Chapter 3- Soil Science

Technology no.1

1. **Name of technology:** Zinc management in low land Rice-Rice cropping system
2. **Source of technology:** RARS, Titabor, AAU
3. **Year of release:** 2015
4. **Agro-climatic zone:** UBVZ and BVZ of Assam
5. **Detail description of technology:** Application of zinc sulphate @ 25 kg/ha

   Management Practices:

   Seed treatment: Mancozeb @ 2.5 g/ kg or Captan @ 2.5 g/ kg

   Land preparation: Thoroughly Puddled

   Manuring: FYM @ 2 ton/ ha

   Fertilization: Basal application of 25 kg $ZnSO_4$/ha (3 kg $ZnSO_4$/bigha) in every three years interval in addition to recommended dose of fertilizers along with 2 t FYM/ha for Sali rice.
6. **Critical inputs required:** Zinc Sulphate
7. **Observations to be recorded:** Temperature (0C), Rainfall (mm), Date of sowing, Date of germination, Date of planting, Date of weeding, Days to 50% flowering, Plant height (cm), Number of ear bearing tillers/m2 , Grain per panicle, Grain type, Pest infestation, Disease infestation, Grain yield (q/ha), B: C Ratio, Farmers' reaction.

Technology no. 2

1. **Name of technology:** INM in utera cropping of Lathyrus in Rice
2. **Source of technology:** RARS, Shillongoni, Nagaon, AAU
3. **Year of release:** 2015
4. **Agro-climatic zone:** All agroclimatic zones of Assam
5. **Detail description of technology:**

   - **Without rhizobium and PSP inoculation**:
     - i. Application of 7.5 kg N and 17.5 kg P_2O_5/ha at the time of sowing before rice harvest
     - ii. Application of second dose @ 7.5 - 17.5 - 15 kg N, P_2O_5, K_2O/ ha at the time of rice harvest. [The fertilizers are to be incubated for 48 hours with compost/ moist soil in 1: 10 ratio before applying]
     - iii. Apply two foliar sprays of 2% urea at branching and pod initiation stages

   - **With rhizobium and PSB inoculation (50 g/kg):**
     - i. Apply 5.0 kg N and 13.0 kg P_2O_5/ha at the time of sowing before rice harvest

ii. Apply second dose @ 5 - 13 - 15 kg N, P2O5, K2O/ ha at the time of rice harvest. [The fertilizers are to be incubated for 48 hours with compost/ moist soil in 1 : 10 ratio before applying]

iii. Apply two foliar sprays of 2% urea at branching and pod initiation stages

Variety: Ratan/Nirmal/Madhuri (JL-1)

Management Practice:

Seed rate: 50 kg/ha

Sowing time: Mid-October to mid-November when soil is at saturation

Duration: 120-125 days

6. **Critical inputs required:** Biofertilizers, fertilizers, organic manure, and variety.
7. **Observations to be recorded:** Initial and final nutrient status in soil, Soil moisture,Nutrient uptake, Plant height (cm), plant stand, pod/plant, seed/pod and seed yield (q/ha), Rainfall and temperature throughout the crop growing period, B: C ratio, Farmers'reaction.

Technology no. 3

1. **Name of technology:** Phosphorous management in Rice-Linseed sequence
2. **Source of technology:** RARS, Shillongoni, Nagaon, AAU
3. **Year of release:** 2017
4. **Agro-climatic zone:** All agro-climatic zones of Assam
5. **Detail description of technology:**

Crop: Linseed

Variety: Rice- Ranjit (June 1st week sown), Linseed- T-397 (Mid Oct. to Mid Nov.)

Treatment: In rice 75% of RD of P2O5 + PSB (50 g/kg seed)

In Linseed 75% of RD of P2O5

Management Practice:

Seed rate: 20 kg/ha

Fertilizer: dose Rice: 40: 20: 40 kg of N: P2O5: K2O/ ha

Linseed: 40: 20: 10 kg of N: P2O5: K2O/ ha

Spacing: 25 cm x 10 cm

6. **Critical inputs required:** Variety, Phosphorus, PSB
7. **Observations to be recorded:** Initial fertility status of the soil, Date of sowing and harvest, Incidence of pest and diseases, Yield and yield attributing characters, B: C ratio, Farmers' reaction

Technology no. 4

1. **Name of technology:** INM in irrigated wheat
2. **Source of technology:** RARS, Shillongoni, Nagaon
3. **Year of release:** 2017
4. **Agro-climatic zone:** All zones except Barak valley zone
5. **Detail description of technology:**

   Treatment:

   T1: 75% Recommended fertilizer + Azotobacter and PSB (50 g each/ kg seed)

   T2: 100% Recommended fertilizer (Control)

   Management Practice:

   Variety: Any recommended variety or released variety for NEPZ

   Seed rate: 100 kg/ha

   Spacing: 20 cm row to row

   Sowing time: Nov.5th to 20th (NBP Zone), 5th Nov. to 15th Dec. (CBV & LBV Zone)

   Fertilizer: dose as per recommended fertilizer doses for different Agril.

   Sub-division
6. **Critical inputs required:** Fertilizers, biofertilizers
7. **Observations to be recorded:** Temperature (0C), Rainfall (mm), Date of sowing, Date of germination, Date of planting, Date of weeding, Days to 50% flowering, Plant height (cm), Number of ear bearing tillers/m2 , Grain per panicle, Grain type, Pest infestation, Disease infestation, Grain yield (q/ha), B: C ratio, Farmers' reaction, Soil status.

Technology no. 5

1. **Name of technology:** INM in Chilli
2. **Source of technology:** Assam Agricultural University
3. **Year of release:** 2015
4. **Agro-climatic zone:** All zones of Assam
5. **Detail description of technology:** Treatment: Biofertilizer (Azotobacter + PSB) @ 2kg + vermicompost 1 t/ha incubated for 15 days and N: P: K @ 60: 30: 30 kg/ha mixture applied as circular band placement at 10 and 30 days after planting (DAP).
6. **Critical inputs required:** Fertilizers, biofertilizers, vermicompost
7. **Observations to be recorded:** Temperature (0C), Rainfall (mm), Date of sowing, Date of germination, Date of planting, Date of weeding, Plant height (cm), No. Of fruits/plant, Pest infestation, Disease infestation, Grain yield (q/ha), B: C ratio, Farmers' reaction, Soil status.

