crop healthy.
- Best suited for foliar spray
- Also contain EDTA a chelating agent
- Also contain Fe, Mn, Zn, Cu, B in a few brands.

**Potassium nitrate (13:0:45)**

- Potassium Nitrate with low nitrate Nitrogen and high water soluble Potash.
- Useful at post bloom and physiological maturity stage.
- Helps in assimilate translocation and sugar formation.
- Helps to resist abiotic stress situations.
- Suitable for Chloride sensitive crops also.
- Suitable for vegetables and fruits

**Mono Ammonium Phosphate (MAP) 12:61:0**

- Mono-ammonium Phosphate, with low Nitrogen in ammoniacal form and rich in water soluble phosphorus.
- Useful for fresh root growth and fast vegetative growth.
- Useful for proper growth of reproductive parts and fertilization.
- Reduce flower drop, increase fruit setting and increases yield and quality of the produce.

**NPK 13:40:13**

- Mixed grade with 1:3:1 ratio.
- Useful at early flowering and early fruit formation and fruit development stage where P requirement is more with less N and K.
- Reduce flower drop, increase fruit setting and increases yield and quality of the produce.

**Mono potassium phosphate 0:52:34**

- Phosphorus and Potash.
- Suitable for pre-bloom as well as post bloom application.
- Popularly used for proper ripening and attractive colour formation of rind in fruits like pomegranate.
- Improves luster, uniform colour and taste.

**Sulphate of potash (SOP) 0:0:50 + 18% S**

- Sulphate of Potash enriched with Sulphur in available form.
- Suitable for application once the crop reaches physiological maturity.
- Useful for sink filling and proper ripening.
- Increase plant Resistance against pest and diseases- Helps to control fungal diseases like powdery mildew when used for foliar application.
- Help to resist abiotic stresses.

**Potassium Magnesium Chloride – $KCl\ MgCl_2.6H_2O$**

- $K_2O$ – 15%, MgO – 13%, low sodium content
- Obtained from natural minerals from dead sea, K & Mg cations held to soil exchange complex
- Chloride weakly held to soil, leached down.
- Used as a source of K & Mg for crops which are not sensitive to high chloride
- Soil, fertigation, Suitable for non-saline soils, and salt tolerant crops.

**Potassium Magnesium sulphate – $K_2SO_4 . 2\ MgSO_4$**

- $K_2O$ – 22%, MgO – 18%, S – 20%
- Obtained from natural mineral langbenite
- K & Mg – in exchange complex, Sulphate is weakly held by soil.
- Usually for soil application, particularly for tree & perennial crops such as banana, citrus fruits, oilpalm, rubber, tea & coffee.
- Source of K, Mg & S

**Urea phosphates**

- 32% urea, 60% phosphoric acid
- 18% N, 44% $P_2O_5$
- Entire N in amide form
- P in orthophosphate form
- Acid forming fertilizer
- Suited for crops grown in alkaline soils, Calcareous soils
- Highly acidic, not suited for acidic soils

**Calcium nitrate (CN) N-15.5%, Ca- 18.8%:**

- Unique source of water soluble calcium.
- Reduces the calcium deficiency of the plant which helps to increase the crop growth and vigour.
- Increase the root growth development-
- Helps to absorb more nutrients from soil.
- Improves pH of soil and increases availability of trace elements.
- Increase fruit setting. Improves rind quality of the fruit gives better market price. Increases crop quality and yield.
- Increases shelf life of the produce.
- Reduces blossom end rot in tomato and leaf spot in potato.

**NP, NPK complexes (Fully Water soluble)**

| Fertilizer | Total N (%) | % of total nitrogen | | |
|---|---|---|---|---|
| | | Ammoniacal | Nitrate | Amide |
| 6:12:36 | 6 | 1.5 | 4.5 | 0 |
| 13:5:25 | 13 | 6 | 7 | |
| 13:40:13 | 13 | 8.6 | 4.4 | |
| 24:24:0 | 24 | 6 | | 18 |
| 28:28:0 | 28 | 6 | | 22 |
| 18:18:18 | 18 | 8.2 | 9.8 | |
| 19:19:19 | 19 | 4.5 | 4 | 10.5 |
| 20:20:20 | 20 | 3 | 4.9 | 12.1 |

## 2. Customized fertilizers

Fertilizer (Control) Order 1985 defined customized fertilizers as "multi nutrient carrier designed to contain macro and /or micro nutrient forms., both from inorganic and/or organic sources, manufactured through a systematic process of granulation, satisfying the crop"s nutritional needs, specific to its site, soil and stage, validated by a scientific crop model capability developed by an accredited fertilizer manufacturing/ marketing company". They are the best available option to correct site specific multi-nutrient deficiencies of soils so as to attain then maximum crop production through improved nutrient use efficiency.

- Site specific nutrient management. Customised fertilisers are in general a combination of nutrients (primary, secondary and micro-nutrients)
- Specific for soil of a region & crop, Based on soil testing and crop requirement of a particular region
- At present more than 30 formulations of customised fertilisers are approved for sales in India.
- These formulations are developed, according to regional requirements of soil nutrients, for crops like paddy, wheat, maize, cotton, sugarcane, potato, onion, chilli, apple there are 33 customized fertilizers approved and notified all India level. Here are few examples of customized fertilizers.

| Sl.No | Grade | Crop | Area |
|---|---|---|---|
| 1. | 15:32:8:0.5 (Zn) | Paddy | East and West Godavari of AP |
| 2. | 18:33:7:0.5 (Zn) | Paddy | Khammam, Krishna and Guntur of AP |
| 3. | 18:27:14:05 (Zn) | Maize | East Godavari, West Godavari and Vizag of A.P. |
| 4 | 24:0:16 | Cotton | Krimnagar, Warangal, Nizamabad, Adilabad, Rangareddy, Medak, Khammam, Krishna, Guntur, Nalgonda and Prakasam |
| 5 | 21:0:9 | Chilli | Krimnagar, Warangal, Khammam, Krishna, Guntur and Prakasam |
| 6 | 10:13:12:6.2 | Sweet sorghum | Nanded dt of Maharashtra |
| 7 | 12:26:18:0.5:5 | Wheat & Paddy | Pratapgaarh, Barabanki, Jaunaaapuar, Raebareilli, Sultanpur, Faizabad, Ambedkarnagar, Lucknow |
| 8 | 17:17:17:4:0.5:0.2 (NPKZnBS) | Groundnut | Anantpur, Chitoor, Kadapaaa, Kurnool, Mahaboobnagardistraicts of AP |
| 9 | 14:24:10.5:0.75:0.25(NPKSZnB) | Potato basal | West Bengal |

**Customized fertilizers notified in 2018**

- 18 grades of customized fertilizers have been identified – rice, maize, sugarcane.
- 126 districts across five states – UP, Uttarkhand, Telangana, TN, AP, and Maharashtra
- Approved & notified in February 2018
- Nagarjuna & Indo Gulf to produce these customized fertilizers

**Application of Customized Fertilizer**

The idea behind the customized fertilizer is to provide site specific nutrient management for getting higher fertilizer use efficiency for the applied nutrient in a cost effective manner. Customized fertilizers are combination of micro nutrients like sulphur, zinc, boron added to the key items such as urea and diammonium phosphate (DAP) and potash, in a proportion that suits specific crops and soil patterns. Soil test play a vital role in deciding the combination of grade of fertilizer.

**3. Coated fertilizers**

- Neem coated urea
- Sulphur coated urea
- Urea Deep Placement
- Physical coating
- Neem coated: Nitrification inhibitors & Slow release

- Sulphur coated: Sulphur is slowly soluble, upon dissolution, urea is exposed and become slowly available to plant
- Urea deep placemat: deep placement delays urea hydrolysis ad slow release is realized.

