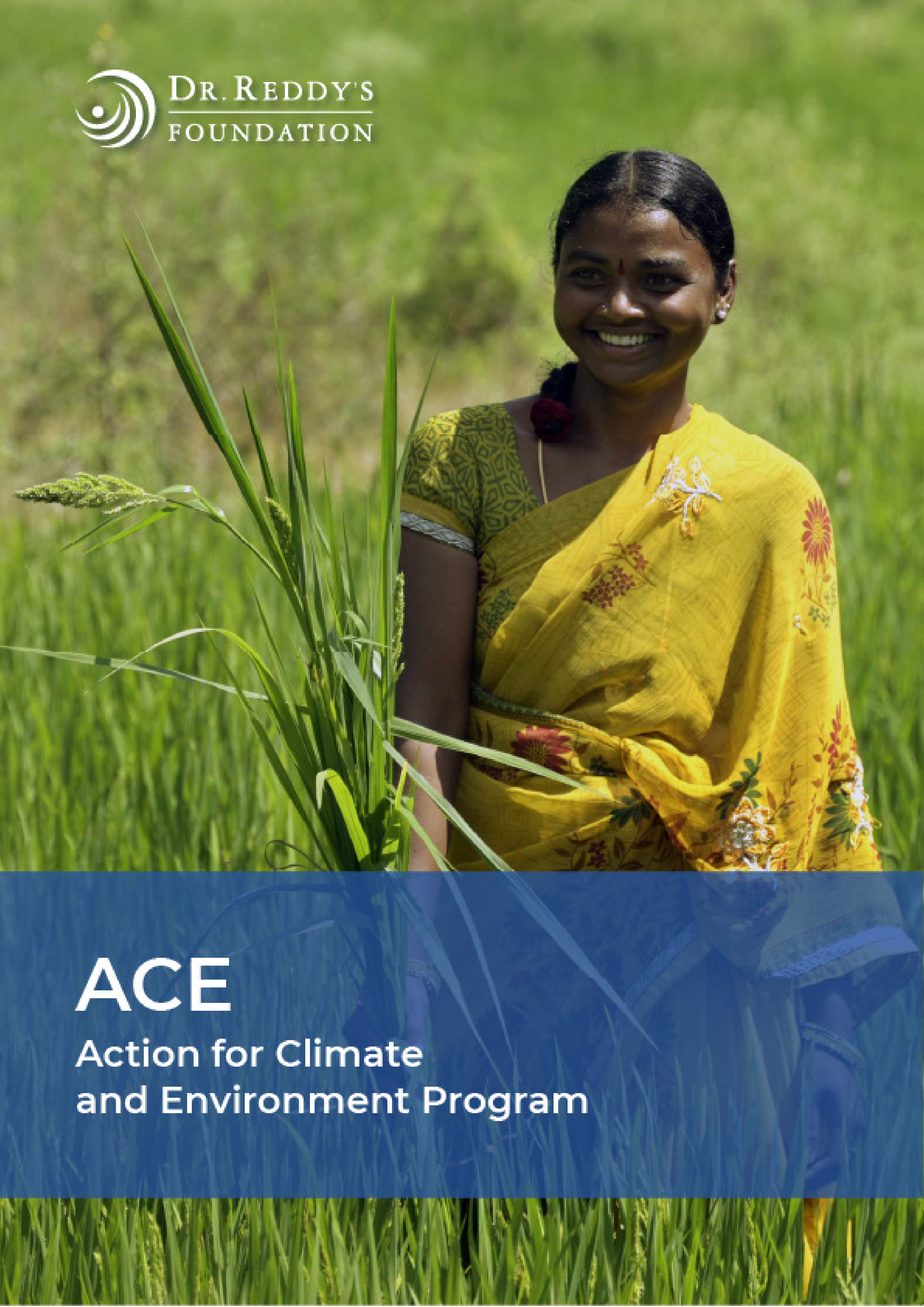
Dr. Reddy's Foundation



ACE

Action for Climate and Environment Program

Introduction

Dr. Reddy's Foundation (DRF) was set up in 1996 to improve the dignity and well-being of communities. We started by working with youth and children and soon included small and marginalized farmers as a priority, based on the needs of the community.

With the support of our partners, our MITRA program, developed a community-owned platform at every village level to help farmers use last-mile connectivity efficiently with the support of "Lead Farmers". Lead farmer is a community elected representative who demonstrates and disseminates best agriculture practices to other farmers in his community known as "Fellow Farmers". The platform has enabled 200,000 farmers with small landholdings to improve their income by reducing the cost of cultivation and increasing yield by facilitating access to quality extension services.

DRF is also committed to climate action since climate change has in recent times emerged as one of the most complex challenge of our times. Given the urgency to address climate change through concerted efforts, our Action for Climate and Environment (ACE) program which started in 2020 works with farmers in two states by exploring and implementing a mix of mitigation and adaptation strategies to reduce the impacts of climate change in a participatory and integrated manner.

