Improved Rice Production Technology

for resource conservation and climate resilience

NICRA

Farmers' Guide

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Authors

Anup Das, D.P. Patel, Ramkrushna G.I., G.C. Munda, S.V. Ngachan, B.U. Choudhury, K.P. Mohapatra, D.J. Rajkhowa, Rajesh Kumar and A.S. Panwar

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UMROI ROAD, UMIAM – 793 103, MEGHALAYA

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Associates: *Manoj Kumar, Samik Choudury, Arvind Kumar, Badapmain Makdoh, Anjan Sharma, Lapynkmen Kharsyntiew, Meghna Haloi, Amethyst Slong and M. Homeswari.*

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Preface

Rice is the main staple food of the North Eastern Region of India and the region is still in deficit of about 0.95 million tons (triennial average) of rice. The situation in 2010-11 was much better with a deficiency of about 3 % only. For centuries, the farmers of the region depended on rice and rice based cropping system for their subsistence and livelihood. The farmers come across various hardships during their production practices. Flood, drought, frost, insect-pests and diseases are some of the common problems regularly posing challenge on rice production systems. In the absence of modern technologies, farmers of the region relied heavily on traditional knowledge systems for managing rice based systems for centuries. Considering the increase in population pressure and subsequent need for higher productivity, it is high time that farmers follow resource conservation and climate resilient technologies for sustainable rice production. Over exploitation of lands coupled with removal of residues and no or meager application of manure and fertilizer has caused degradation of soil health in rice ecosystems. Adoption of optimum production technology along with resource conservation practices will enhance rice productivity in the region. The authors of the present bulletin on "Improved rice production technology for resource conservation and climate resilience" believes that it will serve as resource book for the farmers and extension workers involved in promoting sustainable rice production in the region.

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Authors

Content

1. Introduction

Rice (*Oryza Sativa* L.) is the principal food crop of the North Eastern Region of India occupying an area of about 3.5 m ha with an average productivity of 1.77 t/ha which is much below the national average. The region is still in deficit of about 12 % foodgrains considering last triennium and 2.8 % in 2010-11. The reason for such low productivity is the non adoption of high yielding varieties and improved production technology. While enhancing productivity, equal importance should be given on resource conservation for sustainability and climate resilience. Increased occurrence of extreme events like drought, heavy rainfall, floods, frost etc. as a result of climate change, needs to be considered in rice production process. All India drought of 2009-10 caused about 20 % reduction in rice production. As adaptation and mitigation measures to climate change, management practices like system of rice intensification (SRI), integrated crop management (ICM), direct seeding, conservation agriculture approach in rice (reduced tillage, residue management and crop diversification), in-*situ* residue management, aerobic rice cultivation, land configuration, farming system approach etc. that judiciously utilizes and conserves soil and water, and reduces methane emission (greenhouse gas) should be promoted. With the adoption of appropriate crop production technology, it is possible to reduce the yield loss due to climatic aberrations to a great extent and achieve a yield level of at least 3-5 t/ha in the North East India. Following agro-techniques are recommended for optimum rice productivity in North East India.

2. Variety

Low altitude

IR 64, Naveen, Gomati Dhan, Ranjit, RC-Maniphou-4, RC-Maniphou-5, RC-Maniphou-7, RC Maniphou 10, TRC Borodhan-1, DR 92, Shahsarang 1, Lampnah etc.

Mid altitude

a. ***Transplanted Lowland:***
   Pre-*kharif* season: IR 64, Krishna Hamsha, Shahsarang 1, Vivek Dhan 82
   ***Kharif* season**: Shahsarang 1, Lampnah, IR 64, Vivek Dhan 82, Subhadra etc.
b. ***Direct seeded upland****:* Bhalum 1, Bhalum 2, IURON 514, Bhalum 3, Bhalum 4, RC Maniphou 6

High altitude transplanted*:* Megha rice1, Megha rice 2, Megha rice 3
Short duration variety for lowland: Vivek Dhan 82, VL Dhan 61, Sahabhagi
Boro rice: TRC Borodhan 1, Naveen, Ranjit, Krishna Hamsha
Cold stress: Megha Rice 1, Megha Rice 2, Megha Rice 3
Iron Toxicity: Shahsarang 1, Lampnah
Submergence: Swarna *sub 1*, Sambha mahasuri, IR64 *sub1,* FR13 A
Flood tolerant: Jalashree, Plaban, Jalkuwari

Drought: Sahabhagi, Vivek Dhan 82

- **Short and medium duration high yielding rice varieties matures early and facilitates timely planting of second crop.**
- **Local varieties takes longer duration to mature and delay the sowing of second crop**

3. Seed selection and treatment

Use only sound and healthy seeds. Put the seed in 2.5 % salt solution i.e. 25 g of common salt in 1 liter of water. Select the healthy seed by discarding floating ones. Wash the seeds in clean water and dry in shade. To protect the plant from leaf blast and other diseases the seeds should be soaked with Bavistin 50WP @ 2 g/lit. for 24 hours against seed borne diseases. 2.5 g of chemical is required for 1 kg seed. The treatment can be given in a rotating drum or putting the seed in a container and shaking it well after adding chemical.

- **Healthy and robust seedling production is the key to successful rice cultivation.**

4. Preparation of seed bed

For high altitude, preparation of field to raise nursery should start in the first fortnight of May. For mid and low altitude, it should start from the first fortnight of June. For transplanting one hectare of land by conventional practice, a nursery area of 500-600 sq.m would be sufficient. The area under nursery sowing can be further lowered down to 50-100 sq.m by adopting System of Rice Intensification (SRI) and Integrated Crop Management (ICM) method of rice cultivation.

***Raised seed bed**:* Normally a raised bed is preferred for raising seedlings. A bed of 10 cm height from ground level in high rainfall areas is necessary. Size of each bed may be 10 m in length and 1.25 m width with 30 cm wide channel in between the two seed beds. Treated seeds should be evenly broadcasted in each bed after manuring.

Wet nursery: In a place like Sikkim, Manipur and Tripura wet nursery is suitable under plain valley land condition. Nursery should be thoroughly ploughed and perfectly leveled so that a thin layer of water is maintained during the emergence. After the manuring and puddling, sprouted seeds are uniformly broadcasted in each seed bed. To get sprouted seeds, overnight treated and soaked rice seeds filled in wet gunny bags are kept for about 48 hours.

Manures and fertilizers for seed bed

a. **Raised Bed Nursery** : For raised seed bed (10 m length x 1.25 m breadth x 0.15 m height), application of cow dung or compost @ 15 t/ha (15 kg/seed bed) plus a starter dose of 30:30:20 kg NPK/ha (Urea 80 g, SSP 225 g and MOP 40 g/seed bed) is necessary.

b. **Wet Nursery** : For wet nursery, well decomposed FYM @ 15 t/ha may be applied before puddling and during puddling an extra quantity of 30:30:20 kg NPK/ha (Urea 80 g, SSP 225 g and MOP 40 g/seed bed) is required for raising healthy seedlings.

c. **Modified Mat Nursery (MMN)**: System of Rice Intensification (SRI) and Integrated Crop management (ICM) needs careful nursery preparation. Nursery is prepared in raised bed (5 cm) with soil and FYM (2:1) and spread seed uniformly on the bed. Cover the seeds with mixture of soil and FYM and then cover with paddy straw for 2-3 days and water it by rose cans every day morning or evening hours.

