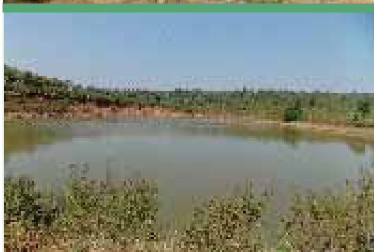
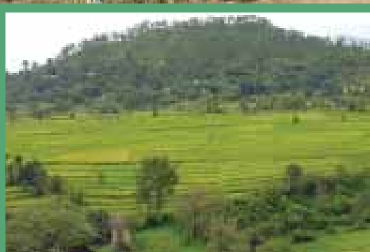
www.icar.org.in

Agricultural TECHNOLOGIES

NATURAL RESOURCE MANAGEMENT





भाकृअनुप
ICAR

Indian Council of Agricultural Research
New Delhi

COMMERCIALIZED TECHNOLOGIES/
READY FOR COMMERCIALIZATION TECHNOLOGIES

NATURAL RESOURCE MANAGEMENT

भाकृअनुप
ICAR

Indian Council of Agricultural Research
New Delhi

Printed: January 2014

Technical Co-ordinators	:	Dr A.K. Sikka Deputy Director General (NRM) Dr Rajbir Singh Dr P.P. Biswas Dr Adlul Islam Dr B. Mohan Kumar
Project Director (DKMA)	:	Dr Rameshwar Singh
Incharge (English Ediotiral Unit)	:	Dr Aruna T Kumar
Editor	:	Dr Sudhir Pradhan
Chief Production Officer	:	Dr V.K. Bharti
Assistant Chief Technical Officer	:	Shri Ashok Shastri

ISBN : 978-81-7164-155-0

Price: ₹350

Disclaimer
The cost mentioned for each technology in the publication is only indicative and suggestive as the technologies were developed in different base years and locations.

Published by Dr Rameshwar Singh, Proeject Director, DIrectorate of Knowledge Management in Agriculture, Indian Council of Agricultural Research, Krishi Anusandhan Bhawan-I, Pusa, New Delhi 110 012; Laser typeset at M/s Dot & Design, D-35, 1st Floor, Ranjeet Nagar Comm. Complex, New Delhi 110 008 and printed at M/s Royal Offset Printers, A-89/1, Naraina Industrial Area, Phase-I, New Delhi 110 028.

'kjn iokj
SHARAD PAWAR

सत्यमेव जयते

Ñf"k ,o [kk| iLdj.k m|kx e=h
Hkkjr ljdkj

MINISTER OF AGRICULTURE &
FOOD PROCESSING INDUSTRIES
GOVERNMENT OF INDIA

MESSAGE

INDIAN agriculture has overcome several challenges in the past and achieved phenomenal success ensuring self-sufficiency in food production. The technologies generated within the National Agricultural Research System (NARS) have significantly contributed to the transformation of Indian agriculture and ushering Rainbow Revolution representing Green, White, Golden, Brown and Blue revolutions defining outstanding technology-led performance in foodgrain, milk, oilseeds and pulses, horticulture and fisheries sectors. Agriculture along with other primary sectors is a major source of strength for the Indian economy. However, burgeoning population, increasing demand for food, feed and fodder, decreasing land availability, natural resource degradation, decreasing factor productivity, climate change, slow growth in farm income and new global trade regulations have put new challenges threatening food, nutritional and livelihood security.

Technological interventions by the NARS have led to spectacular accomplishments relating to input use efficiency, climate resilience, mechanization and secondary agriculture leading to economic transformation. These coupled with the application of information and communication technologies will play a critical role in our future endeavours to accelerate agricultural growth in the country. I am glad that the Subject Matter Divisions of Indian Council of Agricultural Research (ICAR) have synthesized and compiled practical and useful technologies in this series of publications on Agricultural Technologies in a user-friendly mode. I am sure this information will be useful to farming community, extension agencies, entrepreneurs and agro-industries in their efforts to make Indian agriculture economically viable and ecologically secure.

Krishi Bhavan
New Delhi 110 001

(Sharad Pawar)

FOREWORD

AGRICULTURE is the corner-stone of Indian economy. About 70% of India's 1.27 billion population live in rural areas with small and marginal land holdings. India with a geographical area of over 328 million hectares is endowed with diversity of climate, soils and vegetation. This rich resource endowment is, however, threatened with ever increasing population, vagaries of nature and climate change. The National Agricultural Research System (NARS) comprising the Indian Council of Agricultural Research (ICAR), 55 State Agricultural Universities, five Deemed Universities, four Central Universities with agriculture faculty, one Central Agricultural University and 637 Krishi Vigyan Kendras have attained excellence in several frontier areas of agricultural sciences and technology contributing significantly towards the spectacular growth of Indian agriculture during past 60 years.