This compendium captures the impact and learning of the ACE program and it has two purposes. The first is to highlight the key insights from the interventions introduced by ACE in its program sites in the State of Andhra Pradesh and Telangana. Interventions discussed in the compendium are meant to be options to inform implementation mechanisms & road maps for the successful adaption of climate-friendly agriculture practices in the Indian agricultural. The second objective is to share stories of innovative and enterprising farmers who incorporated these interventions in their package of practices and demonstrated the success of climate-friendly practices to their fellow farmers that enabled adaption at a wider scale.

DR. REDDY'S FOUNDATION

Action for Climate and Environment (ACE)

Table of Contents

1. Alleyways in Paddy

1.1 Problem/Concern

Pest outbreaks are a major problem in paddy cultivation as they result in extensive losses in rice production systems. In India, yield losses ranging from 21-51% have been estimated due to moderate to severe incidences of pest attacks (NCAP 2004). In order to tackle pests, farmers also end up using more pesticides than recommended leading to serious adverse environmental and health implications.

1.2 Solution: Alleyways in Paddy

Alleyway formation is the practice of transplanting paddy in equally spaced rows by leaving alleys or pathways of 20-30 cm width after every 2-3 metres i.e. around 8-10 rows in east-west direction. Alleyway formation ensures uniform spacing between rows of paddy and reduces insect pest infestation particularly in Brown planthopper (BPH), and the whitebacked planthopper (WBPH) affected areas (Prakash et al. 2014).

It is a cultural control practiced under integrated pest management of paddy i.e. alleyways are normal agronomic practices that increase crop productivity and also supports pest suppression (NCAP 2004).

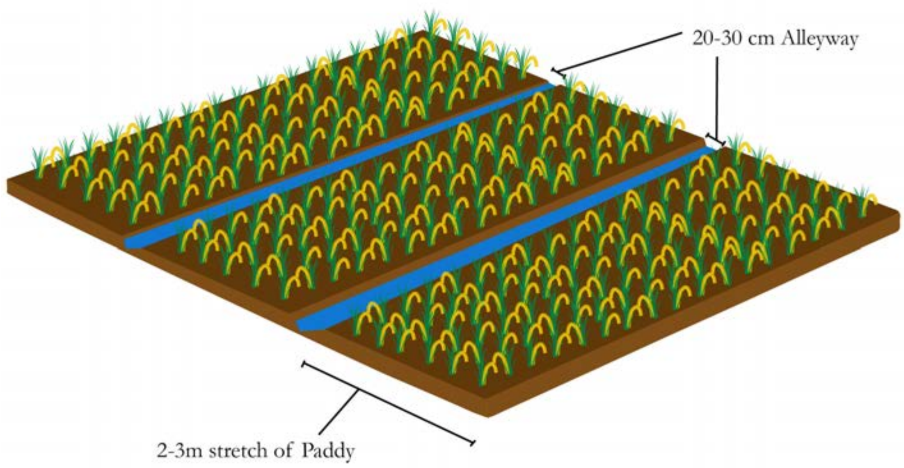


Figure 1.2 Diagram of alleyways in a paddy field

Alleyways permit better transmission of sunlight and better aeration in the rice field. It is also a water saving practice since it supports proper distribution of water. Alleyways also facilitate free movement of farmers in the fields and helps in uniform application of fertilizers, weedicides and pesticides.

1.3 Key Resources or Considerations

The most important aspect of alleyways is to ensure that there is the uniform spacing between the rows of paddy.

1.4 Applicability

Alleyway formation is a highly beneficial, simple, low hanging fruit for growing healthy rice. It requires minimal training and can be easily adopted by farmers in transplanted rice systems.

1.5 Limitations/ Barriers to Adoption

It is labour intensive because farmers have to manually make space between rows of transplanted rice.

1.6 Estimated Costs

It is a cost-effective intervention since alleyways need to be created only once during paddy cultivation at the transplantation stage. However, the cost is dependent on labour availability in the region.

1.7 Entrepreneurs of Tomorrow

Dupati Raju has been a Lead Farmer for over three years in the DRF program. Initially a cotton farmer from Konthalapally, Telangana, Raju shifted to cultivating rice owing to decreasing cotton yields. However, even paddy cultivation came with its own set of challenges. One of the major challenges he suffered was crop damage due to increased pest attacks and he needed an immediate solution.

Through DRF's capacity building initiatives, Raju had the opportunity to train with the local Krishi Vigyan Kendra (KVK) and was exposed to new improved farming technologies as well as inputs. This included training on Integrated pest management practices like Alleyways. Alleyways not only helped him control pest attacks, but it also supported efficient water management and reduced pesticide application. This along with the implementation of the improved package of practices like seed treatment, waste decomposer helped achieve uniform and healthy crop growth leading to better quality yield and reduction in the cost of cultivation. Also, with the adoption of integrated pest management practices like alleyways Raju not only increased his paddy yield from 24 quintals to 28 quintals per acre but has also managed to earn an additional profit of Rs. 7900 per acre. The overall cost saving even helped him diversify his source of income as he managed to invest in a chalk manufacturing business. He also generously gives back to the community by sponsoring 30 underprivileged children. With his ambition and his noble heart, he is an inspiration to many around him.