5. Seed rate

Transplanting: For medium to fine grain rice variety a seed rate of 35-40 kg/ha and for bold type 40-50 kg/ha will be sufficient for transplanting one hectare of land.

Direct seeding: For direct seeding in upland condition, a seed rate of 60-80 kg/ha is required to get good plant stand.

System of Rice Intensification (SRI): 5-7 kg/ha

Integrated Crop Management (ICM): 10 kg/ha

6. Land preparation (main field)

For transplanting: Prepare the land properly and uniformly leveled with peripheral bunding. Puddling may be done 2-3 times to make it weed free and water retentive. Excessive tillage results in degradation of soil quality, causes soil and nutrient loss through erosion during heavy rains and finally yield reduction. All the phosphorus and potash and 50 % of nitrogen fertilizer should be incorporated thoroughly into the soil at the final puddling. Organic manures like farm yard manure or composts should be applied about 15 days before transplanting and mixed with the soil during ploughing.

For direct seeding: Two cross ploughings are necessary to get good tilth of soil and weed free land. Excessive tillage should be avoided. 50 % nitrogen (N) fertilizer and full dose of phosphorus and potash should be placed in furrow before sowing. Organic manures like farm yard manure or composts should be applied about 15 days before transplanting and mixed with the soil during ploughing.

For zero tillage: For zero tillage the field should be properly leveled. The bunds and irrigation channels should be repaired. At least 15 days before transplanting total weed killer herbicides like Glyphosate @ 3 ml/litre may be sprayed to control weeds. Woody shrubs if any may be chopped down for mulching. In zero tillage only root zone is opened for placing fertilizer, manure and seed without disturbing the whole field. In the absence of mechanization, transplanting may be undertaken with metallic end dibblers. Use 25-30 days old seedlings. Avoid use of very young seedlings. For upland, manual/animal drawn furrow opener can be used. At least 30 % residues should be maintained on the surface to get the benefits of zero tillage.

Transplanting of rice with manual dibbler

Opening furrow with manual furrow opener

Field experiment conducted at ICAR Complex, Umiam revealed that continuous zero tillage (no ploughing) and minimum tillage (2 ploughing only) recorded similar to 15 % higher yield of rice compared to conventional tillage (4 ploughing). The cost of cultivation of rice under zero tillage and minimum tillage are much less than conventional tillage and hence, enhances farmers income substantially.

For each liter of diesel consumed (in tillage/irrigation etc.) 2.6 kg of CO_2 is released to the atmosphere. Similarly, for each ploughing, about 25 labourers are required in one hectare. Therefore, under zero tillage and minimum tillage greenhouse gas emission and labour requirement is reduced substantially.

For Furrow and raised bed (FRB): A raised bed of 70 cm width is alternated with furrow of 30 cm width. In plains, tractor drawn bed maker is used. Whereas, in case of hills/ small holdings animal drown implement or manual labour is used to make the bed. 3-4 lines of rice are grown on raised beds. This system encourages crop diversification and conserves resources like water, seed etc.

Rice grown on raised beds

7. Transplanting/sowing

Transplanting

The optimum time of transplanting is first fortnight of July for low and mid altitude. Time of transplanting should be adjusted to avoid low temperature during flowering especially in higher altitudes (above 1300 m). Therefore, under high altitude, transplanting should be completed before 15th June, preferably by first week of June. For mid and low altitude valley land, transplanting can be done as late as last week of July with closer spacing (15 cm x 10 cm) and aged seedling (40-45 days old). Seedling age of 20 -25 days with 20 cm x 15 cm spacing and 2-3 seedlings/hill is considered best for timely transplanted crop. For SRI, 10-12 days and for ICM 15-20 days old seedlings are transplanted. For SRI and ICM methods of rice cultivation, the numbers of seedlings/ hill required are only 1 and 2 seedlings/hill, respectively, with a spacing of 25 cm x 25 cm for SRI and 20 cm x 20 cm for ICM.

For SRI and ICM method, seedlings should be scooped-out from nursery instead of pulling-out to avoid root damage. Transplanting should be done as early as possible after scooping of seedlings to avoid transplanting shock.

Metallic row marker or pre-marked rope/bamboo pieces can be used for maintaining accurate spacing while transplanting.

Direct sown

Upland

In upland direct sown crops, sowing should be completed within second fortnight of June in mid altitude condition. Timely sowing is necessary to have enough time for the succeeding *rabi* crops, which are normally sown in the second fortnight of October. Direct seeded rice is sown in line of 20-25 cm apart maintaining a seed rate of 60-80 kg/ha.

Lowland

Direct seeding has advantages of faster and easier planting, reduced labour and less drudgery with earlier crop maturity by 7-10 days, more efficient water use and high tolerance of water deficit, less methane and often higher profit.

Field is prepared during pre-monsoon season (April) just like upland crops. Direct seeding should be done in the third week of April. Seeding depth should be kept at 2-3 cm. For weed control cono-weeder and hand weeding may be followed. Varieties like Shahsarang 1 (4.7 t/ha), IR 64 (4.5 t/ha) suits well. This technology can overcome the problem of water supply for rice transplanting during pre-*kharif* season and thereby, save resources.

Direct dry seeded pre-*kharif* rice (Shahsarang 1)

8. Nutrient management in main field

Optimum soil health management is the key to success in any crop production. A healthy and vibrant soil can withstand drought/other problems better compared to a sick/ poorly managed soil. Adequate amount of organic manure (FYM, vermicompost, other manure) along with inorganic fertilizer (Urea, SSP, MOP etc) helps in achieving the good soil health and optimize production. Hence, integrated nutrient management (INM) should be followed instead of single application of inorganic fertilizer or organic manure.

Transplanted

Application of fertilizer @ 80:60:40 kg NPK/ha (174 kg Urea, 375 kg Single Super Phosphate and 67 kg Muriate of Potash) is considered sufficient for transplanted rice in low land as well as upland. This dose will vary according to the fertility status of soil. All P and K and 50 % of N should be applied as basal dose and 25 % N at maximum tillering and rest 25 % N at panicle initiation stage. Application of nitrogen fertilizer in split doses reduces losses, facilitates its efficient use, improves growth and yield of rice. Neem coating of urea (mixture of neem cake and tar and mixing well with urea granule) releases N slowly to rice and enhances N use efficiency and reduces N loss through leaching, de-nitrification etc. The crop and weed residues should be chopped and mixed with the soil at the time of first ploughing.