Initiatives by NARS in the country have led to notable accomplishments resulting in the socio- economic transformation of farmers. The agriculture sector is, however, witnessing radical changes and challenges both at national and global level. The emerging challenges and opportunities necessitate wider and faster adoption of the improved technologies by all the stakeholders right from production to consumption in a food chain. In an effort to achieve this, the divisions of crop science, horticulture, animal science, natural resources management, fisheries and agricultural engineering in the ICAR have compiled the technologies already commercialised and the technologies ready for commercialisation. This series of publications, brings out the salient features of the technologies with details on potential users and contact details of the developers for ready and easy access. It will be our endeavour to periodically update this Technology Series. I hope that this publication would be useful to the farming community, extension agencies, entrepreneurs and industry. I greatly appreciate the efforts put in by my colleagues in the Council, research institutes and State Agricultural Universities (SAUs) in bringing out this compilation.

(S. Ayyappan)
Secretary,
Department of Agricultural Research and Education &
Director General,
Indian Council of Agricultural Research

January 2014
New Delhi 110 001

PREFACE

SOIL, water and vegetation are vital natural resources supporting life on earth. Sustainable management of these resources is critical to meet the rising demands of food, fibre, fuel, feed, fodder and industrial raw materials. However, decelerating factor productivity, rising input costs, depleting water resources, land degradation, indiscriminate use of external inputs and the changing climate are major challenges in this respect. Efficient management of natural resources through eco-friendly, resource efficient agro-technologies, therefore, assumes critical importance.

The Natural Resource Management (NRM) related technologies developed by the National Agricultural Research System (NARS) have been compiled in the form of a compendium titled *Agricultural Technologies - Natural Resource Management.* The publication has different sections such as Soil and Nutrient Management, Crop Management/Farming System, Soil and Water Conservation, Weed Management, Management of Saline/alkali and Acidic Soils, Agroforestry System and Miscellaneous technologies. Each technology has been briefly described indicating its salient features, performance results, cost (tentative and indicative), impact and benefits and contact details. I am confident that this publication will serve as a valuable ready reckoner of NRM technologies and will be useful to the stakeholders including extension personnel and entrepreneurs. The technologies presented have the potential for upscaling and may facilitate convergence with schemes/programmes such as MGNREGA, RKVY, NHM, MMA.

I sincerely acknowledge the support of scientists of research institutes and SAUs for contributing relevant technologies for this publication. I appreciate the efforts put in by Dr B. Mohan Kumar, Assistant Director General (Agronomy and Agroforestry) and Drs Rajbir Singh, P P Biswas and Adlul Islam, Principal Scientists of NRM Division in compilation of this valuable document.

Alok K. Sikka
Deputy Director General (NRM)
ICAR, New Delhi

CONTENTS

Message iii
Foreword v
Preface vii

SOIL AND NUTRIENT MANAGEMENT

On-line soil fertility maps of different states and fertilizer recommendation system for targeted yields of crops 1
PUSA soil-test fertilizer recommendation (STFR) Meter 2
Iron (Fe) enrichment in rice, maize and pulses 3
Techniques for correcting zinc (Zn) deficiency 4
Balanced fertilization through by sulphur application 5
Ameliorating deficiency of Manganese (Mn) in field crops 7
Bio-enriched compost 8
Technology for preparation of enriched compost 9
Phosphate solubilizers (*Trichoderma* sp. and *Penicillium* sp.) 10
Vermicomposting technology for recycling of organic wastes 11
Microbial based bio-nutrient package for rice 12
Compost inoculant 14
Liquid inoculants technology of biofertilizer organisms 15
Bacterial inoculant for quality seedling production of apple 16
Bacterial inoculant for rejuvenation of white root rot infested apple orchard 17
Kit for assessing soil organic-carbon 18
Kit for assessing compostability of farm waste 19

CROP MANAGEMENT/FARMING SYSTEM

Integration of reduced tillage and BBF land configuration for better productivity of rainfed cotton 20
Income maximization through participatory INM for soybean-wheat system 21
Modified System of Rice Intensification (SRI) 22
Integrated System of Rice Intensification (SRI) 23
Technology of Direct Seeded Rice (DSR) 24
Redgram as contingency crop for delayed onset of monsoon in black cotton soils 25
Withhold phosphorus application for paddy in P rich vertisols 25