Figure 1.3 Dupati Raju's efforts towards sponsoring underprivileged children

Image 1.2 Dupati Raju in his field

1.8 References

NCAP (2004). Integrated Pest Management in Indian Agriculture. Proceedings 11. NCAP: Delhi.

Prakash A., Bentur JS,........ and Jeyakumar P., et al.. (2014). Integrated Pest Management for Rice. p. 43. Directorate of Plant Protection, Quarantine & Storage:Faridabad.

2. Borewell Recharge Technique

2.1 Problem/Concern

Groundwater is the major source of drinking water and irrigation in rural India. Over the last few decades, India has been grappling with intense and rapid depletion of groundwater driven by over-extraction and more frequent dry spells due to climate change, resulting in the drying-up of existing wells in many areas. Recharging and augmenting groundwater resources is becoming increasingly critical for India in the face of climate change particularly during the dry months.

2.2 Solution: Borewell Recharge Technique

Borewell recharging technique is a sustainable water management technique that focuses on recharging dry wells by diverting surface runoff through field trenches into a borewell recharge unit which comprises a percolation pit (size may vary based on requirement) dug around the bore filled with multiple layers of filters. These filters include a natural filter made up of large and small stones, a layer of gravel and sand and lastly, a fine nylon mesh wrapped around a drilled casing pipe. An additional layer of charcoal is often included to make the water potable for domestic purposes. The layers filter the runoff and remove impurities from the water, fill the area around the pipe casing and allow water to enter into the borewell through the protective mesh, thereby recharging the underlying aquifer with clean, filtered rainwater. On the top, the unit is covered with a cement ring to prevent the sediments from flowing water to enter the unit. Borewell recharging helps in capturing surface water runoff and recharging the aquifers thereby increase water available for both agriculture and domestic purposes. Given, this technique re-uses existing low yielding wells it reduces the overall cost of the structure and the method of testing for suitability of existing well for recharge is also simple and can be easily carried out by a farmer.

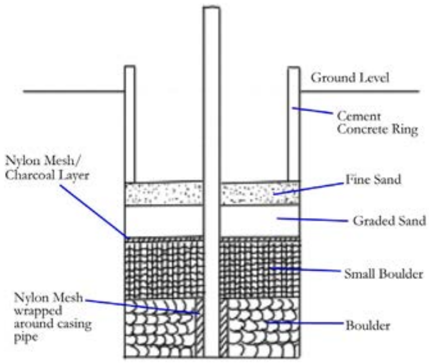


Figure 2.1 Filter Layers of a borewell recharge structure

Image 2.1 Borewell Identification

Image 2.2 Construction of a Borewell

2.3 Key Resources or Considerations

The key information required before the adoption of intervention is to understand the recharge potential of a bore well. This can be done either scientifically through a scientific aquifer mapping test or a simpler and more practical 'input test' or 'tanker test'. In this test, typically a tanker full of water (5000 litres) is poured into the borewell casing pipe and a change in water level and time is taken for the borewell to absorb the water is observed. If the bore well absorbs all the water it is considered suitable for recharging, and if it overflows it is rejected (Ramachandrula et al. 2018).

The bore well recharge design structure needs to take into consideration the area of the catchment upstream of the borewell; the texture of soil; and the potential maximum intensity of rainfall. The water level and quality of the recharged borewell units should be monitored and assessed to understand their efficacy.

2.4 Applicability

The technique is mainly applicable in groundwater-dependent water-scarce regions with existing zero to low yielding borewells. It is most effective in hard-rock hydrogeological conditions, especially in low rainfall regions with intense rainfall events. It has the potential of scaling up across south India which has many dry and low-yielding bore wells (Ramachandrula et al. 2018).

The identification, design and construction of the borewell recharge structure need some technical guidance from experts. It can be constructed locally once proper training and awareness have been given.

2.5 Limitations/ Barriers to Adoption

The key challenge is farmer adoption and contribution for constructing borewell recharge structure. Farmers or communities are reluctant to try something new or want the construction to be done free of charge or through a subsidy. Also, the benefit of the borewell recharge has a time lag period and is first visible only after a rainfall. Those expecting immediate results do not want to try out the intervention. Another challenge is to encourage farmers to not switch to water-intensive crops even with increased water availability but to cultivate water-efficient crops. This technique should be avoided in regions with higher levels of biological and chemical contaminants in run-off water.