**Sulphur coated urea (SCU)**

- N exposed after Sulphur coating is disintegrated
- Slow release depends upon uniformity and thickness of Sulphur coated urea
- Coatingdisintegration,
- Regular use of SCU increases Sulphur content of soil
- S – 12-17%, 3% coated agent

4. **Fortified fertilizers**

- Macro nutrients are commonly used by farmers
- If micronutrients and secondary nutrients are added in the production stage itself of macronutrients in the form of granules (fortified), usage of these, otherwise neglected nutrients can be ensured.
- Results in balanced fertilization

**Straight fertilizers fortified with Zinc**

**Zincated urea**

- N – 43%, Zn – 2%
- Mismatch between Zinc requirement of crop and application of this fertilizer
- More appropriate for foliar application than soil application

**Other fertilizers**

- Zincated DAP 18:46:0:0.5
- Zincated SSP: 14.5% $P_2O_5$, Zn – 0.5, S 11%
- Zincated phosphate (Suspension
    - $P_2O_5$ – 12.9%, Zinc - 19.4%
    - Zinc source not specified
    - Suited for soil application
    - For seedling dipping & seed treatment

**Bentonite Sulphur fortified with Zinc**

- S – 65%, Zinc – 18%
- Zinc most probably as Zinc oxide
- S takes course of Bentonite Sulphur in transformation
- Zinc – if is zinc oxide, transformation is slow
- If it is a soluble source, transformation will be fast like that of Zinc sulphate

**Boronated Single Super Phosphate**

- Simultaneous supply of P & B
- Small amount of Boron is not easy to apply
- Initial targeted crop: Groundnut
- $P_2O_5$ – 16%, B – 0.2%
- Price: 10% more than SSP price

**Calcium nitrate fortified with Boron 14.6:0:0:19:0.2**

- Nitrate N – 13.5%
- Ammoniacal N – 1.1%
- Calcium – 17.1%
- B – 0.25%

**NPK complexes fortified with Micronutrients**

| Fortified with Zinc | Fortified with Boron |
|---|---|
| 1. 12:32:16:0.3 | 1. 18:46:0:0.3 |
| 2. 12:32:16:0.5 | 2. 12:36:16:0.3 |
| 3. 10:26:26:0.3 | 3. 12:36:16:0.3 |
| 4. 10:26:26:0.5 | 4. 24:24:0:0.2 |
| | 5. 15:15:15:0.2 |

**Fertilizers fortified with Sulphur**

| Sl.No | Name of fertilizer | Nutrient content | Special features |
|---|---|---|---|
| 1 | MAP with Sulphur | 13:33:0:15 | N in Ammoniacal form, P 30% water soluble, S in both sulphate and elemental form Basal application |
| 2 | All 15 with Sulphur | 15:15:15:9 | NH4 form – 12%, $NO_3$.N – 3%<br>Citrate soluble P – 15%, Water soluble: 12%<br>Basal application to Sulphur needed crops |
| 3 | UAP with Sulphur | 24:24:0:8 | Suitable for Paddy, Sugarcane, Cotton, Tomato, Onion crops |

**5. Slow & Controlled release fertilizers**

Some mechanism is followed in the production stage itself to ensure slow release of nutrients. It increases nutrient use efficiency.

**Urea formaldehyde**

- 38% N, reaction product of urea and formaldehyde
- Cold water soluble N, hot water soluble N
- Hot water soluble N should not be less than 40% for agronomic effectiveness.
- Salt index 1.5
- urea form is hydrolysed by microbes and transformed in to amide form and process as with urea.
- Fruit, vegetables, basal application, paddy

**Sulphur coated NPK complex**

- 83% fertilizer, 15%S, 0.7% wax, 0.2% mineral coating
- Eight types of Sulphur coated NK, NPK fertilizers are available.

**Organo mineral fertilizers**

- Fertilizers containing prat of N from natural Organic source
- Fertilizers containing part of N from synthetic organic source
- Claimed to be organic and slow release

**Synthetic source of organic Nitrogen**

| Type | Urea | Nitrate | ammonium | Uform |
|---|---|---|---|---|
| 15:7:7 | 0.5 | 0.5 | 6 | 8 |
| 20:5:12:3 | 1.4 | 3.4 | 3.2 | 12 |
| 5:11:10:7 | 0.25 | | 2.75 | 2 |
| 4:16:8:6 | 0.24 | | 1.76 | 2 |

**Natural organic source of N**

| Type | Organic N % | Nitrate N % | Ammonium N % |
|---|---|---|---|
| 2.5:10:0 | 100 | | |
| 4:8:8:2 | 50 | 25 | 25 |
| 5:8:12:3 | 20 | | 80 |

**Elastic polymer technology of controlled release**

- Controlled Release Fertilizers includes products for agriculture, horticulture, ornamentals and turf.
- NPK with release longevities 4,6,8,12 and 16 months for nurseries and ornamentals.
- Controlled released Urea for arable crops

**Slow Release NPK Fertilizer 11-11-16 + Micronutrients (9 months release)**
**Some of the controlled release fertilizers available in the market are listed below.**

1. 15-5-15
2. 25-5-10
3. 16-5-26
4. 26-5-8
5. 28-8-8

**Liquid fertilizers**

- Easily applicable form
- Fertigation
- More liquid fertilizer can be prepared
- Useful for preparation of other forms of nutrients

**Ammonium polyphosphates (10-34-0)**

- Ability to complex/chelate metal ions
- Useful for micronutrient application
- Liquid fertilizer but can be granulated with 11-55-0
- Applied to soil as such
- Used to prepare liquid fertilizers in which required micronutrients can also be added.

**Urea Ammonium Nitrate (URAN) – $CO(NH_4)_2 + NH_4NO_3$**

- Solution of urea and Ammonium Nitrate – 32% N
- Total N – 32%, Urea N – 16.6%, ammoniacal N – 7.7%, Nitrate N – 7.7%
- Applied in soil furrows, foliar application, and with irrigation

**Super phosphoric acid – $H_4P_2O_7$**

(70% - 75% $P_2O_5$)

- Different from Phosphoric acid (54% $P_2O_5$)
- Prepared by dehydrating water from phosphoric acid
- It is less corrosive than phosphoric acid
- Total phosphate 70%, polyphosphate – 18.9%
- Polyphosphate on hydrolysis gives orthophosphate ions
- Used for fertigation, to formulate clear liquid fertilizer
- Due to sequestering properties, it can keep higher concentration of micronutrients.

**Prices of some speciality fertilisers**

| Sl.No | Fertilizer Name | Price per Kg (Rs) |
|---|---|---|
| 1 | NPK: 19:19:19 | 130 |
| 2 | NPK: 20:20:20 | 43 |
| 3 | NPK 12:11:18 | 74 |
| 4 | NPK: 13:40:13 | 60 |
| 5 | NPK: 0:52:34 | 140 |
| 6 | NPK: 0:0:50 | 50 |
| 7 | NPK: 13:0:45 | 100 |

**Taking specialty fertilizers to farmers**

Farmers need to be taught about specialty fertilizers by extension functionaries about the concept, mode operation, application methods, extent of soil nutrient enhancement and the yield benefits due to its usage, importance in balanced nutrition.

# ORGANIC FERTILISERS AND BIOFERTILISERS FOR SUSTAINABLE AGRICULTURE AND THEIR MARKET AVAILABILITY

**Mr.C.Janakiraman, Senior Agricultural Officer, Fertilizer Control Laboratory, Trichy**

---

**ORGANIC – definition**

It refers to not only the type of inputs used but also farm as whole, in which all the component parts – the soil minerals, organic matter, micro organisms, insects, plants, animals and humans – interact to create a coherant whole.

**ORGANIC aims at**

- Environmental protection
- Conservation of non-renewable resources
- Improved food quality
- Reduction in output of surplus products
- Re-orientation of agriculture towards areas of market demand.

**ORGANIC CHARACTERISTICS**

- Providing crop nutrients indirectly
- By using relatively insoluble nutrients which are made available by soil microbial activity.