In zinc deficient soils, application of zinc sulphate ($ZnSO_4$) @ 25 kg/ha at the final land preparation is useful. During the application of fertilizer (Top-dressing) the soil should be moist. Heavy irrigation should be avoided. After fertilizer is applied, the field bunds should be closed for 36 to 48 hours. Application of well decomposed organic manures like FYM @ 10 t/ha or enriched compost @ 5 t/ha (mixed with 60 kg P using Rock phosphate and incubating for 30 days) along with 50 % NPK improve yield and soil health. Green leaf manure (biomass from hedge row species, leguminous tree leaves like *Erythrina*, *Acacia*

Integrated nutrient management (INM): at a glance

- **Use only 50 % of recommended dose of fertilizer.**
- **Apply FYM/Compost/other manure at 5t/ha**
- **Recycle at least 1/3rd rice straw and all the weed biomass into the field.**
- **Use biofertilizer (Azolla, Azotobacter, PSB, Azospirillum etc), bioorganics and green manures.**
- **Follow crop rotation with leguminous crop/pulses (Rice bean, groundnut, soybean, pea, lentil etc).**
- **Under INM on-farm resources are efficiently utilized and dependence on external resources and fertilizer is minimized.**

etc. & forest litters) if available may be applied at the rate of 5 t/ha along with recommended NPK. In case of local varieties (e.g. Mendri, Manipuri etc.) the nitrogen fertilizer dose should be reduced to 50 kg/ha i.e., 87 kg urea to avoid excessive vegetative growth.

Direct sown

In upland direct seeded crop, application of 60:60:40 kg NPK/ha (130 kg Urea, 375 kg Single Super Phosphate and 67 kg Muriate of Potash) is sufficient. Full dose of P and K should be applied at sowing in furrow below the seed while N dose may be divided into 3 equal splits i.e., 1/3rd applied at the time of sowing, next 1/3rd just after first weeding (25-30 days of crop age) and last 1/3rd dose at the panicle initiation stage. Integrated application of 60:60:40 kg NPK/ha + FYM @ 5 t/ha is recommended for higher productivity and maintenance of soil health. Application of Alder (*Alnus nepalensis*) leaves or *Eupatorium* (a weed available in plenty) 5 t/ha + 50 % NPK is equally effective. The crop and weed residues should be chopped and mixed with the soil at the time of first ploughing.

During drought, urea or DAP 2 % (20 g/litre of water) may be sprayed at 15 days interval for better growth and yield of both upland and lowland rice.

Bio-fertilizer application

Application of fresh *Azolla* @ 10 t/ha + 50 % N through urea improve rice yield. *Azolla* should be incorporated into the soil before transplanting or it can be taken as dual crop i.e., inoculation of fresh *Azolla* @ 2 t/ha, at 7-10 days after transplanting (DAT) in standing water (5 cm) with 20 kg Phosphorus/ha. Soil application of *Azotobacter or Azospirillum* @ 1 kg/ha is also recommended for N economy and it can supplement up to 30 kg N/ha i.e. 65 kg Urea. Alternatively rice seedlings may be dipped in biofertizer solution for about 6 hours for better results. For medium and high altitude, cold tolerant species like *Azolla caroliniana* gives better results. Whereas, for warmer area, *Azolla pinata* performs well.

9. Bioorganics for rice production

Bioorganics are the extracts of plants like weeds, tree leaves, crops etc. Beneficial bioorganics for crop production including rice has been identified by ICAR, Umiam.

Lowland rice

Seed for nursery should be soaked for 12 hrs in bioorganic formulations @ 10 % concentration (100 ml/litre water) and one foliar application @ 2 % concentration (20 ml/litre) should be given at 30 days after transplanting. Four different formulations, *viz*., R-9, RCHEC-12L, RF 37, and RF 79 are found to be significantly increasing grain yield. The yield increase to the tune of 20-30 % is possible with the use of biorganics.

Upland rice

At Barapani, rice variety Bhalum 1 was tested in upland field with promising four formulations. Seed soaking for 8 hrs @ 10 % concentration (100 ml/litre water) before sowing along with one foliar application @ 2 % concentration (20 ml/litre) at 35 days after planting may be undertaken. Formulations like RF 79L, R-9, RCHE 686L and RCHE C-12L significantly enhances rice higher yield.

10. Residue management

Residues are integral component of any agricultural production system. In rice, about 4-7 t of straw/ha is produced depending upon management practices, altitudes, production system and varieties. In north east India, rice ecosystem also produces a huge amount of weed biomass (up to 10 t/ha) because of favourable climatic conditions. The nutrient requirement of the monocropped rice in lowland can be met almost completely if 100 % crop and weed residues are recycled effectively. Even if 50 % residues are recycled, 50 % of the nutrient requirement can be met. Besides, retention/ incorporation of residues reduces soil erosion, conserves moisture for second crop and improves soil health.

Residue recycling in rice field

- **Rice is harvested by leaving at least 1/3rd to 2/3rd standing stubbles in the field.**
- **The stubbles may be chopped down by using sickle and incorporated into the field during ploughing/spading.**
- **All the available weed biomass should also be periodically incorporated into the soil.**
- **Through effective residue management it is possible to recycle about 60-80 kg N, 20-30 kg P and 100-120 kg K/ha, annually.**

11. Weed management

Transplanted rice

In north east India mostly hand weeding is practiced. However, in the absence of manpower, herbicides like Butachlor (Machete) 5 % granule @ 30 kg/ha in 3-4 cm standing water within 2-4 days after transplanting (DAT) is applied to control grassy weeds. If granules not available, Butachlor in liquid form may be applied @ 1.5 kg a.i./ ha mixed with 400 litre water or Pendimethalin (Stomp) @ 1.0 kg a.i./ha in 400 litre water. To control sedges (*Cyperus* spp.) and broad leaved weeds, apply 2, 4-DEE 4 % granules @ 20 kg/ha at 4-5 DAT.

Use of cono-weeder in low land rice

Rotary paddy weeder (Cono weeder or Japanese paddy weeder) can be used for weeding by running the weeder in between the rows. Use of cono weeder requires only about 4 to 5 labourers/ha compared to about 20 labourers/ha for hand weeding. It also helps in simultaneous incorporation of weed biomass into the soil and improves soil aeration and root respiration. For SRI and ICM practice, weeding should be done at 15 days interval up to maximum tillering stage. Line transplanting using a spacing of at least 20 cm between rows is prerequisite for using mechanical weeder. Alternatively, farmers can make their paddy weeder using a wooden plank and inserting removable pegs in the floats. At least two weedings (25 and 45 DAT) are required for higher productivity in low land rice.

Upland rice

Weed problem is more in upland rice. First weeding must be completed within 3rd week of crop age and 2nd weeding at 40-45 days after sowing (DAS) to check weed growth. Hoeing should follow each weeding. Butachlor can be used as pre-emergence @ 1.5 kg a.i./ ha or Pendimethalin @ 1 kg a.i./ha in 500 litre water within 2-3 DAS. Pre-emergence application of Butachlor 0.75 kg a.i./ha + 2,4-D 0.50 kg a.i./ha is very good combination for controlling all types of weeds in upland rice.

12. Water management

Rice is a water loving plant and requires about 3000 to 5000 litre of water to produce a kilogram of rice grain. However, it is experimentally proved that by modifying management practices, adopting water efficient varieties, enhancing irrigation efficiency, reducing conveyance losses, etc. the water requirement of rice could be reduced substantially without reducing the productivity. In North Eastern region of India, rice is mostly cultivated under rainfed condition. Wherever, irrigation facility available, water should be applied during critical growth stages like tillering, panicle initiation, panicle emergence and grain filling stage to get maximum yield.