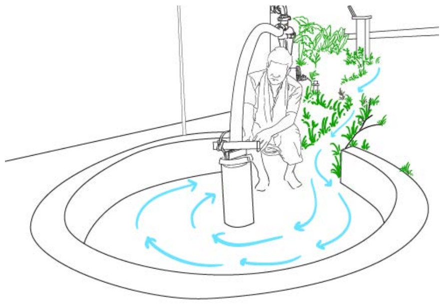


Figure 2.2 Flow of water through diversion channel into borewell inlet

2.6 Estimated Costs

The cost of borewell recharge structure is around Rs. 30,000 to 40,000 per borewell recharged. The cost depends on the availability and cost of locally procuring filter media and construction materials (such as boulders, stones, pebbles and coarse sand and nylon casing).

Image 2.3 Consruction of a Borewell

2.7 Replenishing Dreams

Paddy is a water-intensive crop and with climate change, water has become a scarce resource for most. This was also the case for forty eight year old farmer S. Satyam from Niluvada. Satyam noticed that his crops were suffering in the summer due to lack of water and intense heat. However, Satyam had a progressive approach towards the same. He was one of the few farmers willing to try out DRF introduced borewell recharge intervention for assured irrigation on his farms.

With borewell recharge, he would not only be able to replenish groundwater levels in his area, but would have access to water whenever required. It would also help his cultivation during dry spells. In the last couple of months since the borewell recharge activity was completed, he has already seen a slight increase in the water levels (during the monthly water level monitoring assessment conducted by the DRF team). According to Satyam, such positive outcomes are what gave him the confidence of implementing the other DRF introduced interventions like DSR and ZTM as well in previous seasons.

Figure 2.3 Lack of Groundwater

On a personal note, Satyam reminisced about his grandfather having to sell off their land due to poor yield owing to water shortage. He is grateful that DRF has been introducing successful scientific interventions in his villages. According to him these interventions have enabled him to increase his farm productivity and income and also supported him to buy land of his own.

According to Satyam, in the long run borewell recharge intervention would not only help farmers increase the crop yield but it would also help ease the pressure on them during severe water shortages. Satyam also shared that other farmers have already started approaching him for understanding the importance and functioning of borewell recharge so that it can help them achieve fruitful yield all year round as well.

Image 2.4. Satyam configuring the borewell on his field

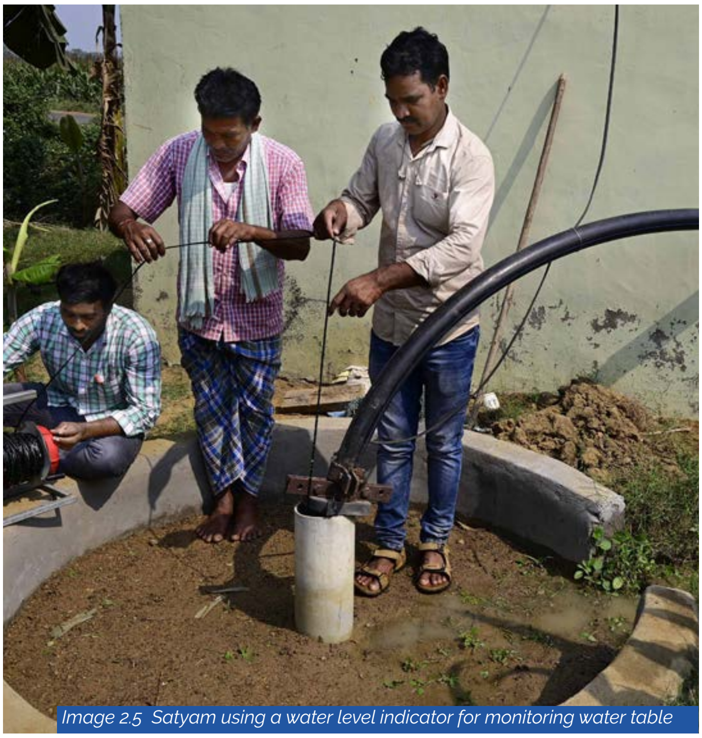


Image 2.5 Satyam using a water level indicator for monitoring water table

2.8 References

Pendke M.S., Asewar B.V., Waskar D.P., Samindre M.S., Gore A.K., Chary G.R., Narsimlu B. (2017). Design and Assessment of Borewell Recharge Technique for Groundwater Enhancement and Recharge in Assured Rainfall Zone of Marathwada Region. Indian J. Dryland Agric. Res. & Dev. 2017 32(2): 56-60.

Ramachandrula V.R. (2018). Converting dried-up bore wells as groundwater recharge wells. Current Science, Vol. 115, No. 2.

3. Dry Direct Seeded Rice

3.1 Problem/Concern

Commonly, practised manual transplanting of rice is a labour intensive and time consuming practice. In recent times, availability of labor during transplanting season has become a big constraint throughout India. Further, India is also increasingly facing shortages of water, energy and adverse effects of repeated puddling on soil physical properties and the yield of succeeding non-rice crops. Flooded rice paddy fields are also one of the world's largest anthropogenic sources of GHGs like methane In order to tackle such conditions farmers are being encouraged to take up Dry Direct Seeding of Rice.