Technology no. 6

1. **Name of technology:** Performance of Biofertilizers in *kharif* blackgram and greengram
2. **Source of technology:** RARS, Shillongoni, Nagaon, AAU
3. **Year of release:** 2015
4. **Agro-climatic zone:** All zones of Assam
5. **Detail description of technology:**

   Technology Seed inoculation with Rhizobium and PSB each @ 50 g/kg seed (seeds are to be moistened carefully with water so as to avoid excessive wetting. Rhizobium and PSB culture is to be mixed with seeds @ 50 g each culture per kg of seed so that a thin layer of inoculums I deposited over the seed coat. Treated seeds are to be dried under shade. Inoculated seed should not be exposed to sun)

   Management Practice

   Seed rate: Blackgram: 22.5 kg/ha; Greengram: 20 kg/ha

   Spacing: 30 X 10 cm

   Sowing time: Mid-August to mid September

   Fertilizer: dose 15 : 35 : 15 N: P2O5: K2O kg/ha

   Land preparation: 3-4 ploughings followed by laddering
6. **Critical inputs required:** Rhizobium and PSB
7. **Observations to be recorded:** Initial and final nutrient status in soil, Nutrient uptake,Date of sowing and harvest, Plant height, plant stand, pod/plant, seed/pod and seed yield (q/ha), Rainfall (mm), and temperature(0C), throughout the crop growing period, Farmers' reaction.

Technology no. 7

1. **Name of technology:** Performance of Biofertilizers in *kharif* blackgram andgreengram.
2. **Source of technology:** RARS, Shillongoni, Nagaon, AAU
3. **Year of release:** 2015
4. **Agro-climatic zone:** All zones of Assam
5. **Detail description of technology:** Technology Seed inoculation with Rhizobium and PSB each @ 50 g/kg seed (seeds are to be moistened carefully with water so as to avoid excessive wetting. Rhizobium and PSB culture is to be mixed with seeds @ 50 g each culture per kg of seed so that a thin layer of inoculums I deposited over the seed coat. Treated seeds are to be dried under shade. Inoculated seed should not be exposed to sun).

   Management Practice

   Seed rate: Blackgram : 22.5 kg/ha; Greengram : 20 kg/ha

Spacing: 30 X 10 cm

Sowing time: Mid-August to mid September

Fertilizer: dose 15 : 35 : 15 N: P2O5: K2O kg/ha

Land preparation: 3-4 ploughings followed by laddering

6. **Critical inputs required:** Rhizobium and PSB
7. **Observations to be recorded:** Initial and final nutrient status in soil, Nutrient uptake,Date of sowing and harvest, Plant height, plant stand,pod/plant, seed/pod and seed yield(q/ha), Rainfall(mm), and temperature(0C), throughout the crop growing period, Farmers' reaction.

Technology no. 8

1. **Name of technology:** INM in lentil along with Biofertilizer component
2. **Source of technology:** RARS, Shillongoni, Nagaon, AAU
3. **Year of release:** 2015
4. **Agro-climatic zone:** All zones of Assam
5. **Detail description of technology:** Application of 10: 20 : 15 N: P2O5: K2O kg/ha along with vermicompost 1 t/ha or FYM 2 t/ha as basal and seed inoculation with Rhizobium and PSB each @ 50 g/kg of seed (seeds are to be moistened carefully with water so as to avoid excessive wetting. Rhizobium and PSB culture is to be mixed with seeds @ 50 g each culture per kg of seed so that a thin layer of inoculums I deposited over the seed coat. Treated seeds are to be dried under shade. Inoculated seed should not be exposed to sun)

Management Practice

Seed rate: 30 kg/ha

Spacing: 25 cm between rows

Duration: 115-120 days

Sowing time: Mid-October to mid-November

Fertilizer dose: 10 : 20 : 15 N: P2O5: K2O kg/ha

Land preparation: 3-4 ploughings followed by laddering

6. **Critical inputs required:** N, P, K, vermicompost/FYM, Rhizobium, PSB
7. **Observations to be recorded:** Initial and final nutrient status in soil, Nutrient uptake, Plant height (cm), plant stand, pod/plant, seed/pod and seed yield (q/ha), Rainfall(mm) and temperature(0C), throughout the crop growing period, B: C ratio, Farmers' reaction, Soil status.

Technology no. 9

1. **Name of technology:** INM in lentil with Foliar spray of Nitrogen
2. **Source of technology:** RARS, Shillongoni, Nagaon, AAU
3. **Year of release:** 2017
4. **Agro-climatic zone:** All zones of Assam
5. **Detail description of technology:**

   Technology: T1 Application of 75% of RD along with vermicompost@ 0.5 t/ha and 2 sprays of 2% urea at branching and pod initiation stages.

   T2: Application of 50% of RD along with vermicompost 1 t/ha as basal and 2 sprays of 2% urea at branching and pod initiation stage

   Management Practice

Variety:	HUL 57/PL 406
Seed rate:	30 kg/ha
Spacing:	25 cm between rows
Duration:	115-120 days
Sowing time:	Mid-October to mid-November
Fertilizer dose:	15 : 35 : 15 kg N: P2O5: K2O /ha
Land preparation:	3-4 ploughings followed by laddering

6. **Critical inputs required:** N, P, K, Vermicompost, Urea,
7. **Observations to be recorded:** Initial and final nutrient status in soil, Nutrient uptake, Plant height (cm), plant stand, pod/plant, seed/pod and seed yield (q/ha), Rainfall(mm) and temperature(0C), throughout the crop growing period, B: C ratio, Farmers' reaction, Soil status.

Technology no. 10

1. **Name of technology:** INM in Rajmah
2. **Source of technology:** RARS, Shillongoni, Nagaon, AAU
3. **Year of release:** 2015
4. **Agro-climatic zone**: All zones of Assam
5. **Detail description of technology:**

   Technology: Application of 60 : 45 : 40 : kg N: P2O5: K2O /ha along with seed inoculation with PSB @ 50 g/kg of seed and three sprays of 2% urea at pre-flowering (45 DAS), 25% pod initiation (60 DAS) and pod development (70 DAS) stages (nitrogen in two equal splits as basal and top dressing at 30 DAS

Management Practice:

Variety:	HUR 301/HUR 203
Seed rate:	75 kg/ha
Spacing:	30 X 10 cm
Duration:	95-105 days
Sowing time:	November 20-30
Fertilizer dose:	60 : 45 : 40 (N: P2O5: K2O) kg/ha
Land preparation:	3-4 ploughings followed by laddering

Bio – fertilizer: PSB 50 g/kg seed Irrigation One each at pre-flowering and pod Initiation stage

6. **Critical inputs required:** N, P, K, PSB, Urea
7. **Observations to be recorded:** (including cost benefit ration) Initial and final nutrient status in soil, Nutrient uptake, Plant height, plant stand, pod/plant, seed/pod and seed yield (q/ha), Rainfall and temperature (0^C), throughout the crop growing period, B: C ratio, Farmers' reaction, Soil status.

Technology no. 11

1. **Name of technology:** Integrated nutrient management in Toria
2. **Source of technology:** RARS, Shillongoni, Nagaon, AAU
3. **Year of release:** 2015
4. **Agro-climatic zone:** All zones of Assam
5. **Detail description of technology:**

   Technology: Integrated nutrient management Application of 75% of recommended dose of N and P and 100 % RD of K when seeds are inoculated with Azotobacter @ 40 g/kg seed and PSB @ 40 g/kg seed for toria.