**BIOMASS**

- All Organic Matter generated through photosynthesis and other biological processes.
- Renewable & Biodegradable Organic Matter generated through life processess.

**BIOMASS CLASSIFICATION**

- Crop residues & farm wastes
- Industrial wastes
- Forest products
- Municipal solid wastes
- Municipal sewage sludges
- Animal wastes
- Marine products
- Silvicultural energy farm products
- Aquatic biomass

**SOIL ORGANIC MATTER**

- The organic constituents of soil excluding undecayed plant & animal tissue and their partial decomposition products and soil biomass.
- It includes :-
- Higher molecular weight organic materials like polysaccharides and proteins
- Simpler substances like sugars, amino acids & other small molecules.
- Humic substances.
- In nature both organic & inorganic co-exist and interact constantly. They form parts and represent different stages of the same system.
- A soil containing 1% organic matter has 20,000 metric tonnes of it per ha in the plough layer.
- Neither a fertiliser nor an organic manure will serve any purpose if it cannot release its nutrients in plant available form.

**ORGANIC MANURE**

- It is incorrect to club all organic manures into one category.
- In Green Manures entire nutrients assimilated by the crop is added to soil, while in crop residues 75% of N & P, 25% of K absorbed is already taken by the harvested grains. This is followed by FYM.
- Very little attention is paid to the nutrient content & quality of FYM. Its composition vary by 60 - 70%
- Addition of OM to sandy soil will increase the availability of moisture to crops & thus reduce the number of irrigations.
- In heavy textured soils OM addition will increase permeability to water and air and increase water infilteration, thereby reducing surface run-off.

**Benefits of soil organic matter – PHYSICAL**

- Enhances aggregate stability and improves soil aeration
- Improved seed germination
- Improves water infiltration by reducing runoff and thus increase water holding capacity
- Reduces the stickiness of clayey soils and thus making them easier to till
- Reduces surface crusting

**Benefits of soil organic matter – CHEMICAL**

- Increases the Cation Exchange Capacity (CEC) of soil or its ability to hold and supply essential nutrients such as calcium, magnesium and potassium
- Enhances fertilizer and water use efficiency
- Improves the buffering capacity *i.e.* ability of a soil to resist pH change
- Accelerates decomposition of soil minerals and making the nutrients available for plant uptake

**Benefits of soil organic matter – BIOLOGICAL**

- Provides food for the living organisms in the soil
- Efficiency of nitrogen fixing microbes is enhanced
- Enhances soil microbial biodiversity and activity which can help in the suppression of diseases and pests
- Enhances pore space through the actions of soil microorganisms and thus increases infiltration and reduced runoff

**GREEN MANURING**

- Fresh plant matter added to soil largely for supplying the nutrients contained in its biomass.
- It can be grown in situ & incorporated or grown elsewhere and brought to field for incorporation.
- Leguminous plants are largely used
- Some non-leguminous plants are occasionally used due to local availability, drought tolerance, quick growth and adaption to adverse conditions.

**Biological & industrial wastes as sources of plant nutrients**

- Sewage sludge
- Biogas slurry
- Waste water
- Fish pond effluent
- Some wastes of food processing industry
- Pressmud
- Phosphogypsum

**BIO AVAILABILITY OF HEAVY METALS**

- High acidity $pH<5.0$, low CEC & OM favour greater availability of heavy metals to plants.
- In calcareous soils & soils with high CEC & OM the bio availability of heavy metal is appreciabily low.
- Cadmium is higher in foliar tissues than fruits, seeds or grains and roots.
- Leafy vegetables like spinach is the highest cadmium accumulator.

**Hazards IN USING SEWAGE**

- Primary treatment removes 35 to 45% pathogens while secondary treatment removes 95% pathogens.
- High degree of health hazard persists in the use of untreated and 1:1 dilutes sewage.
- Spinach, fenugreek, cabbage & cauliflower were contaminated with Salmonella when untreated sewage water is used.

**Pressmud**

- Pressmud obtained from Sulphitation process is more useful for crop production as compared to carbonation process.

**COMPOST**

- Compost helps to control plant nematodes.
- It also helps in mitigating the toxic effects of pesticides.
- Compost reduces the water requirement for plant growth.

**ORGANIC RECYCLING AND IPNS**

- *In-situ* recycling of crops instead of their non-agricultural use. Some nutrients are deficient like P, S, K, Ca, Mg.
- IPNS limits the losses of the system and not a process which supplies plant nutrients for the whole system.
- Use of mineral with organic sources of plant nutrients have complementary & synergistic effects on the crop yield & also increase Fertilizer Use Effienciency (FUE).
- The magnitude of contribution will vary according to sources &agro-ecological conditions.

**HUMUS**

- It is the humus fraction which improves the soil physical condition.
- Aggregation is improved by the action of gum compounds, polysacharides and fulvic acid component of organic matter.
- The humic substance increases P availability owing to their very high Cation Exchange Capacity.
- Humus enhances the utilization of fertiliser nutrients by plants & reduces leaching losses by promoting greater water retention.
- The activity of microbes in soil are stimulated by the fresh supply of humic material.

**CONSTITUENTS OF HUMUS**

- Humic & humus acids, Hymatomelanic acid, Ulmin, Ulmic acid, heinic acid, humic& mull coal, humin, humates, crenic&apocrenic acids, glucinic, apoglucinic, chlorohumic& nitrohumic acids, anitrohumic, sucrohumic, lignohumic&metalignohumic acids, peat &apopeat acids, arvic and apoarvic acids, pyrrole-apocrenic acid, lignocrenic, humocrenic, peat-crenic, anitrocrenic&oxycrenic acids, anitrohumin, nitrohumin, nitrolin, mucic acid, carboulmic acid, siliconitrohumic acid, lignoin, acetoulmic acid, dihydroxyacetoulmic acid, fumic acid, pyrohymatomelanic acid, humalic acid, fulvic acid &protohumic acid……………….

**ESSENTIAL NUTRIENTS**

| S.No. | Nutrient | Forms absorbed | Concentration In plant dry matter |
|---|---|---|---|
| 1 | Nitrogen | $NH_4^+$, $NO_3^-$ | 1.5% |
| 2 | Phosphorous | $H_2PO_4^-$ | 0.1 to 0.4% |
| 3 | Potassium | $K^+$ | 1 to 5% |
| 4 | Sulphur | $SO_4^{--}$ | 0.1 to 0.4% |

| | | | |
|---|---|---|---|
| 5 | Calcium | $Ca^{++}$ | 0.2 to 1% |
| 6 | Magnesium | $Mg^{++}$ | 0.1 to 0.4% |
| 7 | Boron | $H_3BO_3^-$, $H_3BO_3^-$ | 6 to 60 ppm |
| 8 | Iron | $Fe^{++}$ | 50 to 250 ppm |
| 9 | Manganese | $Mn^{++}$ | 20 to 500 ppm |
| 10 | Copper | $Cu^+$, $Cu^{++}$ | 5 to 20 ppm |
| 11 | Zinc | $Zn^{++}$ | 25 to 150 ppm |
| 12 | Molybdenum | $MoO4^{--}$ | Below 1 ppm |
| 13 | Chlorine | $Cl^-$ | 0.2 to 2% |

**SCHEDULES UNDER FCO, 1985**

| S.No. | SCHEDULE | FERTILISERS LISTED |
|---|---|---|
| 1 | I & II | CHEMICAL FERILISERS |
| 2 | III | BIOFERTILISERS |
| 3 | IV | ORGANIC FERTILISERS |
| 4 | V | NON-EDIBLE DE-OILED CAKES |

**SCHEDULE IV UNDER FCO, 1985 & ITS COMPONENTS**

- PART A – SPECIFICATION OF ORGANIC FERTILISERS
- PART B – TOLERANCE OF ORGANIC FERTILISERS
- PART C – PROCEDURE FOR DRAWAL OF ORGANIC FERTILISERS
- PART D – METHOD OF ANALYSIS OF ORGANIC FERTILISERS