3.2 Solution: Dry Direct Seeded Rice (D-DSR)

Dry-DSR is the process of directly sowing rice seeds into the dry soil surface by broadcasting, drilling using tractor powered machines or dibbling/hill planting. There is no nursery preparation or transplantation involved in this method. There are multiple advantages of DSR. Firstly, it can reduce labour requirement by 15-30% since the process is quite simple (Jat et al. 2020). Secondly, DSR also shows faster crop maturity than transplanted rice with increased productivity (~15-20%) (Pandey et al. 2002, Jat et al. 2020).

Plants also do not have to go through the stress of being pulled and manipulated during DSR cultivation. Neither do they have to reproduce fine rootlets for re-establishing on paddy fields (Kaur and Singh 2017) .

It is also less water-intensive (~25%), lowers production costs (USD 20-30/ha), increases profitability (~25% in rice-wheat system), provides better soil physical conditions for subsequent crops, and has a lesser methane emission (50-60% in irrigated NW Indian system) decreasing paddy cultivation's carbon footprint (Balasubramanian and Hill 2002, Jat et al. 2020).

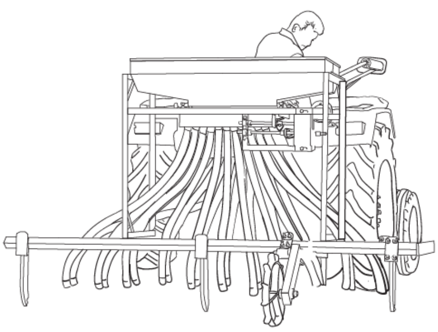


Figure 3.1 Ferticum Seed Drill

Image 3.1 Farmer adjusting the Ferticum Seed Drill

Image 3.2 Ferticum Seed Drill

3.3 Key Resources or Considerations

For Dry -DSR, good land preparation, levelling, and water management are needed for a uniform crop establishment. A smooth, level seedbed is necessary to ensure that seeds are not planted at depths greater than 1 to 2 centimetres.

Further, weed management is critical for the success of D-DSR. In shifting from transplanted rice to dry-seeded rice cultivation focus on nutrient management practices such as fertilizer deep placement and use of controlled-release fertilisers is also necessary (Pandey et al. 2002, Farooq et al. 2011). In this technique, fertilizers can be applied at the same time as the seed.

3.4 Applicability

Usually, D-DSR is practiced in rainfed lowland, upland, and flood-prone areas. In rain fed and deepwater ecosystems, seeds can be easily sown onto dry soil surface, and then incorporated either by ploughing or by harrowing.

However, now D-DSR is cultivated even in irrigated areas where water is becoming scarce. Fields with assured irrigation and medium to heavy textured soils with good drainage show better crop establishment in D-DSR.

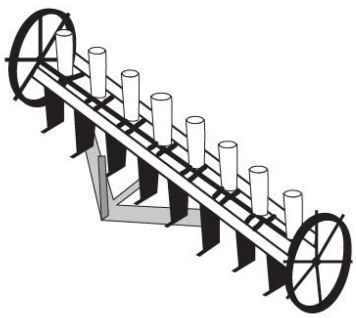


Figure 3.2 Seed Drill

3.5 Limitations/ Barriers to Adoption

The key limitations of DSR are:
(1) availability and access of DSR machinery (seed drills);
(2) competition from weeds;
(3) risk of poor crop establishment due to biotic and abiotic factors;
(4) tendency of a yield penalty in some locations and
(5) availability and access to rice varieties suitable for DSR conditions.

Image 3.3 Tractor pulling drill

3.6 Estimated Costs

DSR using Rice-Wheat Seeder was evaluated against the transplanting method in a farmer's field by ICAR. It showed that DSR led to enhancement in yield by 5 - 25 % at different locations with net saving of about Rs. 10,450 / ha. DSR cost Rs. 8200/ha in comparison to Rs. 20400/ha for TPR (ICAR 2017).

Image 3.4 Tractor powered Ferticum Seed Drill

3.7 Steady steps towards the future

Sealikanti Anjaiah, a 44 year old Lead Farmer from Mukundapura village, a part of the major paddy production belt of Nalgonda, Telangana has observed first hand problems associated with agricultural intensification. From low soil fertility, excessive use of chemical inputs, pesticides and herbicides to declining water quality taking a toll on the crops, Anjaiah was one of the few farmers prompt enough to not only recognize the need for environment friendly agricultural interventions but also proactively implement them on his fields.

With fifteen acres of paddy cultivation in both seasons i.e. Rabi and Kharif, his major concerns were untimely transplanting of paddy seedlings due to labour shortage, water scarcity and declining soil fertility affecting his overall yield. To address these persisting issues, DRF introduced Anjaiah to cultivating rice using Dry DSR technique with the help of Ferticum Seed Drill. In Anjaiah's words, direct seeding using the Ferticum Seed Drill has ensured timely and uniform sowing of seeds in his farms without having to engage in labour intensive activities like nursery preparation and transplanting. The seed drill achieved perfect depth for the seeds and also simultaneously helped in application of fertilizers. Also, the intervention led to faster crop maturity than transplanted rice and reduced his water dependency by 50%. Anjaiah's labour cost went down from 4000-4500 INR to 3000 INR while his yield quality and quantity increased. The success of the intervention spurred twenty more farmers to follow his suit and Anjaiah volunteered to train them as well. He has also implemented other DRF introduced interventions namely waste decomposer and alleyways in his fields.