   Management Practice:

Seed rate:	10 kg/ha
Spacing:	30 cm between rows and 5-7 cm between plants
Duration:	90-95 days
Sowing time:	Mid October to end of November

6. **Critical inputs required:** N, P, K, Azotobacter, and PSB
7. **Observations to be recorded:** Temperature (0C), Rainfall (mm), Date of sowing, Date of germination, Date of planting, Date of weeding, Days to 50% flowering, Plant height (cm), Siliqua/plant, Grain/siliqua, Pest infestation, Disease infestation, Grain yield (q/ha.), B: C ratio, Farmers' reaction, Soil status.

Technology no. 12

1. **Name of technology:** INM in Olitorious Jute
2. **Source of technology:** Assam Agricultural University
3. **Year of release:** 2015
4. **Agro-climatic zone:** All zones of Assam
5. **Detail description of technology:** Seed inoculation with biofertilizers *i.e.* Azotobacter @ 50 g/kg seed and PSB @ 50 g/kg seed and application of 50% N + 50% P2O5 + 100% K2O of RD of fertilizer (i.e. 15-12.5-30 N- P2O5-K2O kg/ha) as basal.
6. **Critical inputs required:** Fertilizers, biofertlizers
7. **Observations to be recorded:** Rainfall (mm), yield attributes, yield (q/ha), fibre length, B: C Ratio, Farmers' reaction, soil nutrient status.

Technology no. 13

1. **Name of technology:** Nutrient management in Rapeseed and Mustard
2. **Source of technology:** Assam Agricultural University
3. **Year of release:** 2015
4. **Agro-climatic zone:** All zones of Assam
5. **Detail description of technology:** Two foliar applications of 1% urea at flowering and pod filling stages along with basal application of recommended fertilizer dose, *i.e.* 60 kg N, 30 kg P2O5 and 30 kg K2O/ha for rapeseed and mustard.
6. **Critical inputs required:** Fertilizers (urea)
7. **Observations to be recorded:** Rainfall (mm), yield attributes, yield (q/ha), B: C Ratio, Farmers' reaction, soil nutrient status.

Technology no. 14

1. **Name of technology:** Nutrient management in Sali Rice under low input condition
2. **Source of technology:** Assam Agricultural University
3. **Year of release:** 2015
4. **Agro-climatic zone:** All zones of Assam
5. **Detail description of technology:** Application of vermicompost (1t/ha) along with FYM (2.5 t/ha) under low input (N: P2O5: K2O @ 20: 10: 10 kg/ha) medium land situation.
6. **Critical inputs required:** Vermicompost, FYM, N, P, K
7. **Observations to be recorded:** Rainfall (mm), yield attributes, yield (q/ha), B: C Ratio, Farmers' reaction, soil nutrient status.

Technology no. 15

1. **Name of technology:** Low cost Vermicomposting technology
2. **Source of technology:** Assam Agricultural University
3. **Year of release:** 2015
4. **Agro-climatic zone:** All zones of Assam
5. **Detail description of technology:** Low cost vermicompost unit fabricated using high quality polyethylene sheet supported with a bamboo structure with 2.5 m (L) × 0.91 m (B) × 0.91 m (D)

- Drainage hole is to be provided at the base of the structure for drainage of excess water from the unit.
- The vermicomposting unit should be filled with partially decomposed waste material and cowdung in 60: 40 ratio followed by subsequent release of 750 gm earthworms.
- A temporary shed made of bamboo and polyethylene sheet has to be provided for protection of units from adverse climatic condition.
- A drain surrounding the vermicposting unit needs to be laid out and kept filled with water as a preventive measure against attack of ants.

6. **Critical inputs required:** Polythene sheet, bamboo, waste materials, cow dung, earthworm,
7. **Observations to be recorded:** Rainfall (mm), B: C Ratio, Farmers' reaction, nutrient content.

Technology no. 16

1. **Name of the technology:** Root-dipping in SSP-MC Slurry Method of P Management
2. **Source of the technology:** Central Agricultural University (Imphal**)**
3. **Year of release:** Have to be released
4. **Agro-climatic zon**Suitable to transplanted rice grown in acidicsoils
5. **Detail description about the technology:**

   Rationale of the technology: The deficiency of phosphorus (P) is widespread especially in acidic soils of the world. In NE India, production of rice is mainly constrained by aluminum (Al) and iron (Fe) induced phosphorous (P) deficiencies. More than 81% soils of North East India suffer from this cause. The use efficiency of water soluble inorganic P fertilizer *viz.* single super phosphate exhibits hardly 15-20% of the applied quantity in a crop season. So, the application of higher quantity of inorganic P fertilizer is mere a wastage of poor farmers' money and can also pose a cause to environmental pollution. As an alternative to conventional way of P management in acid soil, the rhizosphere-based P management approach seems to be pertinent in acid soils for enhancing P-use efficiency and yield of crops because: (a) *There are no substitutes for P in agriculture* and (b) a *potential Global P* *crisis* in near future. The strategies for the aforementioned technology are 3 folds: (1) To increase tissue P content at the seedling stage for better root growth, (ii) to synchronize the rates of P mineralization in soil and P uptake in rice throughout the crop growing period and (iii) To minimize P fixation and mineralization as Fe- and Al-phosphates in the rhizosphere.

Methodological description:

Step-I: Root dipping in soil-water slurry amended with SSP:

A mud slurry bed (45 sq.m.) is prepared in one corner of the main field (area 1 ha). An amount of 7.0 kg SSP is to be mixed thoroughly with mud. Roots of uprooted rice seedling bundles need to be washed free of adhered mud and then roots are to be dipped in the SSP amended mud slurry bed for over-night (optimum duration is 10h). The optimum dose of P applied in the mud slurry bed is 112.5 mg per kg mud slurry.This treatment is usually carried out in the evening hour and seedlings get ready for microbial consortium treatment in the next morning. See Fig.1.

Step-II: Root-dipping in soil-water slurry amended with MC:

Similar to SSP root-dip treatment, a mud slurry bed (45 sq.m.) is to be prepared in one corner of the main field. Approximate 5 kg finely grounded dry compost/FYM along with either 4.0 kg MC biofertilizer (if solid carrier based formulation) or 500 ml liquid MC biofertilizer are to be mixed thoroughly with mud in the slurry bed. Addition of finely grounded dry compost/ FYM increase stickiness of mud. The SSP slurry treated roots of rice seedling bundles are to be dipped in to MC amended mud slurry bed and incubated for 2 h. After this treatment, seedlings are ready for transplanting in the main field. See Fig.1.

Step-III: Prior to transplantation of the SSP-MC treated rice seedlings, RP needs to be broadcasted on the main field @125 kg ha^{-1} along with 50% of the recommended dose of Urea (133 kg ha^{-1}) and MOP (66 kg ha^{-1}).