Transplanted rice

Continuous submergence of 2-5 cm during crop growth (transplanting to maturity) stages give higher yield. This practice helps to suppress weed growth right from the beginning. Water is drained out during fertilizer application. The depth of water should not exceed 5 cm in the field particularly at the tillering stage of the crop. Higher depth of water during tillering reduces the number of tillers/hill causing reduction in yield. After the completion of tillering, the field should be drained out for a week and reflooded again. This will result in higher number of effective tillers/hill. In any case, there should not be any water stress during panicle initiation to grain filling stage. Irrigation should be stopped 15-20 days before harvesting the crop. Under SRI practice no flooding is needed and field is kept saturated. No standing water to be maintained during tillering up to panicle initiation. Intermittent wetting and drying until panicle initiation stage is desirable. The period of drying and wetting can range from 2-7 days depending upon soil type and prevailing weather conditions. Such practice not only saves water but also provides resilience to plants in case of drought like situations.

Direct seeded rice

Cultivation of crops in toposequence helps in better utilization of water in hill slopes and terraces. While rice is cultivated in terraces or slopes, it should be grown in the lower portion of the hill slope where runoff concentrates. Water harvesting in-*situ* in flat or terrace land can be done by providing peripheral bunding (15-20cm height) to increase crop yield. Saturation and submergence are equally effective for direct sown rice.

13. SRI and ICM practice

About 40 % water can be saved under SRI and ICM method of cultivation when grown under irrigated condition. Only saturated field is required for transplanting of young seedlings in case of SRI/ICM. Water is applied whenever hairy cracks develops in the field i.e. a cycle of alternate wetting and drying is practiced. Alternate wetting and drying conditions makes the rice plant hardier, root grows profusely, thus absorbs nutrient and water efficiently and provides resistance against short term droughts. By following SRI and ICM practice, it is possible to achieve about 20 % higher rice productivity with less input. The grain filling is also better. Due to wider spacing and better growth, there is less

Demonstration on SRI in South Garo Hills

problems of disease and pests. This practice is good for maintaining purity of seeds. SRI and ICM rice matures about 15 and 7 days earlier respectively compared to conventional rice and vacates land timely for second crop. Since field is kept under saturated condition and not flooded, SRI and ICM practice releases less methane than flooded rice.

Points to be remembered for effective water management

1. Repair all old bunds (maintain 15-20 cm height in upland and 20-30 cm in lowland) before onset of monsoon and level the fields uniformly to save water.
2. Withhold water for few days during tillering at 25 to 30 days after transplanting to facilitate more number of tiller production
3. Drain-off water one day prior to the application of fertilizers and do not forget to close openings of water channels after fertilizer application to avoid loss.
4. Stop irrigation and drain-off water completely at physiological maturity (About 10 days before harvest). This also helps in taking a second crop like vegetables/ pulses in case of water logged soils.

14. Aerobic rice

The "aerobic rice technology" was developed to address the water crisis in rice production. Under this technology rice is established under non-puddled and non-flooded fields and rice is grown like an upland crop (unsaturated condition) with adequate inputs and supplementary irrigation when rainfall is insufficient. The new concept of aerobic rice may be an alternate strategy, which combines the characteristics of rice varieties adopted in upland with less water requirement and irrigated varieties with high response to inputs. This system is yet to become popular in North East India.

15. Ratooning of rice

In mid altitude (>900 m MSL) double cropping of rice is not possible mainly due to non-availability of extra short duration varieties and low temperature at the time of grain filling, which results sterility in grain. Ratooning of rice transplanted in March/April could be an option to go for double cropping of rice. Pre-*kharif* rice is harvested (end of August) at about 15-20 cm above the ground leaving at least one or two active node in the tillers. The rice field should be kept in saturated condition for better tiller growth. One weeding may be given


Rice ratoons at vegetative stage

15-20 days after harvesting of pre-*kharif* rice. 50% of recommended dose of NPK may be applied for better results. The ratoon rice mature much earlier than transplanted rice and avoids low temperature at grain filling stage. A well managed ratoon rice can produce yield level of 2-2.5 t/ha. The ratooning saves time, seed, labour for nursery preparation and transplanting, field preparation, etc.

16. Plant protection measures

Integrated insect pest and disease management is the best option as it reduces farmers' investment, utilizes farmers' knowledge and on-farm resources effectively. Use of resistant variety, timely sowing/transplanting, indigenous technical knowledge available with the farmers (use of crab traps for *gundi* bug, Use of fresh *Eupatorium* branches for control of sucking pests etc) optimizes the resource use. Balance application of fertilizers, appropriate intercultural operations and crop rotations also reduces insect pest and disease problems substantially. Field sanitation and proper weed management helps to reduce the insect pest and disease problem in rice.

Insect pest management

The major insect pest of rice in the region includes stem borer, *gundhi* bug, leaf folder, root aphid etc. For management of insect pest in rice spray Monocrotophos 36 EC @ 2 ml/litre or Chlorpyriphos 20 EC @ 1 ml/litre of water at 45 DAT for the control of leaf folder, case worm, stem borer and hispa is effective. Dusting with Carbaryl 10 % or Fenvalerate 0.4 % @ 20-25 kg/ha controls *gundi* bug. Under upland conditions, treatment of seeds with 0.75 kg a.i./100 kg seed or application of carbofuran 3g @ 1kg a.i./ha controls termites and white grubs. Use resistant varieties like RC Maniphou 4 and RC Maniphou 5 are tolerant to hispa and gall midge and Shahsarang 1, Lampnah, Bhalum 1 are tolerant to stem borer and leaf folder. Use of healthy and disease free seed also protects the plants from insect pest and diseases. Growing more than one variety (maintain diversity) is a good option to avoid complete crop failure due to pest/disease problem in a particular variety. Botanicals like neem oil 4 ml/litre of water reduces problem of most of the insect pests. Spraying V*erticilium lecanii* @ $1x10^9$ spore/ml reduces the problem of white backed plant hopper (WBPH) in rice. Release of *Trichogramma* egg parasitoids @ 50,000/ha reduces stem borer and leaf folder population to a great extent. Entomophthora fungal infection is severe on white leaf hoppers in North East. The pathogen infects leaf hoppers during booting stage of rice and control the pest population to the tune of 60 percent. Spraying of *Beauveria bassiana* @ 3 g/litre of water for the control of rice hispa is effective.

Disease management

Blast, sheath blight, bacterial leaf blight, brown spot, sheath rot are important diseases of rice. Seed treatment with Bavistin 50 WP @ 2.5 g/kg seed protects the crop from blast in nursery and also up to 25-30 DAT. For management of brown spot and blast treat the seed with Dithane M-45 @ 5 g/kg seed and spray the crop with Tricyclazole 75 WP (0.6 g/litre).

- Higher dose of N fertilizer such as urea makes the rice plant susceptible to insect pest and disease.
- Application of right doses of potassium fertilizer such as MOP improves resistance against insect pest and disease in rice.

17. Harvesting

Rice attains maturity at around 30 days for early and 40 days for medium to late maturing varieties after 50 % flowering (heading stage) in low and mid altitude areas. In high altitude areas, it may take more time to attain maturity. Harvesting is done at the yellow ripening stage to avoid shattering loss in field. Harvesting should be done when 80% grains are matured.