With both his sons moving into the service sector, Anjaiah foresees labour shortage due to migration as a major constraint for farming in the near future. He strongly advocates farm mechanisation and incorporating scientific and environment friendly practices to make farmers more self-sustainable. According to Anjaiah, the success of DRF introduced interventions have made farmers more receptive towards adopting new technology and making informed choices in cultivation. 'Now that seasons have become erratic, we are even considering climate smart crop diversification practices like crop rotation in our paddy fields to increase yield' says Anjaiah.

Image 3.5 Sealikanti Anjaiah in his field

3.8 References

Balasubramanian V. and Hill JE., 2002. Direct seeding of rice in Asia: emerging issues and strategic research needs for the 21st century. In: Pandey, S., Mortimer, M., Wade, L., Tuong, T.P., Lopez, K., Hardy, B. (Eds.), Direct Seeding: Research Strategies and Opportunities. Inter. Rice Res. Inst., Los Ban˜os, Philippines, pp. 15–42.

Farooq M., Siddique KHM., Rehman H., Aziz T., Lee DJ., and Wahid A. (2011). Rice direct seeding: Experiences, challenges and opportunities. Soil and Tillage Research, 111(2), 87–98. doi:10.1016/j.still.2010.10.008

ICAR (2017). Profitable Paddy Cultivation through Direct Seeding Technology by Rice-Wheat Seeder. Accessible online <https://icar.org.in/content/profitable-paddy-cultivation-through-direct-seeding-technology-rice-wheat-seeder>

IRRI (2020). Direct seeding. Accessible online <knowledgebank.irri.org/step-by-step-production/growth/planting/direct-seeding>

Jat M., Jat HS., Agarwal T.,.......Ridaura, SL., et al. (2020). A Compendium of Key Climate Smart Agriculture Practices in Intensive Cereal Based Systems of South Asia. P.42. International Maize and Wheat Improvement Center (CIMMYT), New Delhi, India

Kaur J., and Singh A. (2017) Direct Seeded Rice: Prospects, Problems/Constraints and Researchable Issues in India. Curr Agri Res. 5(1). doi : http://dx.doi.org/10.12944/CARJ.5.1.03

Pandey S., Mortimer M., Wade L., Tuong TP., Lopez K., and Hardy B., editors. (2002). Direct seeding: research issues and opportunities. Proceedings of the International Workshop on Direct Seeding in Asian Rice Systems: Strategic Research Issues and Opportunities, 25-28 January 2000, Bangkok, Thailand. Los Baños (Philippines): International Rice Research Institute. 383 p.

4. Integrated Pest Management (IPM)

4.1 Problem/Concern

Over the years, intensive agriculture in India has led to an onslaught of pest and disease attacks which drastically reduce crop yields. Estimates by Singh et al. (2003) suggests that India faces up to 38% (insect pests and diseases 26%, weeds 10%, and birds 1–2%) annual crop losses due to pests and diseases. Weeds also lead to high yield losses due to their competition with the crop for nutrients and often also lead to increased pests and disease infestations. Methods undertaken to curb such attacks like pesticides and weedicide applications sometimes end up being equally harmful. Extensive use of pesticides and herbicides by farmers can lead to serious adverse environmental and health implications.

4.2 Solution: Integrated Pest Management (IPM)

IPM is a process utilized in agriculture by which pests and insect infestations are curbed through natural, cultural, behavioural and chemical remedies. It focuses on using natural predators or parasites to control pests. It emphasizes growing healthy crops with the least disruptions to the natural ecosystem. It is a method that consists of a series of pest management evaluations, decisions and processes. In IPM, selective pesticides are used only when natural means of pest control fails. The major advantage of IPM is that it reduces the negative impact of the indiscriminate use of insecticides and pesticides on the farmers, consumers and the environment.

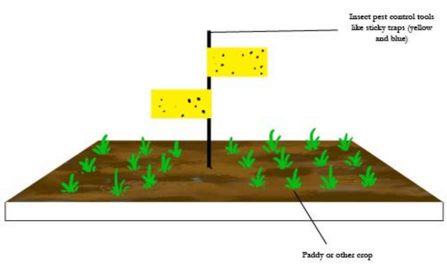


Figure 4.1 Yellow sticky traps on paddy fields

Image 4.1 Pests stuck to yellow traps

Image 4.2 Fungi on coconut plants

Image 4.3 Pest Control Equipment in a farm

4.3 Key Resources or Considerations

For the successful implementation of IPM, the following factors need to be taken into consideration namely
(1) Understanding the agricultural ecosystem;
(2) Planning of agricultural ecosystem;
(3) Evaluating the Cost-benefit ratio;
(4) Tolerance of pest damage;
(5) Leaving a pest residue;
(6) Timing of treatments; and lastly
(7) Public understanding and acceptance (Karupuchamy and Venugopal 2016)

4.4 Limitations/ Barriers to Adoption

The key challenge is effective communication to the farming community for better understanding and acceptance of pest management practices. Public understanding and acceptance are essential for IPM to be widely accepted. In severe pest infestations, natural means of pest control may fail. Depending upon the pest complex and the geography, IPM practices needed may differ drastically for the same crop in different geographies.