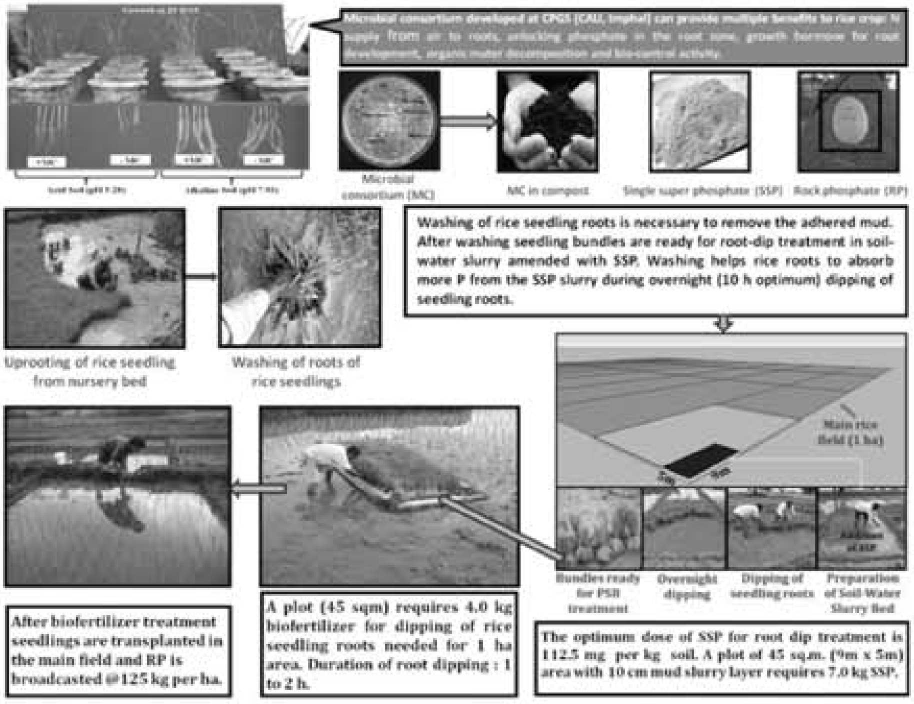

Fig.1: Depiction of Root-Dipping in SSP-MC Slurry Method of P management in acid soil.

6. **Observations to be recorded**
   i. Root growth parameter at 40 to 45 DAT
   ii. Number of effective tillers per hill
   iii. Nos. of grains per panicle
   iv. Grain yield and Biological yield
   v. Harvest Index
   vi. P and Zn concentration in shoot at 45DAT and in edible portion of grain (optional)
7. **Contact address for relevant information**

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   C/o, Dean, College of PG Studies, Central Agricultural University (Imphal), Umiam, Meghalaya.

   Cell No. +91-9436767009, email: thakuria.dwipendra@yahoo.co.in

   Phone No-0364-2570030; e-mail: deancpgs@gmail.com

Technology no.17

1. **Name of the Technology**: Root-dipping in SSP-MC Slurry Method of P Management
2. **Source of the technology**: College of Post Graduate Studies, CAU, Umiam
3. **Year of release**: 2016
4. **Agro-climatic zone**: Suitable to transplanted rice grown in acidic soils
5. **Detail description about the technology** (with suitable photograph)

   Rationale of the technology: The deficiency of phosphorus (P) is widespread especially in acidic soils of the world. In NE India, production of rice is mainly constrained by aluminum (Al) and iron (Fe) induced phosphorous (P) deficiencies. More than 81% soils of North East India suffer from this cause. The use efficiency of water soluble inorganic P fertilizer *viz.* single super phosphate exhibits hardly 15-20% of the applied quantity in a crop season. So, the application of higher quantity of inorganic P fertilizer is mere a wastage of poor farmers' money and can also pose a cause to environmental pollution. As an alternative to conventional way of P management in acid soil, the rhizosphere-based P management approach seems to be pertinent in acid soils for enhancing P-use efficiency and yield of crops because: (a) *There are no substitutes for P in agriculture* and (b) a *potential Global P crisis* in near future. The strategies for the aforementioned technology are 3 folds: (1) To increase tissue P content at the seedling stage for better root growth, (ii) to synchronize the rates of P mineralization in soil and P uptake in rice throughout the crop growing period and (iii) To minimize P fixation and mineralization as Fe- and Al-phosphates in the rhizosphere.

   Methodological description:

   Step-I: Root dipping in soil-water slurry amended with SSP:

   A mud slurry bed (45 sq.m.) is prepared in one corner of the main field (area 1 ha). An amount of 7.0 kg SSP is to be mixed thoroughly with mud. Roots of uprooted rice seedling bundles need to be washed free of adhered mud and then roots are to be dipped in the SSP amended mud slurry bed for over-night (optimum duration is 10h). The optimum dose of P applied in the mud slurry bed is 112.5 mg per kg mud slurry. This treatment is usually carried out in the evening hour and seedlings get ready for microbial consortium treatment in the next morning. See Fig.1.

Step-II: Root-dipping in soil-water slurry amended with MC:

Similar to SSP root-dip treatment, a mud slurry bed (45 sq.m.) is to be prepared in one corner of the main field. Approximate 5 kg finely grounded dry compost/FYM along with either 4.0 kg MC biofertilizer (if solid carrier based formulation) or 500 ml liquid MC biofertilizer are to be mixed thoroughly with mud in the slurry bed. Addition of finely grounded dry compost/ FYM increase stickiness of mud. The SSP slurry treated roots of rice seedling bundles are to be dipped in to MC amended mud slurry bed and incubated for 2 h. After this treatment, seedlings are ready for transplanting in the main field. See Fig.1.

Step-III: Prior to transplantation of the SSP-MC treated rice seedlings, RP needs to be broadcasted on the main field @125 kg ha-1 along with 50% of the recommended dose of Urea (133 kg ha^{-1}) and MOP (66 kg ha^{-1}).