**LIST OF NOTIFIED ORGANIC MANURES UNDER FCO, 1985. SCHEDULE-IV**

- CITY COMPOST
- VERMICOMPOST
- PHOSPHATE RICH ORGANIC MANURE ( PROM )
- ORGANIC MANURE
- BIO-ENRICHED ORGANIC MANURE
- BONE MEAL, RAW
- BONE MEAL, STEAMED
- POTASH DERIVED FROM RHODOPHYTES

**PARAMETERS ANALYSED – PHYSICAL**

- Moisture (%)
- Colour
- Odour
- Particle Size(% pass through 4.0 mm IS sieve)
- Bulk Density (g/cm$^3$)

**PARAMETERS ANALYSED – CHEMICAL**

- pH
- Electrical Conductivity (dsm$^{-1}$)
- Total Organic Carbon (%)
- Total Nitrogen (%)
- Total Phosphorous (%)
- Total Potassium (%)
- C:N Ratio
- Total Ash (%)
- Acid Insoluble Matter (%)
- 2% Citric Acid Soluble Phosphorous (%)
- Total sulphur (%)

**HEAVY METALS (mg/kg)**

- Arsenic
- Cadmium
- Chromium
- Copper
- Mercury
- Nickel
- Zinc
- Lead

**PARAMETERS ANALYSED - MICROBIOLOGICAL**

- **PATHOGENICITY**

a) Presumptive Test

b) Confirmative Test

c) Completed Test

TOTAL VIABLE COUNT

## SPECIFICATION

| S.No. | Paramaters | City Compost | Vermicompost | PROM | Organic Manure |
|---|---|---|---|---|---|
| 1 | Moisture (%) **Maximum** | 25.0 | 15.0 – 25.0 | 25.0 | 25.0 |
| 2 | Colour | -- | Dark brown to black | -- | -- |
| 3 | Odour **(Absence of )** | -- | Foul odour | -- | -- |
| 4 | Particle Size (% pass through 4.0mm IS Sieve ) **Minimum** | 90.0 | 90.0 | 90.0 | 90.0 |
| 5 | Bulk Density ($g/cm^3$) | <1.0 | 0.7 - 0.9 | <1.6 | <1.0 |
| 6 | pH | 6.5-7.5 | -- | 6.7 | 6.5-7.5 |
| 7 | Electrical Conductivity ($dsm^{-1}$) **Maximum** | 4.0 | -- | 8.2 | 4.0 |
| 8 | Total Organic Carbon (%) **Minimum** | 12.0 | 18.0 | 7.9 | 14.0 |
| 9 | Total Nitrogen (%) **Minimum** | -- | 1.0 | 0.40 | 0.50 |
| 10 | Total Phosphates (%) **Minimum** | -- | 0.80 | 10.40 | 0.50 |
| 11 | Total Potash (%)**Minimum** | -- | 0.80 | -- | 0.50 |
| 12 | Total of Nitrogen as N, Phosphate as $P_2O_5$, Total Potash as $K_2O$(%) **Minimum** | 1.20 | -- | -- | -- |
| 13 | C:N Ratio | <20.0 | -- | <20:1 | <20.0 |
| 14 | Total Ash **Maximum** | -- | -- | -- | -- |
| 15 | Arsenic (mg/kg) **Maximum** | 10.0 | -- | 10.0 | 10.0 |
| 16 | Cadmium (mg/kg) **Maximum** | 5.0 | 5.0 | 5.0 | 5.0 |
| 17 | Chromium (mg/kg) **Maximum** | 50.0 | 50.0 | 50.0 | 50.0 |
| 18 | Copper (mg/kg) **Maximum** | 300.0 | -- | 300.0 | 300.0 |
| 19 | Mercury (mg/kg) **Maximum** | 0.15 | -- | 0.15 | 0.15 |
| 20 | Nickel (mg/kg) **Maximum** | 50.0 | 50.0 | 50.0 | 50.0 |
| 21 | Lead (mg/kg) **Maximum** | 100.0 | 100.0 | 100.0 | -- |
| 22 | Zinc (mg/kg) **Maximum** | 1000.0 | -- | 1000.0 | 1000.0 |
| 23 | Pathogens | -- | -- | -- | Nil |
| 24 | Total Viable Count (cfu/g) **Minimum** | -- | -- | -- | -- |

**Tolerance Limit : Total N.P.K not less than1.5% for City Compost &2.5% in Vermicompost. Total N.P.K not less than 3.0% for Bio-enriched Organic Manure. Total N.P.K not less than 3.0% for Organic Manure. 0.5 Unit for N.P.K Combined.**

## SPECIFICATION

| S. No. | Paramaters | Bio-enriched Organic Manure | Bone Meal (Raw) | Bone Meal (Steamed) | Potash derived from Rhodophytes | Non-edible De-oiled Cakes |
|---|---|---|---|---|---|---|
| 1 | Moisture (%) **Maximum** | 30.0-40.0 | 8.0 | 7.0 | 5.0 | 10.0 |
| 2 | Colour | -- | -- | -- | -- | -- |
| 3 | Odour **(Absence of)** | -- | -- | -- | -- | -- |
| 4 | Particle Size (% pass through 4.0mm IS Sieve) **Minimum** | 90.0 | Pass through 2.36mm ISS & 30% retained on 0.85mm ISS | 90% shall pass through 1.18mm ISS | -- | -- |
| 5 | Bulk Density (g/cm3) | <1.0 | -- | -- | -- | -- |
| 6 | pH | 6.5-8.0 | -- | -- | -- | 4.5-6.5 |
| 7 | Electrical Conductivity($dsm^{-1}$) **Maximum** | 4.0 | -- | -- | -- | <4.0 |
| 8 | Total Organic Carbon (%) **Minimum** | 14.0 | -- | -- | -- | 23.0 |
| 9 | Total Nitrogen (%) **Minimum** | 0.80 | 3.0 (in water insoluble portion) | -- | -- | 1.50 |
| 10 | Total Phosphates (%) **Minimum** | 0.50 | 20.0 | 22.0 | -- | 0.20 |
| 11 | Total Potash (%) **Minimum** | 0.80 | -- | -- | 20.0 | 0.50 |
| 12 | C:N Ratio | <18.0 | -- | -- | -- | -- |
| 13 | Total Ash **Maximum** | -- | -- | -- | -- | 15.0 |
| 14 | Arsenic (mg/kg) **Maximum** | 10.0 | -- | -- | 10.0 | -- |
| 15 | Cadmium (mg/kg) **Maximum** | 5.0 | -- | -- | 5.0 | -- |
| 16 | Chromium (mg/kg) **Maximum** | 50.0 | -- | -- | 50.0 | -- |
| 17 | Copper (mg/kg) **Maximum** | 300.0 | -- | -- | 300.0 | -- |
| 18 | Mercury (mg/kg) **Maximum** | 0.15 | -- | -- | 0.15 | -- |
| 19 | Nickel (mg/kg) **Maximum** | 50.0 | -- | -- | 50.0 | -- |
| 20 | Lead (mg/kg) **Maximum** | 100.0 | -- | -- | 100.0 | -- |
| 21 | Zinc (mg/kg) **Maximum** | 1000.0 | -- | -- | 1000.0 | -- |
| 22 | Total Viable Count (cfu/g) **Minimum** | 5.0x10[illegible] | -- | -- | -- | -- |
| 23 | Acid insoluble matter (%) | -- | 12.0 | -- | -- | -- |
| 24 | 2% citric acid soluble phosphorous (%) | -- | 8.0 | 16.0 | -- | -- |
| 25 | Total Sulphur (% by weight) **Minimum** | -- | -- | -- | 1.5 | |

**RECOMMENDED MAXIMUM CUMULATIVE SLUDGE METAL APPLICATIONS**

| S.No. | Element | Unit | Soil CEC ( meq/100g ) | | |
|---|---|---|---|---|---|
| | | | <5 | 5 - 15 | >15 |
| 1 | Zinc | Kg/ha | 250 | 500 | 1000 |
| 2 | Copper | Kg/ha | 125 | 250 | 500 |
| 3 | Nickel | Kg/ha | 50 | 100 | 200 |
| 4 | Cadmium | Kg/ha | 5 | 10 | 20 |
| 5 | Lead | Kg/ha | 500 | 1000 | 2000 |

LIST OF NOTIFIED NON EDIBLE DEOILED CAKES UNDER FCO, 1985. SCHEDULE-V

- NON-EDIBLE DE-OILED CAKE FERTILISERS.