Intercropping of foxtail millet and redgram (5:1) 26
Intercropping of autumn sugarcane and potato 27
In-situ green manuring for sustainable productivity in Western Ghat 28
Bio-intensive complementary cropping systems for higher productivity and profitability 29
Integrated farming system model for western plain zone of Uttar Pradesh 30
Nutrient management for organic maize-potato-onion system 31
Package of practices for organic production of crops in cropping system 32
Conservation agriculture for improving productivity and profitability of wheat in rice-wheat cropping system 35
Broad Bed and Furrow (BBF) land management with maize+pigeonpea in maize-chick pea cropping systems in Vertisols 36
Mechanical harvest borne residue management 37
Makhana *(Euryale ferox*) cultivation in cropping system mode 38
Integration of *makhana (Euryale ferox*) with fish and water chestnut *(Trapa bispinosha*) for higher productivity 39
Integrated farming system (IFS) model for irrigated midland/uplands (one acre model) 40
Multi-tier horticulture land use model for rainfed upland ecosystem of eastern hills and plateau region 41

SOIL AND WATER CONSERVATION

Bench terracing for soil and water conservation measures in the Nilgiris 42
Bio-fencing technology for the Vertisols of semi-arid region 43
Conservation ditching for efficient resource conservation and enhanced productivity of semi arid vertisols 45
Contour furrows for medium deep black soils of south-eastern Rajasthan 47
Improved tillage and mulching practices for resource conservation in red soils 49
Jhola Kundi: a low cost water harvesting technique suitable for Eastern Ghat high lands 50
Improved agri-horticultural system in North-Western Himalayas 51
Recharge filter: a cost effective technology for augmenting groundwater 52
Stabilization of bench terrace risers 53
Improved design of mechanical spurs for control of torrents in the lower Himalayas 54
Technology for rehabilitation of mine wastelands in arid regions 56

WEED MANAGEMENT

Chemical weed control in wheat 57

Herbicidal control of grassy weeds in direct-seeded rice 58

Weed management in pulses 59

Chemical weed control in soybean 60

Soil solarization technique for weed control in vegetables and high-value crops 61

Weed management in zero-till wheat 62

Integrated weed management of tiger grass 64

CRIDA precision planter-cum-herbicide applicator 65

Mass multiplication techniques of *Zygogramma bicolorta* for biological control of *Parthenium* 66

WATER MANAGEMENT

Design and development of rubber dams for watersheds 67

Farm pond technology for water harvesting 68

Crop diversification with *in-situ* rainwater conservation for drought mitigation 69

Rainwater conservation for rice-fish integrated system 70

Raised and sunken-bed technology 71

Sub-surface water harvesting structure for coastal areas 72

Micro-level water resource development through tanks-cum-well system 73

Pond-based farming system for deep waterlogged areas 74

Farm pond-based agricultural diversification model for multiple use in rainfed areas 75

Multiple use of water with trench-cum-raised bed system in waterlogged areas 76

Low cost rainwater harvesting structure (*Doba*) for fruit orchard establishment in uplands 77

Broad Bed and Furrow system for waterlogged areas 78

Three-tier system of farming in coastal valley lands 79

Paddy-cum-fish system for coastal waterlogged areas 80

Buch as alternate crop for water-logged area 81

Software for evaluation of water delivery system in canal commands of irrigation project 82

Equation for determination of acid injection rate and constant for acid treatment through drip irrigation system 83

Tensiometer-based irrigation scheduling to rice 84
Soil moisture indicator 85
Pusa Hydrogel, a novel superabsorbent hydrogel and its use in agriculture 86

MANAGEMENT OF SALINE/ALKALI AND ACIDIC SOILS

Reclamation and management of alkali soils 87
Sub-surface drainage technology for saline soil reclamation 88
Collector well technology for coastal sands (Improved Doruvu Technology) 89
Sub-surface drainage system for reclamation of waterlogged saline soils in coastal region 90
Soil sodicity kit 92
Zinc, Iron, Boron and Sulphur doses for rice-wheat cropping system in calcareous soils 94
Furrow application of lime for amelioration of acid soils 95
Amelioration of acidic soils through headgerow intercropping 96

AGROFORESTRY SYSTEM

Bench grafting in *Aonla* 97
Eucalyptus-based agri-silviculture system 98
Vegetative propagation of *Pongamia pinnata* through stem cuttings 99
Vegetative propagation of *neem* through air-layering for quick evaluation of germplasm 100
Agri-silvi model of poplar and sugarcane 101
Agri-horticulture system: peach grown under wheat-soybean cropping system 102
Superior subabul (*Leucaena leucocephala*) variety (K-636) for pulp wood industry 103
Sunken bed technology for nursery production 104