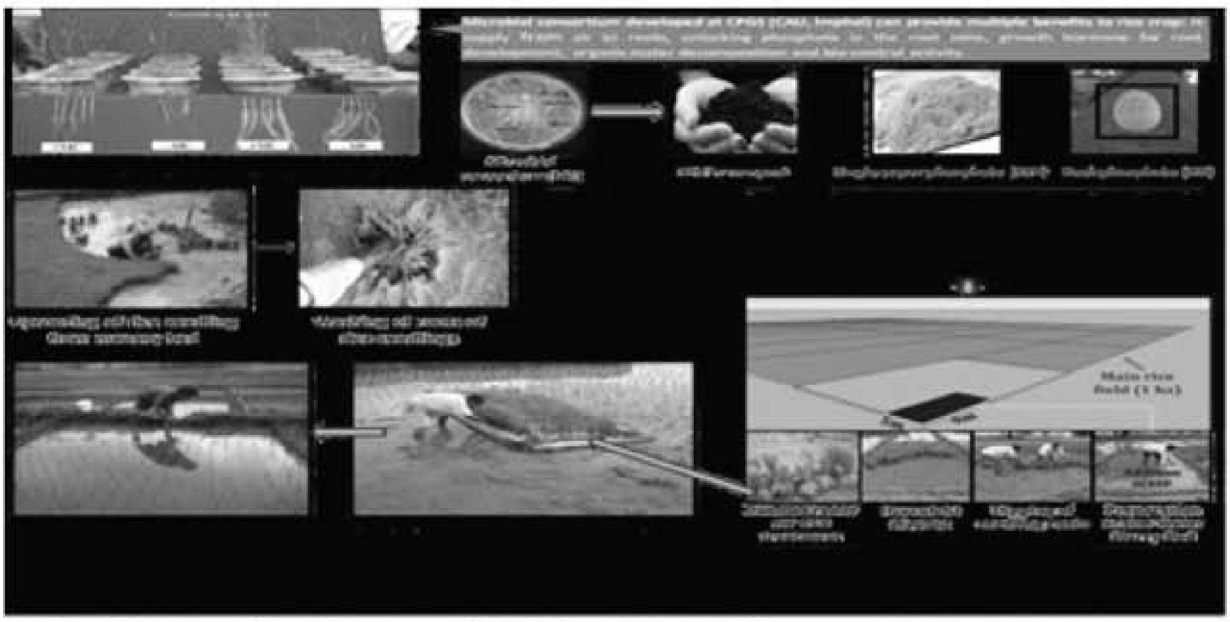

Fig.1. Depiction of Root-Dipping in SSP-MC Slurry Method of P management in acid soil

6. **Observations to be recorded**

   i. Root growth parameter at 40 to 45 DAT

   ii. Number of effective tillers per hill

   iii. Nos. of grains per panicle

   iv. Grain yield and Biological yield

v. Harvest Index

vi. P and Zn concentration in shoot at 45DAT and in edible portion of grain (optional)

7. **Contact address for relevant information**

   Dean, College of PG Studies, Central Agricultural University (Imphal),

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   Mobile No. +91-9436767009, email: thakuria.dwipendra@yahoo.co.in

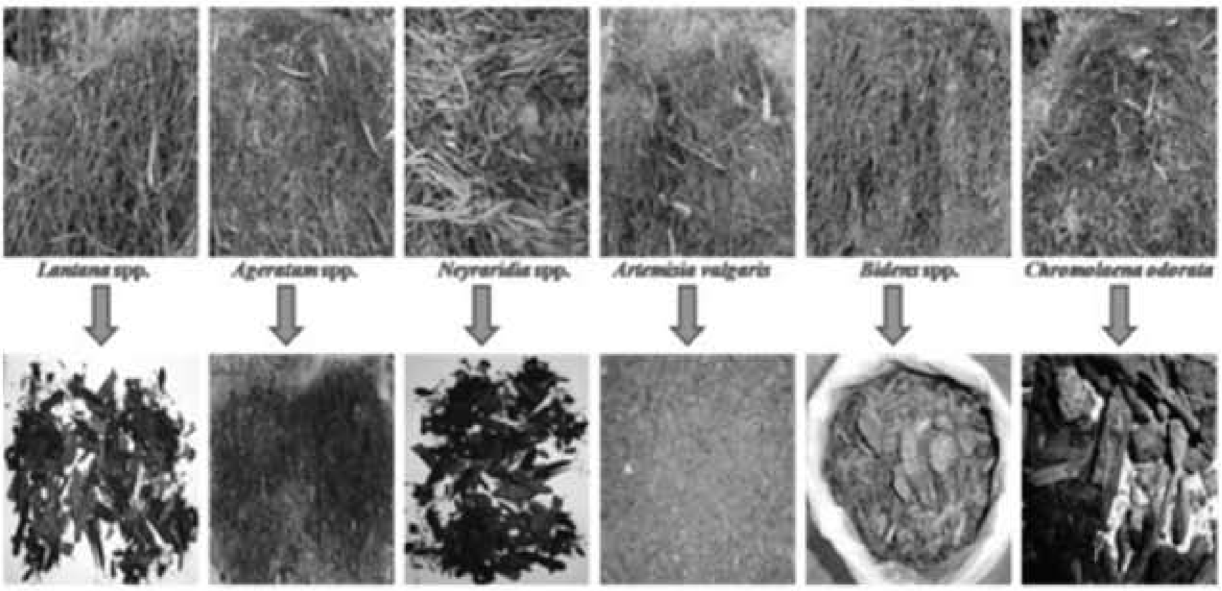
   Phone No-0364-2570030; e-mail: deancpgs@gmail.com

Technology no. 18

1. **Name of the technology:** Biochar technology from locally available weed biomass for acid soil management.
2. **Source of Technology:** ICAR Complex, Sikkim Centre
3. **Year of release:** 2016
4. **Agro-climatic zone:** North East Region with special reference to Sikkim
5. **Details description about the technology (with suitable photograph):**

   Biochar is simply carbon rich charcoal-like substance which is created by heating biomass (organic matter) in limited oxygen condition, through a process known as pyrolysis. If we prepare biochar from locally available weed biomass then it is possible to reduce the weed population in the agricultural field which is a serious problem in organic agriculture. Biochar application increase soil pH, decrease leaching losses of nutrients, enhance nutrient availability and water holding capacity, sequesters huge carbon into soil, decrease N_2O and CH_4 emission into environment, increased nitrogen fixation, root nodule number and nitrogenase activity, remove heavy metals from soil, increase water holding capacity. Biochar should be applied along with other inputs like compost or manure at the same rate every year to realize the actual benefits. Application rates of these organic inputs can be reduced as biochar also contains some nutrients. During conversion of organic residues into biochar, farmers can also obtain an energy yield by capturing energy given off during biochar production process. Biochar is alkaline in nature (pH > 7.0). It can react similarly as dolomite does (by increasing soil pH) and provides an unique opportunity to improve soil fertility for longer period of time. It was found that rates between 5-10 t/ha (0.5-1 kg sqm) have beneficial effect on soil properties and crop yield. Application of higher amounts of biochar to the soil increases the carbon credit benefit to the farmers. During conversion of organic residues into biochar, farmers also obtain an energy yield by capturing energy given off during biochar production process. Biochar increases/improves soil moisture retention upto 20%, nutrient use efficiency upto 15%, CEC upto 35% and crop productivity upto 30%. Biochar increases grain yields (15%) by decreasing leaf SPAD value at sites with low P availability in upland rice.

   ICAR Research Complex for NEH Region, Sikkim Centre, Tadong, Gangtok has utilized six different locally available weed biomass *viz.*, *Ageratum* spp., *Lantana* spp., *Artemisiavulgaris*, *Chromolaena odorata*, *Bidens* spp., *Neyraridia* spp. which were used to prepare biochar. Charring was carried out in a pit (2×2×3 ft^3) to keep the process simple, quick and low cost having production efficiency 13.2, 23.2, 15.1, 16.4, 14.6 and 19.6%, respectively. The biochar prepared from weeds biomass and dolomite were applied at three rates (0, 2.5, and 5.0 t/ha). Amendment type, application rate, and their interaction had significant effects on soil pH ($p<0.05$). Application of *Lantana* spp. biochar had shown a relatively larger increase in soil pH followed by *Ageratum* spp., *Neyraridia* spp., *Artemisia vulgaris*, *Bidens* spp., *Chromolaena odorata*. These weed spp. can be effectively used as potential source of biochar preparation.