**FERTILISER USE EFFICIENCY**

| S.No. | Nutrient | Use Efficiency (%) |
|---|---|---|
| 1 | Nitrogen | 30-50 |
| 2 | Phosphorous | 15-20 |
| 3 | Potassium | 70-80 |
| 4 | Sulphur | 8-10 |
| 5 | Micronutrients | 1-2 |

**BIOFERTILIZERS**

- These are preparations containing live or latent cells of efficient strains of beneficial micro organisms used for application to soil or seed with the objective of increasing their numbers & acclerate certain microbial processes to augment the extent of availability of nutrients in an assimilated form by plants.

**BIOFERTILISERS NOTIFIED UNDER FCO, 1985**

| S.No. | Name of the Strain |
|---|---|
| 1 | RHIZOBIUM |
| 2 | AZOTOBACTER |
| 3 | AZOSPIRILLUM |
| 4 | PHOSPHATE SOLUBILISING BACTERIA |
| 5 | MYCORRHIZAL BIOFERTILISERS |
| 6 | POTASH MOBILISING BACTERIA( KMB ) |
| 7 | ZINC SOLUBILING BACTERIA ( ZSB ) |
| 8 | ACETOBACTER |
| 9 | PHOSPHATE SOLUBILIZING FUNGAL BIOFERTILISER |

**STRAINS PRODUCED BY STATE PRODUCTION UNITS**

**NITROGEN FIXERS**

1.*Azospirillum lipoferum* FOR PADDY

2. *Azospirillum brasilense* for all other crops.

3. *Rhizobium sp.* for Groundnut.

4. *Rhizobium sp.* for Pulses.

**PHOSPHATE SOLUBILIZERS.**

- *Bacillus megatherium* var *phosphaticum* for all crops.

**POTASH MOBILISING BACTERIA**

- *Frateuria aurantia*

**AZOPHOS**

- *Azospirillum brasilense* + *Bacillus megatherium* var *phosphaticum*

**SPECIFICATION OF SOLID BIOFERTILISERS**

| PARAMETER TO BE TESTED | SPECIFICATION |
|---|---|
| BASE | Carrier based in form of moist/dry powder or granules |
| VIABLE CELL COUNT | Cfu minimum 5 x $10^7$ cell/g of powder/granule/carrier |
| CONTAMINATION LEVEL | Nil at $10^5$ dilution |
| pH ( all other strains )<br>Acetobacter | 6.5 - 7.5<br>5.5 - 6.0 |
| PARTICLE SIZE | To pass through 0.15-0.212mm is sieve |
| MOISTURE | 30-40% |
| EFFICIENCY | Listed |

**SPECIFICATION OF PHOSPHATE SOLUBILIZING FUNGAL BIOFERTILISER**

| PARAMETER TO BE TESTED | SPECIFICATION |
|---|---|
| BASE | Carrier based in form of moist/dry powder or granules/liquid |
| SPORE COUNT | Minimum 1 x $10^6$ spores/g of powder /granule/carrier or1 x $10^7$ viable spores/ml of liquid |
| CONTAMINATION LEVEL | Nil for liquid & 1 x$10^3$ cells/gram for carrier based. |
| pH -LIQUID<br>CARRIER | 3.5 - 5.5<br>6.0 - 7.0 |
| MOISTURE | 10% |
| EFFICIENCY | Listed |

## SPECIFICATION OF LIQUID BIOFERTILISERS

| PARAMETER TO BE TESTED | SPECIFICATION |
|---|---|
| BASE | Liquid based |
| VIABLE CELL COUNT | 1 x $10^8$ cell/ml. Of liquid |
| CONTAMINATION LEVEL | Nil at $10^5$ dilution |
| pH (PSB,KMB,ZSB )<br>For other strains<br>Acetobacter | 5.0 – 7.5<br>6.5 - 7.5<br>3.5 - 6.0 |
| EFFICIENCY | As listed in subsequent table |

## SPECIFICATION OF BIOFERTILISERS

| STRAIN | EFFICIENCY TEST |
|---|---|
| RHIZOBIUM | Should show effective nodulation on all species listed on the packet. |
| AZOTOBACTER | Should be capable of fixing at least 10 mg of nitrogen per g of sucrose consumed. |
| AZOSPIRILLUM | Formation of white pellicle in semisolid nitrogen free bromothymol blue medium. |
| PHOSPHATE SOLUBILISING BACTERIA | Minimum 30% phosphate solubilising capacity or minimum 5 mm solubilising zone in prescribed media having atleast 3 mm thickness |
| MYCORRHIZAL BIOFERTILISERS | 80 infection points in test root / gm of mycorrhizal inoculum used. |
| STRAIN | Efficiency test |
| POTASH MOBILISING BACTERIA (KMB ) | Minimum 10 mm solubilising zone in prescribed media having at least 3 mm thickness |
| ZINC SOLUBILING BACTERIA (ZSB ) | Minimum 10 mm solubilising zone in prescribed media having atleast 3 mm thickness |
| ACETOBACTER | Formation of yellow pellicle in semisolid nitrogen free medium. |
| PHOSPHATE SOLUBILIZING FUNGAL BIOFERTILISER | Minimum 30% phosphate solubilising capacity or minimum 10 mm solubilising zone in prescribed media having at least 3 mm thickness |

# IMPORTANT TECHNOLOGIES TO INCREASE THE FERTILIZER USE EFFICIENCY IN FIELD

**R .Jagadeeswaran and P.P. Mahendran**
**Department of Crop Management,**
**Agricultural College and Research Institute (TNAU), Kudumiyanmalai 622 104.**

---

## 1. Introduction

Nutrient Use Efficiency (NUE) is an important concept in the contest of fertilizer management for sustainable and improved crop production system. Nutrient Use Efficiency helps to assess and quantify the amount of fertilizer nutrients utilized by the plants, the quantity lost from the system and its detrimental effect on the environment. A cropping system with increased nutrient use efficiency said to be environmental friendly and helps to reduce the input cost. Tilman *et al.* (2011) estimated that global crop demand will increase by 100 to 110 % from 2005 to 2050 and the World will need 60% more cereal production between 2000 and 2050 (FAO, 2009), while (Glenn *et al.* (2008) predict food demand will double within 30 years.

One of the critical constraints to higher crop productivity is the low efficiency of applied nutrients especially N and P. Nutrient use efficiency is often expressed in terms of agronomic efficiency, physiological efficiency, chemical efficiency or apparent recovery, efficiency ratio, partial factor productivity etc. The NUE is thus a function of nutrients supplied from soil, type and quantity of fertilizer applied, the ability of plant to acquire and transport in root and shoot. Use efficiency of applied N as estimated by the difference in N uptake of the above-ground portions of N fertilized and unfertilized plots, and expressed as percentage of N fertilizer applied to the crop is only about 30-40 percent. The P efficiency ranges from 20-40 percent only. Hence, there is a need to increase nutrient use efficiency from the view point of input costs. There were genuine concerns over nutrient use efficiency, in general, and Nitrogen use efficiency in particular, for economic as well as environmental reasons. Worldwide, NUE for cereal production is as low as 33 percent. The unaccounted 67 percent represents an annual loss of N fertilizer worth up to Rs. 72,000 crores (NAAS 2005). Low NUE for crops implies higher costs to producers and consumers and, therefore, reduced competitiveness. Loss of Nitrogen from soil plant system results from gaseous plant emission, nitrification, denitrification, surface runoff, volatilization and leaching beyond rooting zone of crops.