MISCELLANEOUS TECHNOLOGIES

Gum inducer technology for production of gum-Arabic from *Acacia senegal* 105
Neem pellets for the control of termites 106
Bio-formulations for managing soil-borne plant pathogens 107
Bio-Phos – a native phosphorus mobilizing organism 108
Biodegradable plastics from poly-hydroxy butyrate production by eco-friendly *Rhizobia* 109
Integrated rodent pest management using environment friendly plant-based products 110

On-line soil fertility maps of different states and fertilizer recommendation system for targeted yields of crops

Salient features

The soil fertility data on N, P and K index values at district level for the states of Andhra Pradesh, Maharashtra, Chhattisgarh, West Bengal, Haryana, Odisha, Himachal Pradesh, Karnataka, Punjab, Tamil Nadu and Bihar have been developed in MS-Access. From the attribute database, the different thematic layers have been reclassified to generate various thematic maps on N, P and K index values (IVs). The calculated soil-test values were incorporated into the developed fertility maps to prescribe nutrients for targeted yields. This application software was developed to recommend fertilizer doses for the targeted yield at the district level. This system has the facility to input actual soil test values at the farmers' fields to obtain optimum doses of fertilizers. The application is a user-friendly tool. It will aid to the farmer in improving the efficiency (appropriate dose) of fertilizer use to achieve a specific crop yield. The system is explained with the example of Tamil Nadu. The system works as a ready reckonner to give prescription in the form of fertilizer available (eg. Urea, SSP, MOP etc).

Performance results

This decision support system provides real use of fertility maps to the users. It can be used up to field level, if the farmer has the knowledge of his field fertility status and the yield target. It can be further narrowed down to block/village level depending on the availability of information. The experiments conducted at different locations in the states suggest that a considerable amount of fertilizer can be saved, if the fertilizers are prescribed using soil-test values.

Cost of technology

Technology available in public domain (www.iiss.nic.in)

Impact and benefits

- Ensure site specific balanced fertilizers
- Facilitate distribution of fertilizer in the country
- Monitoring soil fertility status

Contact
Director
Indian Institute of Soil Science
Nabi Bagh, Berasia Road, Bhopal (Madhya Pradesh) 462 038
Tel: 0755- 2730946; *Fax:* 0755- 2733310
E mail: director@iiss.res.in

PUSA soil-test fertilizer recommendation (STFR) meter

Salient features

Pusa STFR Meter is a low cost, user friendly digital embedded system instrument which is programmed according to type of soil, type of crop and yield based on ICAR research data base. The unique features of this instrument are:

- It can quantitatively estimate as many as five important soil parameters viz.,pH, Electrical conductivity, organic carbon, phosphorus, potassium (sulphur, zinc and boron in pipeline).
- It gives quantitative values, thus is more accurate than other soil-test kits available in the market, which are based on visual colour comparison.
- It is portable, and can be operated both by electricity and battery.
- It is user-friendly and easy to operate with minimum training.
- Unlike other soil test kits, it gives fertilizer recommendations for selected crops using the in-built program.

Performance results

Tested and validated over one year with different soils with minimum 80 % accuracy.

Cost of technology

Maximum ₹30,000 with complete package of soil-testing.

Impact and benefits

In view of the ever-expanding multi-nutrient deficiencies in soils, site specific nutrient management, which is considered as Fertilizer Best Management Practice, needs to be promoted to improve soil health and crop productivity. Inadequate and unreliable soil-testing facilities, poor awareness of farmers about balanced plant nutrition and lack of appropriate policy are the major constraints in adoption of Fertilizer Best Management Practices. It is realized that the soil-testing service has not made the desired impact and farmers have not yet been able to adopt it in large numbers. On the other hand, on-station and on-farm experiments conducted under diverse agro-ecologies across the country established the significance of soil-test based balanced fertilizer use in improving crop yields and nutrient use efficiency. Compared with farmers' fertilizer practice, 20-25% yield gain could be easily obtained with the adoption of soil-test based recommendations, although much greater advantages are also reported depending on soil conditions and crops/cropping systems. The Pusa STFR Meter would increase farmers' access to soil testing, and thus help them to achieve higher yields owing to soil test based fertilizer application.