4.5 Estimated Costs

The cost of IPM varies according to the crops grown and the type of measures that are employed. It is relatively cost-effective.

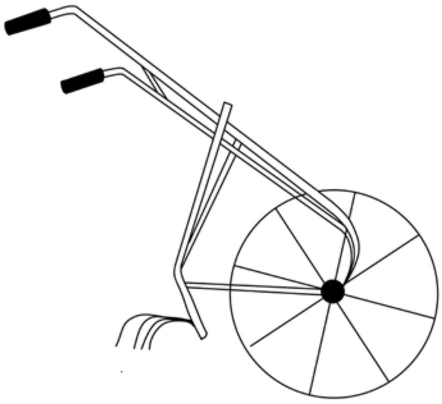


Figure 4.2 Cycle Weeder

4.6 Applicability

There is an extensive scope and applicability of IPM. For example, in our project location Pydibhimavaram, Andhra Pradesh multiple IPM practices are being practised in maize, coconut and vegetables. In Tripuraram, Telangana similar practices are being adopted in rice cultivation.

Maize
- Trichogramma spp. is an egg parasitoid (parasitoids that both attack and complete their development within a host egg, Mills 2009) that controls fall armyworm, Spodoptera frugiperda, a key pest causing yield reductions in maize production systems.
- Azadirachta indica (Neem) oil contains Azadirachtin, the primary antifeedant component of neem seed, which has shown selective activity against many pest species. Additionally, neem derivatives have pronounced behavioural and physiological effects on insects.

Coconut
- Isaria fumosorosea is an entomopathogenic fungus (a group of fungi living in the soil that infect insects by penetrating their cuticles and their bodies to eventually kill them and feed on them). It is used as biological control of invasive pest spiralling rugose whitefly in coconut.
- Encarsia formosa is a parasitoid (an insect whose larvae feeds and develops within or on the bodies of other arthropods) of the whitefly in coconut and used for its biological control in coconut
- Rhinoceros beetle (RB) lure is the pheromones extracted from the female Rhinoceros beetle. RB lure attracts the males from the surroundings and traps them in a coco trap disrupting their mating cycle and hence reducing the beetle population.
- Red Palm Weevil (RPW) lure is the pheromone extracted from the males which attracts both males and females from the surroundings and gets them trapped in the coco trap.

Vegetables
- Insect pest control tools like sticky traps (yellow and blue) and chemical-attractant or pheromone lure traps (WOTA-T, funnel trap) have been introduced in vegetables.

Paddy
- Insect pest control tools like sticky traps (yellow and blue) have been introduced in paddy.
- Alleyways are also a part of IPM cultural practice utilized in rice cultivation.

Weed management
- Cycle weeder is a mechanical weed management implement that can be easily used for crops like groundnut, maize and vegetables with a spacing of 30-40cm between the lines and 15 -20 cm within the plants. It helps decrease the drudgery of manual weeding.

4.7 Torchbearers of Innovation in Pest Management

Pests are a farmer's worst enemy. There are multiple conventional ways to control infestations, however, sometimes these methods cause more harm than good. More often than not, conventional chemical-based weed and pest control practices are not enough to help eradicate infestations. It requires more labour, more time and yet fails to produce the desired results. It also leads to increased pollution of surface and groundwater adversely impacting human and ecosystem health. Henceforth, DRF introduced a package of Integrated Pest Management practices, which was a sigh of relief to many.

One of the stories is of Naveen Reddy, a young entrepreneurial farmer with a degree from ITI wanting to bring in progressive and effective solutions for improving his crop growth and health. His coconut orchards were suffering from pest infestation of spiralling rugose white fly that heavily affected the yield. DRF introduced him to the biological pest control method of using Isaria fumosorosea to tackle the infestation. Reddy along with 16 other lead farmers received training in the Regional Agri-Research Station in Anakapalli under an entomologist. Isaria culture can be developed by using locally available rice in an inoculation chamber. They were taught how to do this procedure at home. They had to soak the rice overnight, then transfer the rice into an autoclavable disposable plastic bag. The process needed to be done in a sterilized environment for it to be successful and the mother culture was added to water and allowed to multiply. Finally, after 15 days a kilo of the Isaria culture could be added to 200L of water and sprayed in the coconut farm. Before the Isaria application, Reddy was collecting approximately 1200 nuts from his 3 acres of land, and post the intervention, he now collects around 3000-4000 nuts. With his training, he has also been producing and distributing Isaria for over a year now. Having tasted the success of Isaria, Reddy soon wants to start selling the same i.e., 1kg of Isaria culture for Rs.100/ to make a living out of his hard work.