6. **Observation to be recorded:** Initial soil properties before sowing of crops and final soil properties after harvest of crops (pH, SOC, N, P, K, micronutrients, BD and available moisture)
7. **Contact address for relevant information:** Joint Director, ICAR-NOFRI, Tadong, Gangtok, Sikkim,

   The Director, ICAR Research Complex for NEH Region, Umroi Road, Umiam, Meghalaya.

Technology no. 19

1. **Name of technology:** Furrow application of lime for improving crop productivity on acid soils
2. **Source of Technology:** Soil Science Section (Division of NRM), ICAR RC NEHR, Umiam
3. **Year of release:** Technology developed over a period of time through various field experiments in trials in farmers' field.
4. **Agro climatic Zone :** Suitable for all acid soils of NEH Region
5. **Detailed Description about the technologywith suitable photographs:**

   Soil acidity is a major constraint to crop productivity in northeastern hill regions of India. About 21 million ha area in the region is affected by soil acidity, of which 16 million ha area is afflicted by high levels of soil acidity (pH <5.5). Many essential nutrients (such as P, Ca, Mg etc) are highly deficient on these soils, while many others present in toxic concentrations (viz. Al, Fe & Mn). These nutritional imbalances severely affect the crop productivity on these soils. Liming is usually recommended to get rid of these nutritional deficiency and toxicity problems. However, the lime requirement for broadcasting and the cost associated therewith are prohibitively very high, which makes this practice unaffordable by the farmers. Keeping this in view, an alternate method of lime application (furrow application of lime @2-4 q/ha) has been found to be more cost effective and easily affordable by the farmers. In this method, lime is applied only in furrow (for furrow grown crops) for every crops,unlike broadcast application which is done usually once in four years.

Furrow application of lime in farmers' field (by a potato growing farmer)

In a series of field trials with different crops including cereals, oilseed, pulses, tuber crops etc. furrow application of lime @ 2-4 q/ha has been found to increase the crop yields by 14-50 percent over farmers' practice. Yield improvement can be further enhanced by applying lime along with NPK fertilizers. The yields with 50% recommended NPK + lime are usually equal or slightly higher than the yields with 100% NPK. Liming can therefore save chemical fertilizers by 50 percent.

Yield under farmers' practice (No lime)Yield under farmers' practice + liming

6. **Critical input requires:** Agricultural lime or lime sludge
7. **Observation to be recorded**
   i. Crop growth and yield parameters (plant height, root length and mass, leaf greenness, crop yield)
   ii. Soil pH, Al toxicity, P availability etc
8. **Contact address of relevant information**

   Division of NRM (Soil Science), ICAR Research Complex for NEH Region, Umiam

Technology no. 20

1. **Name of technology:** Enriched compost (Made from locally available biomass**)**
2. **Source of the technology:** ICAR Research Complex for NEH Region, Umiam
3. **Year of release:** 2014
4. **Agro climatic zones:** Suitable to all type of soils
5. **Details description about the technology with suitable photographs:**

   For preparation of enriched compost, locally available substrates like crop residues (paddy straw, maize stalk etc.), weed biomass (local abundant weed) are converted in to compost with the help of locally available organic nutrient sources as well as judicious use of mineral additives. In the preparation of desired compost, following steps have to be followed.

   i. The dry and hardy substrates (weed biomass & crop residues) are chopped in small size (2.5 to 10 cm, depending on resources) using sharp knife to increase the surface area of biomass for faster decomposition.
   ii. The naturally dry crop residues and weed biomass are mixed with green and succulent ones in roughly equal proportions to maintain the C: N ratio at desired levels to fasten the decomposition.

iii. Pits of 3m (L) x 2m (B) x 1m (D) (or different size, according to convenient) dimensions were dug in a location of the farm which is free from water stagnation. This dimension, can accommodate approximately 3 quintals of mixed substrate.

iv. The sides and the bottom of the pit should be made free from cracks and crevices to avoid the seepage and leaching.

v. Before filling the pit with substrates, the inner sides and bottom of the pit are plastered using the slurry. The slurry consisted of cow dung/poultry excreta/pig dung, soil and well rottencompost in the ratio of 1: 1: 0.5. Slurry prepared from 100 l of water containing 35 kg offresh cowdung/poultry excreta (one month old) /pig dung (one month old), 35 kg dry soiland 17 kg of well rotten compost is enough for a single pit of 3m (L) x 2m (B) x 1 m (D)dimension. Before making slurry, poultry excreta and pig dung are dried under shade, debrisremoved and lumps broken. Slurry is used as microbial inoculum and for supplementingnutrients to the compost.

vi. Plastering with slurry creates a nearly impervious layer that checks seepage loss of nutrients and prevents entry of water from outside. The slurry at the pit bottom also provides an ideal seat for microbial activity.

vii. The most critical part of the whole composting process is proper filling of the pit with layers of substrate, slurry and mineral additives.

viii. Approximately 20cm thick layer of the substrate is placed uniformly on the pit bottom. Care should be taken to avoid too much compaction of the substrate while putting in layers.

ix. After placing each layer of the substrate, the slurry (composition given above) is sprinkled over each of the layers in sufficient quantity to ensure a coating of the whole substrate with slurry, which acts as a sticker that helps the mineral additives to adhere on the substrate.

x. Immediately after sprinkling of slurry, mineral additives are applied to the substrate layer. In general, nitrogen (N) was applied @ 0.5% as urea; phosphorus (P) @ 1.5% as Mussoorie rock phosphate and sulphur (S) @ 0.5% as elemental sulphur are used.

xi. After adding mineral additives, another new layer of substrate is placed in the similar fashion and steps are repeated till the pit gets filled up with substrate and reaches a height of 1ft above the ground level.

xii. The materials inside the pit are moistened with water sufficiently (70% moisture content). After filling the pit, a dome shape is given to the substrates remaining above the ground level.

xiii. The pit top is plastered with a thick layer of the slurry (as above) and care should be taken to maintain proper consistency of the slurry so that cracks do not develop on drying.

xiv. After plastering the pit top, the compost pit is kept as such for 20 days. After 20 days the materials inside the pit is turned manually. The moisture content of the partially decomposed substrate inside the pit is to be checked and water is added, if necessary, to maintain moisture level of nearly 70%. The pit top should be covered again with slurry.

xv. Same process to be repeated at an interval of 20 days till the completion of composting (till 100-105 days).

xvi. Frequent turning of substrate is considered vital for rapid composting process to succeed.

xvii. Turning is very important which ensures uniform distribution of temperature throughout the compost pile, facilitating production of a homogenous end product, maintain moisture uniformly, and facilitates proper aeration and uninterrupted faster decomposition.

xviii. The completion of the composting process is marked by a number of indicators-both physical and chemical. As it is not possible for the farmers to evaluate the chemical indices, they have to rely on the physical indicators only. Usually, when the temperature inside the compost heap is similar as that of ambient temperature, the composting process appears to be complete.

xix. Once composting process is complete, the compost is collected from the pit and care should be taken to avoid scraping of the pit-bottom-soil along with compost which deteriorates the quality of the compost.

xx. After collection from the pit, compost is spread under a shade to remove excess moisture and unwanted materials like, stone, pebbles, plastics, metals etc. (If any)

xxi. The final product should contain 35-50% moisture (Optimum) and sieved using 1 inch mesh to obtain a uniform size.

xxii. The processed compost is then stored in a cool dry place for future use.