Contact

Director
Indian Agricultural Research Institute
New Delhi 110 012
Tel: 011-25843375, 25842367; *Fax:* 011-25846420
E mail: director@iari.res.in

Iron (Fe) enrichment in rice, maize and pulses

Salient features

- About 15% Indian soils are deficient in Fe and it is the most common nutritional disorder in human beings affecting at least half of the India's population.
- The fertilization strategies physiological interventions have been developed to enrich the grains with Fe.
- In rice and maize, two sprays of ferrous sulphate @ 0.5% solution at the time of pre- and post-anthesis are sufficient along with basal application of ferrous sulphate @ 50 kg ha^{-1} at planting. In Fe rich soils, only two foliar sprays are enough to enrich the grains with Fe.
- In pulse crops (chick pea and pigeon pea), 25% defoliation or nipping at bud before flowering along with one spray either at flowering or pod formation stage has proved to be effective in enhancing grain Fe concentration.

Performance results

- One foliar spray along with 25% defoliation is best strategy for enhancing Fe content in chick pea (17-25%) while nipping is the best strategy to enhance Fe content in pigeon pea grain (24-32.8%).
- Fe concentration in grains of rice and maize can be increased by 9-23% with the application of ferrous sulphate @ 50 kg ha^{-1} along with two foliar sprays at pre- and post- anthesis.

Cost of technology

- Cost of Fe enrichment varies with crop, the soil types, amount of fertilizer used and method of fertilizer application.
- Manual nipping and defoliation enhances the cost but new machinery may be useful in minimizing labour cost on such intervention. On an average, cost of Fe enrichment varies between ₹1,500 and 3,500/ha.
- Output also varies with crop response to fertilization. On average, output range between ₹7,000 and 20,000/ha.

Impact and benefits

This strategy is considered as a relatively low cost, highly efficient and safer than diet supplementation approaches in prevention of nutritional deficiencies to combat dietary mineral inadequacies in rural areas. Fe bio-fortified products appear to be better sources of potentially bioavailable Fe in comparison with the non-fortified analogues.

Contact
Project Coordinator (Micronutrient)
Indian Institute of Soil Science
Nabi Bagh, Berasia Road, Bhopal (Madhya Pradesh) 462 038
Tel: 0755- 2730946; *Fax:* 0755- 2733310
E mail: director@iiss.res.in

Techniques for correcting zinc (Zn) deficiency

Salient features

- Wide spread Zn deficiency in soils of India (45%) not only causes loss in crops yield but also overlaps with malnutrition in animal and human. It is further hampered by low use efficiency of Zn carriers/ fertilizers (seldom exceeds 5%).
- Zinc, which is associated with many metallo-enzymes in plant can be supplemented in crops through different sources *viz.* zinc sulphate hepta hydrate ($ZnSO_4.7H_2O$), Zn chelates, Zincated urea/ super phosphate, Zinc oxide, Zinc phosphate and Zn enriched organic manures. Among these sources, $ZnSO_4$ is cheapest, easily available and most effective source of Zn in crops.
- Zinc can be supplemented to different crops at different time through any of the following methods (as suitable to the crop).

  Seed Coating: zinc oxide/ Teprosyn-Zn/ zinc phosphate slurry
  Root dipping: zinc oxide/ zinc phosphate
  Basal application : zinc sulphate @ 5.0 kg Zn ha^{-1} sufficient for 2-3 crop cycles (rate varied with crops and soils)

or 4-5t FYM+2.5 kg Zn ha^{-1}
or Top dressing : zinc sulphate (if not applied as basal)
Foliar application : 0.5 to 2.0% zinc sulphate (supplement to basal application)

Performance results

- Use of Zn in balanced fertilization improved yield of different crops to a tune of 10-35% depending upon soil types, severity of deficiency, crops etc.
- Application of Zn alone contributes about 25 million tonne of total food grain production. It sustained the productivity over the years.
- The National Food Security Mission has adopted the Zn in fertilization package and provides a subsidy of ₹500 ha^{-1} for Zn fertilizer to each crop.

Cost of technology

Cost of Zn application varies with amount of Zn fertilizer used and labour required. On an average, cost of Zn fertilizer use varies between ₹500 and 2,000 ha^{-1}. Output also varied with crop response to fertilization. On average, output range between ₹1,000 and 20,000ha^{-1}.

Impact and benefits

Application of zinc enchances crop yield and profit by 10-35% and can has the potential to contribute 25 million tonnes of food grain production. Besides, the package has become a part of National Food Security Mission (NFSM).