18. Cropping systems/Farming systems

Since successful *rabi* cropping is very difficult under rainfed upland in North East Hills (NEH) region, cropping intensity and total productivity can be increased by intercropping soybean, arhar and groundnut with rice in upland. It has been found that rice + arhar (4:1 row ratio) and rice + groundnut/soybean (4:2 row ratio) are promising in NEH regions. Intercropping with legumes helps in reducing weed problem, improves soil fertility and enhances farm income.

Under high altitude conditions, monoculture of rice is prevalent but cropping sequence of potato-rice is recommended. Under mid and low altitude, rice-mustard, rice-pea/lentil is recommended. Rice - tomato, rice-mustard, rice-frenchbean, rice- carrot, etc. are recommended for lowland conditions. In these systems, rice is grown during *kharif* season as usually practiced, whereas, vegetables are grown in temporary raised beds to create favourable soil condition. Under wet and marshy valley land of Meghalaya or elsewhere in NEH Region, permanent raised and sunken beds (width of raised bed- 1m, width of sunken beds -1 m, bed height 0.3 to 0.5 as per situation) system is recommended for crop diversification and effective utilization of land. In this

Rice on sunken beds and bhindi on raised beds

Rice + soybean (4:2) intercropping systems

system rice –rice or rice-pea/lentil/toria on sunken beds and tomato/carrot/frenchbean – bhindi-frenchbean on sunken bed is practiced.

Rice + fish farming

Rice + fish farming or integrating rice with composite fish culture, livestock (Duck, Pig, etc.) and horticultural crops (vegetable on bunds etc) will reduce farmers risk due to weather uncertainties and provide assured income.

Incase of rice cultivation in sloppy lands/hill slopes, toposequence should be followed with top 1/3 portion of the slope under natural forest to catch rainfall, middle 1/3 under horticultural crops, plantation crops and lower 1/3 under maize and rice based cropping systems. Rice cultivation should be practiced at the bottom terraces for better water management and higher rice productivity.

19. Contingency plan for aberrant weather conditions

The weather in the region is showing aberrant conditions in the recent past and climate change impacts are evident on the globe as a whole. The rainfall which is most important input for rice cultivation in the region is becoming more and more unpredictable. The drought of 2009 and excess rainfall of 2010-11 are some recent examples. In rain-fed areas where rains are likely to be delayed and where a normal transplanted rice crop is ruled out, short duration upland rice varieties (IURON 514, Bhalum 1, Bhalum 2, Bhalum 3 and Bhalum 4) or those rice varieties that are suitable for direct seeding either in dry or wet (Vivek Dhan 82, VL Dhan 61 etc) condition and subsequent flooding are recommended. In case of a early season drought nursery may be prepared by modified mat nursery (MMN) method and SRI practice may be followed. In MMN, nursery is prepared by mixing soil and organic

A well managed rice (Shasarang 1) crop under resource conservation experiment in lowland

Excellent upland rice (IURON 514) under resource conservation in upland terrace condition

manure in 2:1 ratio and very low seed rate of about 50 g/m^2 area as against about 100 g/m^2 area in conventional practice to produce robust healthy seedlings. For mid season drought, conservation of rain water is very important. There is need to evolve a standard site specific contingency crop plan to cope up in better way with the unfavorable weather conditions (Table 1). Under upland condition, rice should be rotated with groundnut/soybean/ricebean once in every 2 years for building soil fertility and resilience. Agroadvisory services with forecasting for abnormal weather conditions such as heavy rain, delay in rain, frost, cyclone etc. will help farmers to adapt contingency measures and reduce losses due to climatic anomalies.

Table 1. Contingency crop planning under various weather aberrant situations

Weather condition/ aberrations	Contingency planning
Normal monsoon	• Follow the package of practices recommended for the region • Do not plant all the area under varieties of same duration • Short duration varieties in rainfed areas are preferable
Timely onset and sudden withdrawal of monsoon	• Avoid sowing till sufficient rains have been received • If sowing is delayed, plant short duration varieties • Practice thinning of crop stand, reduce plant population and use the biomass as mulch, intercultural Operation to control weeds in case of upland rice • Conserve rain water in ponds/tanks/field for irrigation during critical growth stages • Foliar application of nutrients (Urea 2 %) may be done where moisture is a constraint
Delay in onset of monsoon: Maximum of three weeks from normal date for the given region	• Shift from long duration to short duration crops/varieties • Sowing of paddy nursery at 15 days interval. May be more area put under nursery • Conservation of pre-monsoon soil moisture through soil/straw/grass mulching practices • Adopt closure spacing and increase seed rate and N fertilizer rate by 20 to 25% • SRI rice matures about 15 days earlier and may be followed to save time • Raising community nurseries of rice is a viable option • Stock rice seedling (bundles) in corner of main field for gap filling after t ransplanting
Break in monsoon (dry spell conditions for 2 to 3 weeks consecutively)	• Follow water conservation (farm pond, raising bund height, etc.) and management (life saving irrigation, mulching, thinning plant population, 2 % urea supply, etc.) practices • Possibility of taking a catch crop (Black gram in upland). • Conserving moisture for 'rabi' sowing • Utilizing paddy fallows for second crop • Spraying of boron (Borax) and potassium (Potassium chloride) increases drought tolerance
Early withdrawal of monsoon: By last week of August (late season drought)	• Follow water conservation and management practices • Efficient use of stored water for life saving irrigation • Harvesting the crop at physiological maturity. • Short duration varieties of pulses, oilseeds, minor millets • Appropriate pest and disease management • Prepare for the ensuing '*rabi*' season to reduce the loss

20. Yield

A well managed direct seeded rice crop yields about 3.0-3.5 t/ha in upland and transplanted crop yields about 4.5 -6.0 t/ha.

21. Methane (CH_4) emission and management

The country's total emission from rice field was estimated at 3.39 million ton (mt)/ year. The CH_4 emission potential of rice fields of the North East India was extrapolated from the estimated emission rates under various rice land uses by the Space Application Centre (SAC), ISRO, Ahmedabad (2009). The total CH_4 emission potential of North East India was estimated at 0.51 mt/year (Table 2). Bringing about 25 % rice area under SRI/ aerobic cultivation would reduce CH_4 emission by about 0.062 mt (12 %) of present level in NE India. Similarly, efficient nitrogen management would reduce the nitrous oxide emission from the rice fields.