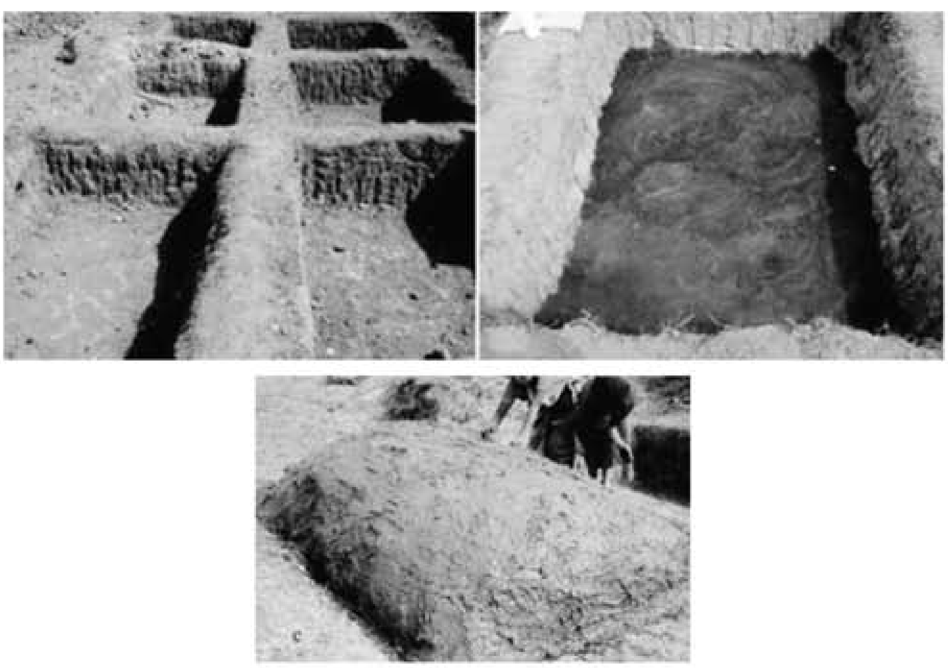


Figure: Preparation and filling of compost pit

6. Critical input requires

i. Crop residue viz., paddy straw, maize Stover, groundnut and soybean stalks.

ii. Weed biomass viz., *Ambrossiaartimisifolia*, *Eupatorium* spp., *Ageratum conyzoides*, *Lantana camara etc.*

iii. Slurry (Slurry consisted of cow dung/ poultry excreta/pig dung, soil and well rotten compost in the ratio of 1: 1: 0.5)

iv. Mineral additive (external addition of nutrients such as N, P and S to the substrate for hastens the process of composting and improves the quality of compost. Urea, rock phosphate and elemental sulphur are added as mineral additive)

7. **Observation to be recorded**

   i. There should no more reduction in volume of compost.

   ii. Conversion of the substrate to a dark brown to black colored mass.

   iii. Absence of the pleasant smell

   iv. Little or no presence of original substrate.

   v. Complete cooling down of the compost pile and no more heating upon wetting.

   vi. Production of a mass- friable and brittle when dry.

   vii. Almost dry and friable

8. **Contact address of relevant information:** Division of NRM (Soil Science), ICAR Research Complex for NEH Region, Umiam.

Technology no. 21

1. **Name of technology:** Seed priming for improving crop productivity and nutrient efficiency in acid soils

2. **Source of Technology:** Soil Science (Division of NRM), ICAR RC NEHR, Umiam

3. **Year of release:** 2015

4. **Agro climatic Zone :** Technology tested in Subtropical Meghalaya

5. **Detailed Description about the technology with suitable photographs:**

   Crop productivity in northeastern hill regions of India is constrained by a range of edapho-climatic limitations. Among the soil-related factors, nutrient deficiencies and low use efficiency of applied nutrients are the major constraints. Phosphorus and zinc are respectively the most deficient major and micro nutrient in acidic soils of NEH Region. Thus, if crop productivity has to improve in the region, deficiency of these essential nutrients must be addressed. Presently, external application of these nutrients through mineral fertilizers is extremely low, mainly due to associated high cost and some other logistical limitations. Whatever little fertilizer is applied, their use efficiency is extremely low (particularly of phosphorus), due mainly to higher P fixation capacity of the soils and low uptake efficiency of plant roots growing in acid soil environment. Moisture deficiency in *Rabi* season is also a constraint which limits germination, seedling establishment and overall productivity of the crop in NEH region. Therefore, a cost effective technology is required which could simultaneously aim at reducing the doses of applied nutrient, improving their use efficiency, and overcoming the nutritional and moisture stress to crops, at least during the initial phases of crop growth. Seed priming has been testedand established as one such technology which addresses all these issues simultaneously.

It's a very simple, easily adoptable and enormously cost effective technology where crop seeds are soaked overnight in either simple water or nutrients solutions (1% $ZnSO4.7H_2O$, 1% KH_2PO_4). After overnight soaking, the seeds are sown in field or air dried if storing for a brief period is required. This practice helps in fast germination, better seedling establishment, better initial root growth and thereby more efficient uptake of moisture and nutrients, leading ultimately to improved yield and nutrient use efficiency.

Seed priming with water is particularly effective in improving germination and seedling establishment in moisture stress condition. Priming with Zn and P solution also offers this advantage with some additional advantages as well. On an average, Zn and P priming improves crop yield by 14-15%. They reduces the fertilizer requirement by 30 kg P_2O_5/ha and 5 kg Zn/ha (soil applied) respectively. Foliar application of Zn can also be combined with Zn seed priming for better results. Agronomic P use efficiency increases by nearly 10 kg kg^{-1} $P_2O_5$by seed priming with P solution, while agronomic efficiency of soil- and foliar-applied Zn could almost be doubled by seed priming with $ZnSO_4$ solution.

6. **Critical input requires: -**10 g of $ZnSO_4$or KH_2PO_4per litre of water
7. **Observation to be recorded:** Germination percentage, days to 50% germination, plant height, days to flowering/maturity and crop yield.
8. **Contact address of relevant information-** Division of NRM (Soil Science), ICAR Research Complex for NEH Region, Umiam

Technology no.22

1. **Name of the Technology:** Production of Vermicompost
2. **Source of the Technology:** College of Horticulture & Forestry, CAU, Pasighat
3. **Year of release:** 2013-14
4. **Agro Climatic Zone:** NEH Region/Eastern Himalayan Region
5. **Detail description about the technology**
6. **Vermicomposting**

Vermicomposting is the process of recycling organic matter into nutrient rich compost using earth worms. It is very important for the all the north east state It is carried out generally under aerobic condition for production of organic manure in a lesser time and to get rid of the bad odor of the degrading organic wastes. Vermicompost is stable organic manure produced as vermicast by earthworm feeding on biological waste materials. It is an efficient recycling process of animal, agriculture and industrial waste. Vermicompost is a mixture of warm cast, humus, live earthworms and their cocoons and other organisms like insect, mold and micro organisms. The major constituents are essential macro and micro nutrients, immobilized enzymes, vitamins, antibiotics, humic acid and growth hormones.