Contact
Project Coordinator (Micronutrient)
Indian Institute of Soil Science
Nabi Bagh, Berasia Road, Bhopal (Madhya Pradesh) 462 038
Tel: 0755- 2730946; *Fax:* 0755- 2733310
E mail: director@iiss.res.in

Balanced fertilization through sulphur application

Salient features

- About 40% of Indian soils are deficient in S which causes great economic loss in several crops especially, oilseeds and pulses.
- Inclusion of sulphur in balanced NPK fertilization schedule in S deficient soil is based on large number of experiments conducted at farmers' fields at varying S status with different sources, rates and methods of application.
- Sulphur uptake by crops ranged from 5 kg to more than 50 kg S ha^{-1} year^{-1} depending on type of crop, available S at the crops' disposal, availability of other nutrients, growth conditions and cropping intensity.
- Among different sources, single super phosphate, gypsum, phospho-gypsum, ammonium sulphate, bentonite S pastilles were better for rectification of S deficiency. Pyrite, a good source of S should be applied in moist soil through surface broadcast before one month of planting to meet S requirement of the crops.
- Basal application of S sources is beneficial, however, it can be used at 25-30 days crop growth stages in case of oilseeds.
- The recommendations/technology options developed for correction of S deficiency for different crops/ cropping systems are:
- Rice-wheat cropping system : 30 kg S ha^{-1} in each crop
  45 kg S ha^{-1} to rice
- Other cereal based cropping system(s) : 30- 45 kg S ha^{-1}
- Pulse-based cropping system(s) : 35-45 kg S ha^{-1}
- Oilseeds-based cropping system(s) : 45-60 kg S ha^{-1}
- Sugarcane : 80 kg ha^{-1}
- Green gram/Black gram/Lentil : 30 kg S ha^{-1}

Performance results

- More than 40 crops responded to S application in S deficient soils in more than 140 districts of the country.
- The yield advantage due to S application over NPK recorded from 10 to 30% in cereals, 15-40% in pulses and 15-45% in oilseeds. The additional net profit obtained with S application varied from ₹5,000 to ₹39,000 per hectare.
- Long-term experiments showed sustainable yield trend with NPKS fertilization schedule and utilization efficiency of NPK increased with inclusion of S in fertilization schedule.

Cost of technology

Cost of S fertilization varies from ₹700 to 1,500 ha^{-1}.

Impact and benefits

The technology has the scope of improving yield (10-40%) of various crops and enhancing oil content in oil seed crops. It has vast scope of application in more than 140 districts of the country.

Contact
Project Coordinator (Micronutrient)
Indian Institute of Soil Science
Nabi Bagh, Berasia Road, Bhopal (Madhya Pradesh) 462 038
Tel: 0755- 2730946; *Fax:* 0755- 2733310
E mail: director@iiss.res.in

Ameliorating deficiency of Manganese (Mn) in field crops

Salient features

- Manganese deficiency is increasing in rice-wheat systems grown in Indo-gangetic plains having highly permeable coarse textured alkaline soils with low organic matter.
- The principle of any micronutrient including Mn recommendations for different crops and cropping systems is based on its available status in soil, requirements to meet the crops/cropping system and fixation in soil complex and other losses.
- Durum wheat genotypes are more susceptible to Mn deficiency than *aestivum* wheat.
- Manganese (Mn) can be supplied through the sulphate salt of Mn i.e. $MnSO_4$ either through soil or foliar.
- Three to four foliar spray of 0.5-1.0% $MnSO_4$ solution is more efficient and economical for enhancing wheat yield in sandy soils.
- Foliar spray of $MnSO_4$ solution one before and two after first irrigation is effective in mitigating Mn deficiency in crops in Mn-deficient soils.

Performance results

- Different crops and cropping systems, especially wheat performed tremendously with application of Mn in deficient soils.
- Application of Mn enhances the farmers profit by 10-35% depending upon crop type and crop response to Mn fertilization.
- Replenishment of Mn improves the fertility and soil health, and also increases the utilization of other macronutrients, reducing leaching losses and thus helpful in saving environment.

Cost of technology

Cost of Mn application varies with amount of fertilizer used and labour required. Foliar spray enhances labour cost. On average, cost of micronutrient fertilizer use varied between ₹700 and 2,000 ha^{-1}. Output also varies with crop response to fertilization. On average, output ranges between ₹2,500 and 15,000 ha^{-1}.

Impact and benefits

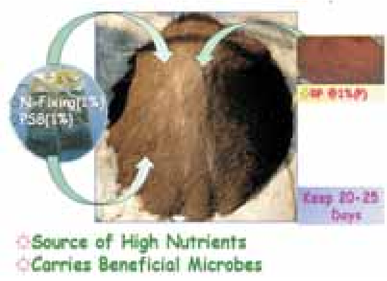
Application of Mn enhances the farmer profit and improve the soil health.