Thus, sustainable nutrient management must be both efficient and effective to deliver anticipated economic, social, and environmental benefits. As the cost of nutrients increasing, profitable use puts increased emphasis on high efficiency and the greater nutrient amounts that high yielding crops remove requires application of higher quantity of fertilizer nutrients and associate loss from the production system. An efficient crop production system must increase both nutrient use efficiency and crop productivity. The nutrient management approaches which consider economic, social and environmental aspects in a sustainable agricultural systems are the best management practices such as 4R *viz.,* application of the right nutrient source, at the right rate, in the right place and at the right time.

**2. Methods of measuring Nutrient Use Efficiency**

The main objective of nutrient use is to increase the overall performance of cropping systems by providing economically optimum nourishment to the crop while minimizing nutrient losses from the field. Therefore, management practices that improve NUE without reducing crop productivity and reduced impact on the environment are the most valuable one. Nutrient use efficiency (NUE) is often expressed in the following terms,

**2.1 Partial factor productivity (PFP)** is a simple production efficiency expression, calculated in units of crop yield per unit of nutrient applied. However, partial factor productivity values vary among crops in different cropping systems, because the nutrient requirement of crops generally varies.

$$Partial\ factor\ productivity = \frac{Yield\ obtained\ in\ nutrient\ applied\ plot}{Quantity\ of\ nutrient\ applied}$$

**2.2. Agronomic efficiency (AE)** is calculated in units of yield increase per unit of nutrient applied. It indicates the impact of an applied fertilizer on the economic return.

$$\text{Agronomic efficiency} = \frac{Yield\ obtained\ in\ nutrient\ applied\ plot - yield\ with\ control\ plot}{Quantity\ of\ nutrient\ applied}$$

**2.3. Physiological efficiency (PE)** is defined as the yield increase in relation to the increase in crop uptake of the nutrient in above-ground parts of the plant. This calculation requires estimation of nutrient concentrations in the crop and is mainly used in research studies.

$$\text{Physiological efficiency} = \frac{Yield\ obtained\ in\ nutrient\ applied\ plot - yield\ with\ control\ plot}{nutrient\ uptake\ in\ nutrient\ applied\ plot - nutrient\ uptake\ in\ control\ plot}$$

**3. Use Efficiency of different Nutrients**

In modern agriculture use of essential plant nutrients in crop production is very important to increase productivity and maintain sustainability of the cropping system. Use of nutrients in crop production is influenced by climatic, soil, plant, and social-economical condition of the farmers. Overall, nutrient use efficiency by crop plants is lower than 50 % under all agro-ecological conditions. Hence, large part of the applied nutrients is lost in the soil-plant system. The lower nutrient use efficiency is related to loss and/or unavailability due to many environmental factors. The low nutrient use efficiency is not only increase cost of crop production but also responsible for environmental pollution. In most cases it is helpful to use more than one NUE term when evaluating any management practice, allowing for a better understanding and quantification of the crop response to the applied nutrient.

**Table 1. Use efficiency of various nutrients**

| Sl. No | Nutrient | Nutrient Use Efficiency (%) | Causes for Low efficiency |
|---|---|---|---|
| 1 | Nitrogen | 30 – 50 | Immobilizaion, volatalization, denitrification and leaching |
| 2 | Phosphorus | 15 – 20 | Fixation in soil as Al-P, Fe-P, Ca-P & Mg-P |
| 3 | Potassium | 70 - 80 | Fixation in Clay-lattice |
| 4 | Sulphur | 8 – 12 | Immobilizaion and leaching with water |
| 5 | Zinc | 2 – 5 | Fixation in soils |
| 6 | Iron | 1 – 2 | Fixation in soils |
| 7 | Copper | 1 – 2 | Fixation in soils |

Source: Vision 2030, iiss.nic.in

Estimates of NUE calculated from research plots on experiment stations are generally greater than those for the same practices applied by farmers in production fields (Cassman *et al.*, 2002; Dobermann, 2007). Differences in scale between research plots and whole fields for management of fertilizer practices, tillage, seeding, pest management, irrigation and harvest contribute to these differences. Table 2 presents the nutrient use efficiency of N, P & K with rice, wheat and maize system

**Table 2. Average yield response and NUE for field trials in China (Jin, 2012).**

| SL No | Crop | Nutrient | Number of trials | Average fertilizer rate | Yield increase | Agronomic efficiency |
|---|---|---|---|---|---|---|
| | | | | kg/ha | % | kg/kg |
| 1 | Rice | N | 51 | 187 | 40 | 12 |
| 2 | Wheat | N | 30 | 181 | 43 | 11 |
| 3 | Maize | N | 70 | 219 | 38 | 12 |
| 4 | Rice | P | 62 | 41 | 13 | 26 |
| 5 | Wheat | P | 39 | 52 | 24 | 21 |
| 6 | Maize | P | 71 | 49 | 15 | 26 |
| 7 | Rice | K | 67 | 122 | 21 | 11 |
| 8 | Wheat | K | 51 | 100 | 18 | 8 |
| 9 | Maize | K | 84 | 118 | 17 | 13 |

## 4. Deficiency symptoms

Nutrient deficiency symptoms result of imbalance in metabolic activities of plant system (Robson and Snowball, 1986). Deficiency symptoms on plants are typical for given nutrients; hence, it is possible to diagnose nutritional disorders by visual symptoms deficient plants show stunted growth, yellow leaves, reduced tillering in cereals, reduced pods in legumes, and consequently, yield reductions in both cereals and legumes. Overall reductions of plant biomass as well as premature senescence are important symptoms of its deficiency (McConnell *et al.*, 1995). N is placed in category of highly mobile nutrient in the soil as well in plants; hence its deficiency sign are unique and first visible on the lower leaves. Leaves become pale and yellowish green in the early stages of growth, and become more yellow and even orange or red in later stages (Kravchecko *et al.*, 2003) If N deficiency persists for long durations, older leaves may dry and fall off due to senescence, especially in legumes. Severe N deficiency for a short duration can reduce leaf area which leads to lower interception of solar radiation; lower the beneficial use of intercepted radiation and lower photosynthetic rates in crop plants (Fageria and Barbosa, 2001). Phosphorous deficiency reduces the leaf area, leaves become purple in color, delays maturity and growth is stunted (Barbieri *et al.*, 2000).

The deficiency of nutrients in Indian soils are presented in Table 3.

**Table 3. Status of plant nutrient deficiency in soils of India**

| Sl No | Nutrient | Status in soil (%) | | |
|---|---|---|---|---|
| | | Low / deficient | Medium | High |
| 1 | Nitrogen | 57 | 36 | 7 |
| 2 | Phosphorus | 51 | 40 | 9 |
| 3 | Potassium | 9 | 42 | 49 |
| 4 | Zinc | 49 | - | - |
| 5 | Sulphur | 41 | - | - |
| 6 | Iron | 12 | - | - |
| 7 | Copper | 3 | - | - |
| 8 | Manganese | 4 | - | - |

Source: Vision 2030, iiss.nic.in

**5. Reasons for Low Nutrient efficiency in crop lands**

**5.1. Nutrient supply and Soil Fertility**

a. Susceptibility of N fertilizers to losses by various mechanisms.
b. Imbalanced use fertilizers.
c. Poor management of secondary and micronutrients.
d. Use of high analysis fertilizers like urea and Di Ammonium Phosphate (DAP)
e. Inadequate addition of organic manures.
f. Inappropriate rate, time and method of application.
g. Low status of soil organic carbon and
h. Soil degradation due to high salinity, sodicity, acidity, waterlogging and adverse effect on micro-organisms.