The species most commonly used for vermi-composting is *Eisenia foetida.* It can thrive well under wide range of temperature 4-30⁰C and moisture of about 30-60 % and can live in organic waste in a p^H range from 6-8. It is ideal natural manure that improves the physical, chemical and biological characteristics of the soil.

Farm waste for vermicomposting

- Two weeks old farm yard manure
- Fruits and vegetables waste
- Crop residue and weed etc.

Some common species of earthworms used for vermicomposting are:

- *Eisenia foetida* (Red worm)
- *Eudrilus eugeninae* (African night crawler)
- *Perionyx excavates* (Blue worm)

In this region, most common one is Red worm (***Eisenia foetida***) which is clearly recognized by their alternating red and buff stripes. The worm has a wide range of temperature tolerance but prefers 20-25⁰C for fast growth and double its population within 2-3 months.

Why vermi-composting?

- An important source of organic manure.
- Helps in recycling any organic wastes into a useful bio-fertilizer and leaves no chance of environmental pollution.
- An eco-friendly, non-toxic product, consumes low energy input
- A preferred balanced nutrient source.
- Improves physical, chemical and biological properties of soil without any residual toxicity.
- Reduces the incidences of pests and diseases in crop production.
- Improves quality of agricultural produce.

Fig. 1. Red worm (Eisenia foetida)

Production Technology

Prepare a bed as per space availability in shade and keep the following layers as follows:

Vermicompost in pit: -

- Selection of Earthworms: Earthworms which are native of the locality may be used for vermicomposting.
- Size of pit: The pit of convenient size such as 2m X 1 m X 1 m may be prepared with bamboo or cemented permanent structure.
- Preparation of vermin-bed: A 6 inch thick layer of dry fodder or good loamy soil spread in the bottom of pit and above it a 6 inch ripen FYM or fresh cattle dung is spread and leave up to 48h after watering.
- Inoculation of Earth worms: About 100 earthworms/square feet are uniformly incubated to maintain an optimum inoculating density of about 2mXlmXlm compost pit.
- Organic layering: The compost pit is then layered to about 6 inch with dry leaves or hay. Moisture content of the pit is maintained through addition of water without flooding.
- Mixing of vermicompost layers: Mixing of vermicompost layers done after one month without disturbing the vermin bed ensures proper vermin-composting and wet it till the vermicompost is mature within 60-65 days after inoculation.
- Harvesting of vermin-compost: At maturation the moisture contents is brought down by stopping the addition of water for 3-4 days. This ensures drying of compost and migration of worms into the vermin-beds, the mature compost and a fine loose granular mass is dug out from the pit, sieved, cleaned and packed.

Precaution: bed should be located in a shady place at a higher plane and free from water stagnation.

Advantages of Vermicompost

1. In comparison to other fertilizers and organic manures, vermicomposting is very simple, prepared in lesser time, environmentally safe, and useful in increasing yield and making productive soils.
2. Vermicompost has microbes of various types, micronutrients, minerals (calcium, potassium, and nitrogen), vitamins, enzymes and bacteria in sample quantities, which

Fig. 2. Constructed newly vermicompost unit

essential for plants and to maintain the environment.

3. Provides proper environment to soil, water and microbes and conserve them.
4. There is no need of fertilizers, and soil fertility is regenerated by regular use of vermicompost.
5. The plants remain healthy yield more and regenerate resistance against insects and diseases.
6. Vermicomposting is a simple, cheap and profitable enterprise which attracts youth for employment generation.

Recommended dose of application of vermicompost is as follows:

1. **Seeds Beds, Domestic lawn and flower plots** - Apply vermi-compost @100-200g/sq feet area in seed beds or lawn.
2. **Horticulture Crops:** in fruit plants 5-10kg/plants vermicompost along with equal quantity of FYM may be applied depending upon the age and size of the plants. Mature vermicompost is recommended @ 5tones/ha
3. **Vegetables:** For vegetable@ 5tones/ha vermicompost is recommended. It gives best result when mixed with equal amount of FYM.
4. **Agricultural Crops:** In field crops like soybean, maize, bajra, kharif pulses, wheat, barley, mustard, gram *etc.,* vermicompost may be applied @ 2-3 tones/ha along with FYM.

Constituents of Vermicompost

Organic Carbon	19.89%
Nitrogen (N)	1.54 to 1.60%
Phosphorus (P_2O_2)	1.29 to 1.33%
POTASH (K_2O)	0.86 to 0.95%
Mineral content at 46% moisture	
Ca	1.70%
Mg	0.80%
S	0.35%
Zn	158 ppm
Cu	28 ppm
Fe	7497 ppm
Mn	257 ppm

Ready-reckoners for soil test based fertilizer recommendations for wheat.

The fertilizer recommendations based on targeted yield approach are not only balanced but also remove the arbitrariness in fertilizer recommendations and ensure the yield that could be achieved. It provides the basis where fertilizer recommendations can be tailored to the need, management and input investment capacity of the farmers. Ready reckoners were prepared from the fertilizer adjustment equations, for different soil test values, which will provide a working basis for soil testing laboratories for making fertilizer recommendations based on targeted yield. This recommendation is applicable for Delhi and adjoining areas having similar soil agro- climatic conditions. The requirement of fertilizers is decrease with the increase in soil values.

Soil test based fertilizer adjustment equations

Wheat

$FN = 5.31t-0.51\ SN$

$FP_2O_5 = 3.45T-5.55\ SP$

$FK_2O = 2.75T-0.32\ SK$

Where FN, FP2O2 and FK2O= fertilizer dose (kg/ha), SN, SP and SK= soil test values (kg/ha), T stand for targeted yield of the crop in q/ha and amount of N added through DAP will be adjusted.

Cost benefit ratio of vermin compost

Raw materials required for preparation of one tones of nutrient enriched compost

S. No.	Material	Amount (in kg)	Estimated cost (₹)
1	Crop residue	2000	Nil
2	Poultry droppings/Cow dung	200	600
3	Rock phosphate	50	500
4	Compost inoculants	0.50	200
5	Earth worm	1000/pit	1000
6	Total cost (Rs)		2,300

S. No.	Market price of vermin compost	Amount (₹)
1	Market price of 1000 kg compost @ Rs 10/kg	10,000
2	Input Cost	2,300
3	Profit	7,700

7. Contact Address for relevant information:

Dr. Dinesh Sah

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