Table 2. Methane emission (CH_4) potential of rice fields and management

Rice Land Use	Area (mha)	CH_4 Emission (g/m^2)	Total Emission (kg/year)
Lowland	2.907	13.78	400×10^6 kg
Upland	0.336	5.50	18.5×10^6 kg
Deepwater	0.267	34.38	91.8×10^6 kg
Total	3.51	-	510×10^6 kg = 0.51mt

22. Rice cultivation in *Jhum* fields

Jhuming (shifting cultivation) is still practiced in an area of about 0.88 m ha in the North Eastern Region. Rice occupies majority of the area under *jhum*. *Jhum* rice is grown under most fragile and risk-prone ecosystem. The rice productivity under *jhum* is less than a tonne/hectare. The crop is entirely rainfed and grown on in-*situ* soil fertility. Growing low yielding local varieties, no fertilizer and manure application, lack of irrigation facilities, soil erosion due to cultivation in hill slopes, pest and disease problems are the major bottlenecks in improving *jhum* rice productivity. Following package of practices may be adopted to improve productivity and conserve soil and moisture

- Grow high yielding rice varieties like Bhalum 1, Bhalum 2, Bhalum 3, Bhalum 4, IURON 514 etc.
- Adopt dibbling (*chutaki*) method instead of broadcasting for maintaining adequate plant population, spacing and sowing depth.
- Wherever possible, fertilizer mixture (30:30:20 kg NPK/ha) along with well decomposed manure (500 kg FYM or 250 kg vermicompost/ha) may be applied. For one hectare (10,000 m^2) area, the requirement will be 65 kg urea, 185 kg SSP and 33 kg MOP.

- Strip cropping (row planting in alternate strips of rice with legumes like groundnut, soybean, black gram, red gram, rice bean, etc. across the slopes helps in resisting the soil erosion and improves soil fertility. 2 rows of legumes (groundnut, soybean, etc) may be sown after every 4 to 6 rows of rice.
- Urea or DAP solution at 2 % concentration may be sprayed at vegetative stage and at flowering stage for better growth and yield of rice.
- During drought, potassium chloride (2 %) may be sprayed at 15 days interval for reducing the stress on plant.
- At least 2 weeding should be done. Hand weeding is most common practice. Use of common salt 2-4 % is also common in many parts. Pre-emergence application of butachlor 0.75 kg a.i./ha + 2,4-D 0.5 kg a.i./ha is good combination for controlling all types of weeds in upland/*jhum* rice.
- Prophylactic measures should be adopted for pest and disease management. Use of resistant varieties, healthy seeds, ITKs (use of crab traps, etc) are the best options.
- Rain water harvesting (*Jalkund*s, farm ponds), composting, terracing, planting hedge row species (*Tephrosia* sp., *Indigofera* spp. etc.) along the contours,

Rice in *Jhum* Fields

mulching, etc. should be practiced wherever possible for sustainable *jhum* farming.

- During every alternate year, cover crops and/or soil fertility building crops such as ricebean, groundnut, velvet bean (mucuna) etc. should be grown in rice field for developing resilience of the soil.

23. Rice Cultivation in Flood Affected Areas

Flash flooding and submergence are widespread in Southeast Asia, Bangladesh and northeastern India and affect about 22 m ha (16 % of world rice area) including 15 million ha of potential short duration flash floods in rainfed lowlands and 5 million ha of deep water rice (called *Bao* in Assam). Parts of Assam, Tripura, Manipur and Garo Hills of Meghalaya suffers due to flash floods. The rice productivity in such areas are low. Flash flooding includes three drastic environmental changes -

- the tendency of restricting respiration during submergence due to a shortage of oxygen,
- a drastic inhibition to the entry of carbon dioxide restricting photosynthesis during submergence, and,
- the damaging effects of the subsequent reversal back to fully aerobic conditions when flood water recedes.

Adoption of appropriate agro-techniques can reduce the damage due to seasonal floods and rice yields can be enhanced substantially.

Some of the locally grown *Bao* rice in Assam are Neghari-*Bao*, Dal-*Bao*, Panindra and Maguri-*Bao* Padmatai, Panikekoa, Padmanath, Sabita, Rangi-Bao, Badal, etc. *Bao* rice is generally grown in low-laying areas with water stagnation beyond 50 cm for more than a month in the season. The area covered has no option but to grow *Bao* rice with very low productivity and full of risk, both abiotic and biotic. Low plant population due to early inundation is the reason for the poor yield of *Bao* rice. Advancing the sowing season to March-April and direct seeding ensure early crop establishment and higher plant population. Agronomic practices like basal fertilizer application to tolerate submergence gives some assurance of yield to farmers.

The photo-insensitive varieties bearing submergence tolerance capability for at least two weeks in the vegetative stage and varieties having staggering ability in planting time are the best choice for flood affected areas. In low lying areas varieties like Ranjit, Bahadur yielded best in July planting with 30-35 days old seedlings under normal rainfed conditions. However, under submergence condition varieties Developed by Regional Agricultural Research Station (RARS), Titabar, Assam such as Jalashree, Jalkuwari, Plaban having submergence tolerance of 15 to 18 are better options. Under situation, where transplanting has to be delayed beyond August due to floods, varieties having staggering in seedling age such as Prafulla, Gitesh etc. may be planted up to first fortnight of September. These varieties can be transplanted at 60-75 days seedling age under closer spacing 10 cm x10 cm for maintaining higher plant population. The new short duration varieties by RARS like Luit, Kapilee reported to produce reasonable yield when direct seeded up to September 10 after recession of flood water. For Manipur valley, RCM 9 has been identified by ICAR research Complex for NEH Region for submergence tolerance**.** Planting young seedlings of 10-15 days old of short duration varieties after flood water recession is another option to get a good yield of rice as rice duration is reported to reduce by about 10-15 days when young seedlings are transplanted. Double transplanting is another option to mitigate the affect of floods. Maintaining a community nursery in raised areas of the locality is another contingency measure in flood affected areas. Integrated nutrient management, pest and disease management are important to get higher yield in flood affected areas. Wherever possible adequate drainage facilities should be provided to give rice a favourable condition for growth and development.

24. Calculation of Fertilizer and Pesticides in Agriculture

Application of fertilizer and pesticides in correct dose and amount are the prerequisites for getting optimum response in growth and management of pest and diseases in crops. It is very important to apply correct dose of nutrient to the crops as per soil fertility status. Calculation of accurate dose of chemicals required for field application particularly in case of pesticides and herbicides are still complicated and many a time difficult even for extension personnel to compute, leave aside the farmers. Accurate dose of application of chemicals would not only avoid over or under dose in crops but would also save resources and increase productivity. For field functionaries and farmers an easy method of computation should be made available avoiding the complexities in calculation. For example if a farmer has to apply 60 kg N in rice, he needs to apply 60 x 2.17 or 130 kg urea. This is very simple to understand and avoids the chances of any unforeseen mistake by the farmers.

25. Fertilizer dose calculation

The crop nutrient requirements are commonly recommended in terms of the nutrient values. For example, recommendation for rice is 80-60-40 NPK per ha. But the field application has to be on the basis of the quantities of commercial fertilizers required to meet the recommended rates of NPK. This conversion involves some amount of calculations.

Criteria to be considered while calculating the fertilizer dose:

1. Crop under consideration
2. Area to be fertilized
3. Type of fertilizer available
4. Method of application
5. Split application

Basic formula for fertilizer dose calculation:

$$\text{Quantity of fertilizer} = \frac{100 \times \text{Recommended dose}}{\text{Nutrient content in fertilizer}}$$

Example 1

Calculate commercial fertilizer required to fertilize the rice crop through straight fertilizer using urea, single superphosphate (SSP) and murate of potash (MOP). Recommended dose for rice is 80:60:40 kg NPK/ha.