**5.2. Agronomic practices results in low efficiency**

a. Delayed sowing and or planting.
b. Low seed rate resulting in poor crop stand.
c. Poor weed management.
d. Inefficient irrigation and rainwater management.
e. Large scale monoculture and non-inclusion of legumes in cropping systems.
f. Lack of consideration of previous cropping in the same field.
g. Inadequate plant protection.
h. Lack of more efficient N using genotypes.

**6. Methods or Technologies for increasing Nutrient Use Efficiency**

The following are the general ways or approaches to minimize Nutrient losses from soil system

a. Identification of the most suitable fertilizer material.
b. Adopting right method of application (split application/band placement).
c. Coating of fertilizer materials with chemicals and organics
d. Judicious and balanced application of fertilizers for synergistic interactions.
e. Application of organic sources along with mineral fertilizers esp., micronutrients.
f. Efficient agronomic management practices such as tillage, irrigation, mulching, weed control, plant population and use of varieties with higher NUE.

In addition to the above general methods the following specific methods may be adopted to achieve maximum use efficiency and to minimize nutrient loss

**6.1. Reducing gaseous loss**

Applied Nitrogen is lost from soil by volatilization of ammonia and part of the nitrogen is lost as $N_2O$ and $N_2$ gas by denitrification. Volatilization loss of ammonia can be minimized by mixing of nitrogen fertilizers in soil rather than broadcasting on soil surface, deep placement of Urea Super Granules (USG) in puddle rice field, using urease inhibitors like thiourea, methyl urea, caprylohydroxamic acid, Phenyl Phosphoro Diamidate (PPD), ammonium thiosulphate etc. Some coated material like Sulphur Coated Urea (SCU), Neem Coated Urea (NCU), Gypsum Coated Urea (GCU), Plastic Coated Urea (PCU), mud ball urea and synthetic slow release urea based fertilizers *viz.,* Iso Butylidene Di Urea (IBDU) and Crotobylidene Di Urea (CDU) etc. may be used to retard the rate of urea hydrolysis and thereby, reducing ammonia volatilization.

**6.2. Reducing leaching loss**

Mobile nutrients like nitrogen is lost from the soil-plant system with the percolating water which may pollute the groundwater. The groundwater having more than 10 mg (nitrate) $NO3^-$ per litre is unfit for drinking purpose (WHO). Leaching loss of nitrate can be minimized by balanced fertilization, split application of urea synchronizing with crop demand, manipulation of water application and rooting depth, appropriate crop rotations and use of slow release fertilizers and nitrification inhibitors like N-serve, DCD, AM, CCC and neem-coated urea.

### 6.3. Reducing runoff and erosion losses

Many water-soluble nutrients are lost through runoff. This loss can be minimized by proper land management and selection of proper crops and cropping systems, tillage and mulching. Nutrients sorbed on the surface of soil particles – clay, silt and soil organic matter are lost when the top soil is eroded by water or wind. Thus, proper soil conservation measures should be adopted to minimize these loss.

### 6.4. Reducing fixation of nutrients in soil

Nutrient fixation mostly regulated by soil pH, in acid soils phosphorus is fixed as Fe and Al phosphates and in neutral and calcareous soils it gets fixed as Ca & Mg-phosphate. The availability of these fixed phosphates to plants is very low. Phosphate-fixation in acid soil can be reduced by combined application of rock phosphate and single super phosphate and liming of acid soils. In both acid and calcareous soils phosphorus fixation can be minimized by band placement of phosphatic fertilizers along with crop rows. Vesicular-Arbuscular Mycorrhizal (VAM) fungi are helpful in mobilizing both applied and native P reserves. Similarly potassium and ammonium ions are also fixed in the interlayer of 2:1 clay minerals like illite, vermiculite etc.

### 6.5. Integrated plant nutrient management system

The high cost of fertilizers coupled with relatively greater losses of fertilizer N leading to environmental pollution and yield decline over the year's calls for a cheaper and more sustainable measure to improve productivity by substituting part of the inorganic fertilizers by organic sources of nutrients. Organic sources of nutrients alone cannot sustain the crop yield at higher level to meet the demand of growing population. There is need to combine the use of inorganic fertilizers and organic sources of nutrients *viz*., manures, green manures, crop residues, biofertilizers etc., in a synergistic manner, which is referred as Integrated Plant Nutrient Supply (IPNS) System. Integrated nutrient supply system sustains and improves the physical, chemical and biological health of soil and enhances the availability of both applied and native soil nutrients during growing season of the crops.

### 6.6. Enhancing recovery of added nutrients by crops

The nutrient management practices that help in enhancing nutrient recovery by crops, maximizing yield and minimizing losses of nutrient include selection of crops and cropping systems, balanced nutrition application and selection of proper, rate, time and method of nutrient application, optimum interaction with other inputs and amelioration of problem soils.

### 6.7. Selection of crops and cropping systems

Proper genotype of a crop should be selected which can mine the nutrients from soil and applied sources and converts them into desired output. Crops and cropping systems should be selected such that the residual nutrient left by one crop is efficiently utilized by the following crops.

### 6.8. Balanced fertilization

Major factor responsible for the low and declining crop response to fertilizers is the continuous mining of soil without adequate replenishment to a desired extent called imbalanced fertilization. The continuous use of N fertilizers alone or with inadequate P and K application has led to mining of native soil P and K. it is estimated that about 28 million tones of NPK are removed annually by crops in India, while only 18 million tonnes or even less are added as fertilizer, leaving a net negative balance of 10 million tonnes. Further, soil are getting continuously depleted of S and micronutrients like Zn, B, Fe and Mn due to continued adoption of intensive cropping systems and use of high analysis fertilizers without adequate addition of organics. Balanced fertilizer use at the macro level in India is generally equated with a nutrient consumption ration of 4:2:1 (N: $P_2O_5$:$K_2O$). The N: $P_2O_5$:$K_2O$ ratio is as wide as 30.8:8.8:1 in Punjab, 48.2,14.9:1 in Haryana and 53.0:19.3:1 in Rajasthan compared with all India average of 6.7 : 2.7 : 1.0 (Annual Report 2018-19, Ministry of Agriculture, Cooperation and Farmers Welfare, GOI). Balanced fertilizer involves use of fertilizer nutrients in right proportion and in adequate amount are considers as promising agro-techniques to sustain yield, increase fertilizer use efficiency and to restore soil health (Yadav *et al.* 1998). This can be achieved by testing the soils prior to cropping followed by soil test based fertilizer recommendation. Soil Test Crop Response (STCR) based fertilizer recommendation is being generated for various crop and soils in Tamil Nadu and are well validated for adoption at farm level.

### 6.9. Organic manures

Organic manures are important to enhance use efficiency of fertilizer inputs and also serve as alternative source of nutrients to chemical fertilizers. Combined use of organic manure and N fertilizer maintains a continuous N supply, checks losses and thus helps in more efficient utilization of applied fertilizers. Incorporation and decomposition of organic manures has a solubilising effect on native soil N and other nutrients including micronutrients. Inclusion of legumes in cropping systems for green manuring, fodder or grain purposes is an assured agro-technology to improve nutrient-use efficiency, especially that of N. The advantages of green manuring are indicated by increased N availability in soil, higher recovery of green manure N and its greater contribution towards grain production of crop.

### 6.10. Selection of source, rate, and time and method of nutrient application

The nature of fertilizer used and the rate, time and method of its application influences the recovery of the added nutrient by crop plants and it varies with the crop and root type. Ammonium nitrate is considered to be a better source of nitrogenous fertilizer for upland crops whereas ammonical and amide form of N are superior to the nitrate containing sources for lowland rice crop. However, urea is the most economic source of nitrogeneous fertilizer. Fertilizer rates greater than the optimum level lead to lower utilization efficiency. Timing of fertilizer application should match with the crop demand especially during critical crop growth stages. Split application of N is superior to basal application. Phosphorus is usually applied as basal and in some light textured soils split application of K is advisable.