Contact
Project Coordinator (Micronutrient)
Indian Institute of Soil Science
Nabi Bagh, Berasia Road, Bhopal (Madhya Pradesh) 462 038
Tel: 0755- 2730946; *Fax:* 0755- 2733310
E mail: director@iiss.res.in

Bio-enriched compost

Salient features

Bi-enriched Compost



Normal farm compost could be converted into a superior bio-enriched compost by amending with 1% P as rock phosphate along with inoculating *Azospirillum/Azotobacter* and Phosphate Solubilizing Bacteria (PSB) (10^8-10^9 cfu/g) each and subsequently curing for about 20 to 25 days in shade at 25% moisture level. To maintain the moisture, curing materials should be covered with a polythene sheet/gunny bags. Quality improvement of the final product results because of the change of following characteristics over normal farm compost:-

- Stabilization of C:N ratio around 10.0 to12:1
- pH stabilizes around neutral (7 to 7.5)
- CEC of final product increases above 25%
- Microbial carbon increases more than 100 times.
- Viable population of *Azospirillum/ Azotobacter* and PSB increases 300-400 times and six times, respectively.

Performance results

- Use of bio-enriched compost @ 1 tonne/ha could minimize the recommended nitrogenous and phosphatic fertilizer to 50% without any yield loss of crops grown in rice- *toria* and rice- wheat sequence.
- Biofertilizers with increased dose of compost @ 2 tonne/ha, more specifically enriched compost could reduce recommended N, P fertilizer up to 75% in subsequent year due to cumulative effects of INM package.

Cost of technology

Preparation of Bio-enriched compost involves modest additional cost of the price of low grade Rock Phosphate and biofertilizer over that of normal compost. Every tonne of Bio-enriched compost requires around 170 kg rock phosphate and 10 kg of *Azospirillum/ Azotobacter* and Phosphate Solubilizing Bacteria (PSB) biofertilizer. Considering the cost of Rock Phosphate ₹3/ kg and biofertilizer ₹75/ kg, additional cost for each tonne of Bio-enriched compost preparation is about ₹2,000/ only.

Impact and benefits

Incorporation of enriched compost with subsequent reduction of fertilizers (N, P) showed improved soil health. Huge amount of foreign exchange can be saved for importing chemical fertilzers.

Contact

Principal Investigator (PI), AINP on Soil Biodiversity-Biofertilizers (ICAR)
Department of Soil Science, AAU, Jorhat (Asom) 785 013
Tel.: 0376-2340814; *E mail:* ndhrubajyoti@yahoo.in
Project Coordinator (Biofertilizers), Indian Institute of Soil Science
Bhopal (Madhya Pradesh) 462 038; *Tel:* 0755-2736846; *Fax:* 0755-2733310
E mail: dlnrao@iiss.res.in

Technology for preparation of enriched compost

Salient features

- A new technology has been developed to prepare enriched compost using low-grade rock phosphate, waste mica and crop residues.
- For this purpose, a trench or pit is filled layer-wise (5-6 layers).
- Biodegradable organic materials like crop residues, farm wastes, animal feed wastes and tree leaves are spread on the floor of the trench (about 20-cm thick layer).
- A layer of rock phosphate (RP), followed by waste mica is then spread over biodegradable organic material.
- Cattle-dung is made into slurry by adding water, and this is sprinkled over RP and waste-mica layer.
- Layering is repeated till whole compostable materials are added.
- Moisture content is maintained throughout the composting period at 60% of water-holding capacity.
- Periodic turning (monthly interval) is done to provide aeration.
- Composting is continued for 4 months.
- For the preparation of 1 t enriched compost, 1 t biomass (crop residues/ biodegradable wastes, 200 kg low-grade rock phosphate (18-20% P_2O_5), 200 kg waste mica (9-10% K_2O), and 100 kg fresh cattle dung are required.

Performance results

- The enriched compost contains 1.4-1.5% total N, 5.0–6.0% total P_2O_5 and 2.5-3.0% K_2O, respectively. Therefore, addition of one tonne (1,000 kg) of enriched compost will substitute about 14-15 kg of N, 50-60 kg of P_2O_5 and 25-30 kg of K_2O, respectively.

Cost of technology

₹2,00,000

Impact and benefits

Enriched compost would reduce dependence on costly phosphorus and potassium fertilizers. Hence, it will reduce cost of cultivation in one hand and increase income of the farmers on the other. Large quantities of crop residues may be recycled back to the field after converting them into quality manure. Substantial amounts of rock phosphate and waste mica may be recycled in agriculture as a source of phosphorus and potassium and thus lead to the utilization of indigenous mineral resources. Huge amount of foreign exchange can be saved partly or wholly on import of costly P and K fertilizers.