➢ Solution:

1. Urea contains 46% N
   To supply 80 kg N = (100 x 80)/46
   = 173.6 kg Urea
2. SSP contains 16% P
   To supply 60 kg P = (100 x 60)/16
   = 375 kg SSP
3. MOP contains 60% K
   To supply 40 kg K = (100 x 40)/60
   = 66.6 kg or 67 kg MOP

Example 2

Find out the quantity of fertilizer required to fertilize the rice crop through Diammonium phosphate (DAP), urea, murate of potash (MOP). Recommended dose is 100:60:40 kg NPK to fertilize one hectare area of rice.

➢ Solution:

Here DAP is as source for P (46 %) but it also contain N (18 %). Let us first apply P through DAP:

To supply 60 kg P	=	(100 x 60)/46
	=	130.4 kg DAP
And amount of N		
supplied through DAP	=	(130.4 x 18)/ 100
	=	23.5 kg N
Rest of N i.e. 80-23.5	=	56.5 is applied through urea (46 % N)
	=	(100 x 76.5)/ 46
	=	122.8 or 123 kg urea

K is supplied through MOP (60 % K)

To supply 40 kg K = (100 x 40)/ 60

= 66.66 or 67 kg MOP

Hence, 130.4 kg DAP, 123 kg urea and 67 kg MOP is required to fertilize the rice crop.

Table 3. **Conversion factors for nutrient to transform into required quantity of fertilizers**

Nutrient	Factor	Name of Fertilizer
N	2.17	Urea
N	5.56	Diammonium Phosphate (DAP)
N	4.76	Ammonium sulphate
P	2.17	Diammonium Phosphate (DAP)
P	2.08	Triple Super Phosphate
P	6.25	Single Superphosphate (SSP)
K	1.67	Murate of Potash (MOP)
K	2.00	Sulphate of Potash
N	200	Farm Yard Manure (FYM)
N	100	Vermicompost

Based on the above factors to apply 80:60:40 NPK kg/ha, the farmers need to apply-

80 x 2.17 = 173.6 kg urea/ha

60 x 6.25 = 375 kg SSP/ha

40 x 1.67 = 66.8 kg MOP/ha

How to economize fertilizer use?

1. The fertilizer recommendations should be based on soil test values.
2. Balanced use of fertilizer should be advocated for better economic returns.
3. Use of nitrogenous fertilizer in split doses economizes fertilizer use.
4. Micronutrient deficiencies should be corrected as and when needed.
5. Fertilizer schedule should be adopted for the whole crop sequence instead of a single crop.
6. To get the maximum benefit from the applied fertilizers, crops should be irrigated at the critical growth stages.

What is the calculation procedure for foliar sprays?

1. Suppose the recommended foliar spray of Urea is 2 % concentration.
2. 100 parts of spray solution should have 2 parts of Urea. To get this, 2 kg of urea should be dissolved in 100 liters of water or 2 kg of Urea in 100 liters of water i.e., 20 g urea in 1 litre of water makes 2 % Urea solution.

3. If the amount of water required to cover one hectare is 500 liters, then a 2 % spray liquid is prepared by dissolving 10 kg of Urea in 500 liters of water.

26. Pesticides dose calculation

In preparing spray solution of pesticide to spray in the field, it is most important to add the correct amount of pesticide to the mix. Too little may result in a poor job, while too much may result in injury to the treated surface, illegal residues, or unnecessary expense. Being highly toxic, pesticides are not sold in its pure form. They are subjected to dilution with any carrier to avoid the hazards of poisoning to applicator or human being. Pesticides are commercially manufactured in various formulations (by adding various additives) like emulsifiable concentrates, water-dispersible powders, dusts, granules, solutions etc. The strength or active ingredient is mentioned on the label. Directions for preparing final solution are given on the label and very simple calculations are necessary.

Key points to be considered

1. Understand the importance of adding the correct amount of pesticide to a mix.
2. Learn to do correct calculations for mixtures of pesticides.

What is **active ingredient**?

It is the actual toxicant in commercial products which is directly responsible for its toxic effect.

What is **acid equivalent?**

It refers to the formulation that theoretically can be converted to the parent acid. Some herbicides are active organic acids like phenoxy acetic acid, picloram & chloramben and some are generally supplied in the form of their salts and esters as in 2, 4-D.

Some commercially available pesticides are-

Insecticides: Malathion 50EC, Metasystox 25EC, Phorate 10G, Carbofuran 3G, Imidacloprid 17 SL

Herbicides: Propanil 35EC, Benthiocarb, Nitrofen, Atrazine 50 WP, Simazine 60 WP, Paraquat 24WSC, Fluchloralin 45EC, Butachlor 50EC or 5G, Glyphosate 41WSC, 2, 4-D Ethyle ester 18 & 35 %, 2, 4-D Amine salt 58 & 72 %, 2, 4-D Sodium salt 80 & 85P, Cyhalofop butyl, Bisparibac sodium, Clomazone, etc.

Fungicides: Carbendazim 50 SC, Carbendazim 50 WP, Copper Oxychloride 50WP, Difenconazole 24.9EC, Dithianon 5SC, Hexaconazole 5, 10EC, Hexaconazole 5 SC, Mancozeb 80, 75 WP, Miclobutanil 10 WP, Propiconazole 10, 25 EC, Tebuconazole 24.9 EW, Tricyclozole 75 WP, Triadimefon 25 % WP, etc.

Pesticides are recommended in three ways for its field application such as amount of pesticides per hectare (kg/ha), amount of active ingredient or acid equivalent per hectare (kg a.i./ha) and concentration of solution to be applied (e.g. 0.07 % of Monocrotophos). Before application or purchase of pesticides it is always strike in the mind of farmers that how much amount of insecticides or herbicides or fungicides etc would be required for application on their farm of definite size so that he could purchase only the required amount. Let us see the methods for calculating the pesticide dose with some example.

If pesticide dose is recommended as kg a.i./ha:

Rate of herbicides is given mainly in terms of a.i. or a.e. /ha

$$\text{Quantity of material required per hectare} = \frac{\text{Rate of application}}{\text{Active ingredient in \%}} \times 100$$

Example 3

Find out the quantity of Butachlor 50 EC to be sprayed in one hectare area of soybean as pre-emergence application, if rate of application is 2 kg a. i. /ha

➢ Quantity of Butachlor /ha = $\frac{2 \times 100}{50}$ = 4.00 litre / ha

Example 4

Find out the quantity of Carbofuran 3G to be applied in one hectare area if rate of application is 0.35 kg a.i. /ha

➢ Quantity of Carbofuran/ha = $\frac{0.35 \times 100}{3}$ = 11.66 i.e. 12.00 Kg granules / ha

For the calculation of this type we must know the a.i. present in the commercial product.

If recommended as kg/ha:

To spray one hectare with a hydraulic nozzle sprayer in good working condition and a 15 liter knapsack sprayer, one will need 300 liters of solution, i.e. 20 sprayer loads.

Example 5

To control all kinds of weeds in uncropped area, 1 liter of Round Up (Glyphosate) should be applied per hectare.

➢ It means

1 liter = 1000 ml

20 sprayers (15 L each) per ha

1000 ml/ 20 = 50

i. e. 50 ml per 1 small knapsack sprayer and 20 loads will be required.