### 6.11. Drip Fertigation

Drip fertigation has potential to reduce fertilizer dose in comparison to surface application in many crops by increasing its' use efficiency in soils. Research and field trails proved that application of 75 % of recommended dose of fertilizers (as water soluble fertilizers) through drip irrigation resulted in higher yield, increased use efficiency and loss to environment. Thus, increased nutrient use efficiency can be achieved with decreasing dose of N, P and K.

### 6.12. Crop rotation involving legumes

Crop rotations involving growing legumes always beneficial for Biological Nitrogen Fixation (BNF) and subsequent use by crop plants. Nitrogen use efficiency can be increased in cereals - legumes system than in cereals - cereals or fallow system. N derived from BNF in legumes varies from 40-80 percent and residual effect on succeeding crops is variable and depends on several factors. The more intensive systems (growing more crops in a given period of time) require greater fertilizer N inputs but are economically advantageous to farming community.

## 7.0. Conclusions

Consumption of fertilizer nutrients by global agricultural practices is around 200 million tonnes (NPK) of which the use efficiency stands less than 50 % compared to 68 % in the early 1960s (Luis Lassaletta *et al.*, 2014). This means that more than half the N and P used for crop fertilization is currently lost into the environment, eventhough a significant improvement in nutrient use efficiency through the adoption of various practices occurred in many countries. Continuous improvement in cropping system performance is a fundamental objective to achieve high yield and crop productivity. In that respect, improvement of agronomical practices and adoption of any alone or in combination of the above discussed methodologies will helps to increase the nutrient use efficiency besides reducing the loss and subsequent impact on the environment.

# NANO UREA AN INNOVATION in Agriculture

---

## IFFCO LAUNCHED NANOTECHNOLOGY LIQUID UREA

Presently Agriculture in our country is facing a wide range of challenges andthe important are,. crop yield stagnation, decrease in arable land due to land degradation and urbanization, declining crop nutrient use efficiency,deficiencies of more crop nutrients in the soil, declining soil organic matter and soil health, dearth of irrigation water availability resulting declined crop production and productivity.

Under these challenges, it would be an arduous challenge to produce enoughfood to feed the ever increasing populations, in our country which is expected to cross 2 billion by 2050.

Nanoscience and Nanotechnology research in agriculture and horticulture is a note worthy and a welcome harbinger under thepresent scenario to boost sustainable agriculture.

Conventional bulk fertilizers are not only expensive for the farmers, but tosome extent may be harmful to the environment also.

This has led to the search to produce environmentally friendly fertilizers or smart fertilizer, mainly with high nutrient-use efficiency, and nanotechnology is propelling as a promising and a wishful alternative to derive more benefits to the farmers ensuring the sustainability of crop production necessitates exploring other sources of nutrients and modifying prevalent nutrient sources.

Nanotechnology, which utilizes nanomaterials of less than 100 nm size, may offer an unprecedented opportunity to develop concentrated sources of plant nutrients having higher-absorption rate, utilization efficacy, and minimum losses.

Nanofertilizers are being prepared by encapsulating plant nutrients into nanomaterials, employing thin coating of nanomaterials on plant nutrients, and delivering in the form of nano-sized emulsions.

The stomatal openings in plant leaves facilitate the nanomaterial uptake and their penetration deep inside the plant system leading tohigher nutrient use efficiency (NUE).

In agriculture, nanotechnology products are being tested by the research institutions for various crops under various varied climatic zones and confirmed the efficient uptake or slow release of active ingredients.

Nano technology in Nano fertilizer used for both materials of a physical diameter between 1 and 100 nm (nano meter) in atleast one dimensions and those existing at the bulk scale with more than100 nm in size but that have been modified with nanoscale particles.

The exceptional properties of nanoparticles, such as high surface area/volume size ratio and enhanced optoelectronic and physicochemical properties, compared to bulk fertilizers, is now emerging as a promising strategy to promote plant growth and crop productivity enhancement.

Nano fertilizers have the potential to mobilize other inherent nutrients, suchas phosphorous and potash.

Major advantages of Nano fertilizer over Conventional bulk fertilizers

Farmers mainly apply conventional bulk fertilizers through the soil by either surface broadcasting, subsurface placement, or as fertigation or solubilizing with irrigation water.

However, the fate of large portion of applied fertilizers is lost due to volatalisation in to the atmosphere or enters to water bodies, finally pollutingour ecosystems.

For example, the 75% N of urea after application in the field lost through volatilization (as NH3 or emission as N2O or NO) or through NO3 leaching orrunoff to water bodies.

The current N fertilizers, therefore, face the problem of low nitrogen useefficiency (<20%), whereby loss of N in the environment causes eutrophication and greenhouse gas increase.

It can be seen that key macronutrient elements, including N, P, andK, applied to the soil are lost by 40–70 %, 80–90 % and 50–90%, respectively, causing a considerable loss of resources.The excess phosphorus become "fixed" in soil, causing P fixation in the soil where it forms chemical bonds with other nutrients and becomes unavailable for uptake of nutrient by the plants.

The Important benefits of nano fertilizers over conventionalfertilizers rely on

(a) Their nutrient delivery system as they regulate the availability of nutrients in crops through slow/control release mechanisms. Such a slowdelivery of nutrients is associated with the covering or cementing of nutrients with nanomaterials.

By taking advantage of this slow nutrient delivery, the farmers can increase their crop growth because of consistently long-term delivery of nutrients to plants. For example, nutrients can be released over 40–50 days in a slow release fashion rather than the 4–10 days by the conventional fertilizers.

(b) In addition, nano fertilizers required in small amount which reduce the exhobitant cost on transportation and field application.

(c) An additional major advantage is over accumulation of salt in soil can be minimized as it required in small quantities.

(d) Another advantage for using nano fertilizers is that they can be synthesized according to the nutrient requirements of planned crops. In this regard, biosensors can be attached to a new innovative fertilizer that controls the delivery of the nutrients according to soil nutrient status, growthperiod of a crop or environmental conditions.

(e) The miniature size, high specific surface area and high reactivity of nanofertilzers increase the bio availability of nutrients.

(f) Providing balanced nutrition, nano fertilizers facilitate the crop plants to fight various biotic and abiotic stresses.

It is also reported through research conducted in several crops, thatuse of nanofertlizers and nano materials enhanced the growth and yield in several crops relative to plant treated with conventional fertilizers

However, the extensive use of nano fertilizers in agriculture may have some important limitations, which must also be considered and it is crucial to determine the toxicity/bio compatibility of nano fertilizers..on the crop plants.

Cooperative giant IFFCO has launched the maiden Nano Urea Liquid, a nutrient to provide nitrogen to plants as an alternative to the conventional urea which is equivalent to the impact of nitrogennutrient provided by one bag of conventional urea

The Nano Urea Liquid, developed by IFFCO will be available in 500 ml bottlesand IFFCO has priced Nano Urea at Rs 240 per 500 ml bottle for the farmers, which is 10% cheaper than the cost of a bag of conventional Urea.

IFFCO, says that it has further tested this Liquid Nano Urea in more than 11,000 farmers' fields for 94 crops like rice and wheat and proved that It is more effective than the conventional granular urea as the conventional urea is effective 30-40 per cent in N use efficiency to plants, while the use efficiency by the crops of the Nano Urea Liquid used is over 80per cent.

Nano fertilizers applied alone or in conjunction with organic materials have the potential to reduce environmental pollution owing to significant less losses and higher absorption rate. In addition, nanomaterials were recorded to improve germination rate, plant height, root development and number of roots, leaf chlorophylland fruits antioxidant contents

Moreover, controlled and slow released fertilizers having coating of nano particles, boost nutrient use efficiency and absorption of photosynthetically active radiation along with considerably lower wastage of nutrients will be a boon and an asset to the farmers of INDIA...