Contact

Director

Indian Agricultural Research Institute, New Delhi 110 012

Tel: 011-25843375, 25842367; *Fax:* 011-25846420

E mail: director@iari.res.in

Phosphate solubilizers
(*Trichoderma* sp. and *Penicillium* sp.)

Salient features

- Phosphorus is considered to be one of the major nutrient elements limiting agricultural production in acidic soils. Phosphate solubilizing fungi (PSF) play an important role in supplementing phosphorus from insoluble phosphate source to the plants.
- Easy multiplication of PSF for application in phosphate deficient soils. It also increases plant growth, induces resistance and control soil borne phytopathogens like *Fusarium*, *Rhizoctonia*, *Sclerotium* and *Sclerotinia*.
- The *Trichoderma* and *Penicillium* based formulations, respectively, have 50-67 and 40-45% phosphate solubilising potential on inorganic insoluble source of phosphate like ferric phosphate and tricalcium phosphate.

Performance results

The technology is cost effective and easy to apply in the acidic soils.

Cost of technology

₹400.0 per ha (or) ₹100 per kg.

Impact and benefits

Adoption of technology leads to enhanced (i) phosphorus availability, (ii) growth promotion and (iii) biological disease management in acidic soils.

Contact
Director
ICAR Research Complex for Eastern Region
ICAR Parisar, P.O.: Bihar Veterinary College, Patna (Bihar) 800 014
Tel: 0612-2223962; *Fax:* +91-612-2223956
E mail: drbpbhatt.icar@yahoo.com

Vermicomposting technology for recycling of organic wastes

Salient features

Vermicomposting is a very effective method of converting wastes into useful manure with the help of earthworms. For vermicomposting, open permanent pits of 102 ft × 32 ft × 22 ft dimensions are made under the shade of a tree at an elevated place, about 2 feet above the ground to avoid entry of rainwater into the pits. Brick walls are constructed above the floor of the pits leaving 5-6 gaps in the pit wall of 10 cm dia to facilitate aeration. These holes are blocked with nylon screen (100 mesh) to prevent escape of earthworms from the pits. 3-4 cm thick layer of partially decomposed dung (about 2-month-old) is spread on the bottom of the pits. A layer of litter/residue and dung in the ratio of 1:1 (w/w) is then added. A second layer of dung is then applied followed by another layer of litter/crop residue in the same ratio up to a height of 2 feet. Two species of epigeic earthworms *viz., Eisenia foetida* and *Perionyx excavatus* are inoculated in the pits or heaps. Watering by sprinkler is done intermittently. Moisture content is maintained at 60-70% throughout the composting period. Jute bags (gunny bags) are spread uniformly on the surface to facilitate maintenance of suitable moisture regime and temperature. The material is allowed to decompose for 15-20 days to stabilize the temperature after the initial thermophilic stage. Earthworms were then inoculated in the pit @ 10 adult earthworms per kg of waste material and a total of 5,000 worms were added to each pit or heap. The materials were allowed to decompose for 110 days. The forest litter decomposes faster (75 to 85 days) than farm residues (110-115 days). In the heap method the waste materials and partially decomposed dung (1:1 w/w) are made out into heaps of 10 feet length × 3 feet width × 2 feet high and during inoculation, channels are made by hand and earthworm @ 1 kg per quintal of waste are inoculated and then watering is done by sprinkling. Pieces of jute cloth are used as covering material.

Performance results

Under organic farming systems, combined application of cattle dung manure (2 t/ha) + Vermicompost (1.5 tonne/ha) and poultry manure (1.5 tonne/ha) + biofertilizer @5kg/ha sustained the productivity of soybean, chick pea and mustard and *isabgol* crops as well as biological health of soil.

Cost of technology

About 3 tonnes of vermicompost can be produced from 10 beds of 10 ft × 3 ft × 2 ft each. The cost of earthworms is ₹400-500 per kg. A 50-kg bag of vermicompost can be sold for ₹150 (₹3,000/tonne). Basically, vermicompost is used like any other manure: ₹5,000 kg/ha in cropping and 1-10 kg/ tree in plantations, depending on the size of tree.

Impact and benefits

This technology is better in terms of faster decomposition of the waste over conventional method. Secondly the nutrient composition of the vermicompost is superior over conventional compost.

Contact
Director
Indian Institute of Soil Science
Nabi Bagh, Berasia Road, Bhopal (Madhya Pradesh) 462 038
Tel: 0755-2730946; *Fax:* 0755- 2733310
*E mail:*director@iiss.res.in

भाकृअनुप
ICAR