If recommended as % concentration:

By formulae

$$\text{Amount of pesticide} = \frac{\text{Volume of spray solution (litre)} \times \text{\% strength of pesticide solution to be sprayed}}{\text{\% strength of pesticide given (a.i./l or kg)}}$$

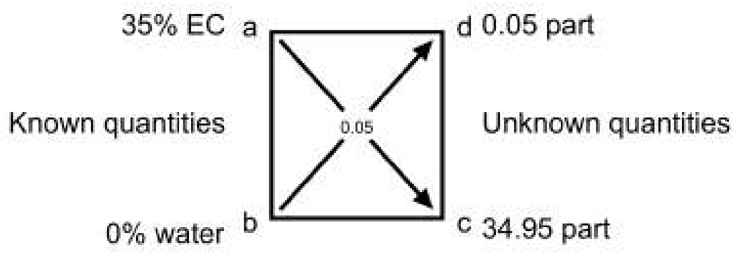
➢ Example: Amount of Metasystox 25 EC when applied as 0.025 % solution

$$= \frac{300 \times 0.025}{25}$$

$= 0.3$ liter or 300 ml/ ha

By Pearson's square method:

Example: To prepare 0.05 % mixture from a pesticide with a.i. 35 EC.



To get the required amount of insecticide and water, substract the smaller figure from the higher ones (i.e., 0.05-0=0.05 and 35-0.05=34.95), diagonally.

Put 0.05 opposite EC at **d** and 34.95 opposite water at **c** point.

This means that to make 0.05 % solution out of the endosulfan 35 EC, we require 0.05 part of endosulfan + 34.95 part of water.

Some more formula for herbicide calculation:

Small area

$$\text{Herbicide rate (g)} = \frac{10 \text{ x R x A}}{\text{P}}$$

Where,
R = Rate of Application (kg a.i./ha)
A = Area to be treated in Sq.m.
P = % a.i. in product

Large area

$$\text{Herbicide rate (kg)} = \frac{10 \times R \times A}{P}$$

Where,
R = Rate of Application (kg a.i./ha)
A = Area to be treated in ha
P = % a.i. in product

How to economize pesticides use?

1. The pesticides should be used only when the level of damage is above **economic threshold level** (ETL) values.
2. Cultural methods, use of resistant varieties should be encouraged
3. Possibility of applying more than one chemical together should be explored by studying their compatibility to save labour and time.
4. Balanced fertilization reduces pest problems.
5. Integrated pest and disease management reduces residue problem and economize their use.

Table 4. Nitrient content in commonly available fertilizers

Fertilizer	**Amount of nutrients (%)**				
	N	P	K	S	Others
Urea	45	-	-	-	-
Zinc coated urea	43	-	-	-	2 (Zn)
Ammonium Sulphate	21	-	-	24	-
Ammonium Chloride	26	-	-	-	-
Single Super Phosphate (SSP)	-	16	-	12	20 (Ca)
Boronated SSP	-	16	-	-	0.18 (B)
Potassium Chloride	-	-	60	-	48 (Cl)
Potassium Sulphate	-	-	50	18	-
Di- Ammonium Phosphate	18	46	-	-	-
Urea Ammonium Phosphate	28	28	-	-	-
Ammonium Phosphate Sulphate	16	20	-	15	-
Ammonium Phosphate Sulphate	20	20	-	15	-
Nitro Phosphate	20	20	-	-	-
Nitro Phosphate	23	23	-	-	-

Contd....

Nitro Phosphate	15	15	15	-	-
NPK Complex	12	32	16	-	-
NPK Complex	10	26	26	-	-
NPK Complex	17	17	17	-	-
NPK Complex	19	19	19	-	-
NPK Complex	14	35	14	-	-
Rock Phosphate	-	20-30	-	-	35 (Ca)
Gypsum (Agriculture grade)	-	-	-	13-18	16-19 (Ca)
Rock phosphate	-	18-20		-	-
Phospho Gypsum	-	-	-	16	21 (Ca)
Pyrite (Agriculture grade)	-	-	-	22-24	20 (Fe)
Magnesium Sulphate	-	-	-	13	9.6 (Mg)
Borax	-	-	-	-	10.5 (B)
Solubore	-	-	-	-	19 (B)
Copper sulphate $CuSO_4.5H_2O$					
$CuSO_4.5H_2O$	-	-	-	13	24 (Cu)
35 (Cu)					
Ferrous sulphate	-	-	-	12	19 (Fe)
FE-EDTA	-	-	-	-	12 (Fe)
Manganese sulphate	-	-	-	15	30.5 (Mn)
Zinc Sulphate, $ZnSO_4.H_2O$					
$ZnSO_4.7H_2O$	-	-	-	11-16	33 (Zn)
21 (Zn)					
Zinc- EDTA	-	-	-	-	12 (Zn)

Table 5. Amount of nutrients in common organic manures/green manures and plant residues

Fertilizer	Amount of nutrients (%)		
	N	P	K
Farm yard manure (FYM)	0.93	0.25	0.91
Pig manure	1.19	0.39	1.01
Poultry manure	1.87	0.54	2.15
Compost	1.5	0.35	0.85
Vermicompost	1.02	0.60	0.18
Rockphosphate enriched compost	1.02	2.77	1.0
Mustard oil cake	4.8	2.0	1.3
Neem cake	5.2	1.1	1.5
Rice straw	0.36	0.10	0.71
Groundnut stover	0.92	0.18	0.60
Rice bean stover	0.85	0.22	0.52
Ambrosia spp.	3.15	0.11	0.79
Eupatorium spp.	3.36	0.10	0.82
Azolla	2.38	0.51	2.75

Table 6. List of some important herbicides used in rice with recommended dose

S.No.	Herbicide	Recommended Dose (kg a.i/ha)
1.	Bensulfuron-methyl	50 – 60*
2.	Bentazon	1.0 – 2.0
3.	Benthiocarb	1.0 – 1.5
4.	Bisparibac sodium	30.00*
5.	Butachlor	1.0 – 1.5
6.	Cyhalofop butyl	190 – 280*
7.	Fluchloraline	1.00
8.	Metsulfuron -methyl 10% + Chloromuron-ethyl 10%	4.0*
9.	Metsulfuron-methyl	4 – 8*
10.	Oxadizon	0.5 – 0.75
11.	Pendimethalin	1.00
12.	Pretilachlor	0.4 – 0.5
13.	Pyrazosulfuron-ethyl	15 – 20*
14.	Trifluraline	1.00

Note: * indicate dose in gram

Conversion factors for area

1 hectare	=	2.47 acre
1 acre	=	0.40 hectare
1 hectare	=	10,000 sq meter
1 acre	=	4,048 sq meter
	=	4,840 sq yard
	=	43,560 sq feet

1 million hectare: 10 lakh hectare

Conversion factors for weight

1 Metric ton	=	1,000 kg
1 Metric ton	=	10 quintal
1 quintal	=	100 kg
1 Mann	=	37.32 kg

1 million tonne: 10 lakh tonne

Note: The phosphorus and potassium content of fertilizers and manures in this publication are given as P and K, respectively which should be read as oxidized forms of P and K i.e. P_2O_5 and K_2O, respectively.