In Reddy's words, DRF's training has not only helped him gain knowledge about various IPM practices but now he has an added sense of confidence in understanding how pests can appropriately be dealt with. He can now recognize signs of infestation and tackle them in time with correct measures. He is passionate about bringing change and with his entrepreneurial and innovative initiatives. He is currently distributing Isaria culture for free within the community while trying to develop a sustainable business model. Reddy even took the initiative to develop a modified motorbike mounted sprayer for the application of the culture.

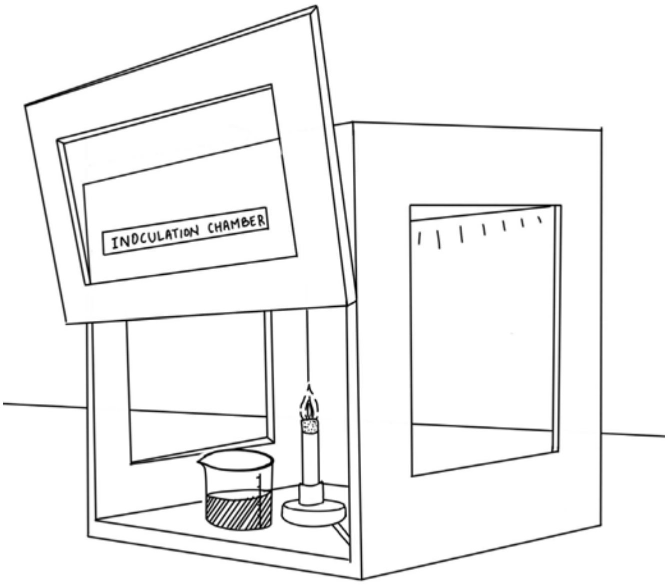


Figure 4.3 Inoculation Chamber

Image 4.4 Naveen Reddy preparing Isaria culture

Similarly, DRF took note of another rising concern i.e., conventional methods of weed management was a time consuming laborious process that was often relegated to women farmers. Therefore, DRF introduced IPM intervention like cycle weeders for weed management for women Lead farmers. The introduction of cycle weeder in vegetable and maize fields, not only helped these women effectively eliminate weeds but also alleviated the ease of doing the work which has been beneficial for their health.. 'Our backaches have lessened' they said. As cycle weeders are more time and energy-efficient, women farmers can now devote more time to their families and earn some additional income by working on NREGA initiatives as well.

Image 4.5 Group of women operating a cycleweeder

Stakeholders like Santosh from Pest Control India Pvt. Ltd are also working extensively with DRF on promoting IPM practices. Santosh has actively been promoting IPM tools like coco traps, funnel traps, sticky traps and pheromone traps for eradicating different pests in multiple crops including vegetables, maize, paddy and coconut. For example, he introduced RB lure a pheromone trap for controlling rhinoceros beetles which cause the highest damage in coconut leaves. He has also introduced and marketed Trichoderma fungal solution for the control of soil pathogens with the help of DRF. 'DRF has been very supportive in getting us at least two new fields every season' says Santosh who is delighted at the prospect of a DRF collaboration with PCI. Lastly, given the scale of adoption of IPM, PCI has also started extending support in procuring high-quality seeds of vegetables, fruits, mangoes, bananas, guavas, maize from their labs in Bangalore.

Stakeholders like PCI and KVK play a critical role in capacity building and strengthening the adoption of Climate Smart and sustainable agricultural practices. DRF has acted as a bridge between the different actors of the value chain and helped the farmers in improving their yield by introducing simple IPM practices. IPM helps them take robust action against pests to prevent crop damage and also ensures that they spend less time, money and labour on the field.

Image 4.6 Santosh, a representative of PCI Pvt. Ltd.

Image 4.7 Funnel Trap in paddy field

4.8 References

de Lourdes Corrêa Figueiredo M., Cruz I., da Silva RB. et al. (2015). Biological control with Trichogramma pretiosum increases organic maize productivity by 19.4%. Agron. Sustain. Dev. 35, 1175–1183. DOI https://doi.org/10.1007/s13593-015-0312-3

Karuppuchamy P. (2016). Ecofriendly Pest Management for Food Security. Integrated Pest Management. Pp. 651–684. doi:10.1016/B978-0-12-803265-7.00021-X

Mills N. (2009) Egg Parasitoids in Biological Control and Integrated Pest Management. In: Consoli F., Parra J., Zucchi R. (eds) Egg Parasitoids in Agroecosystems with Emphasis on Trichogramma. Progress in Biological Control, vol 9. Springer, Dordrecht. https://doi.org/10.1007/978-1-4020-9110-0_15

Maredia KM., Segura OL., Mihm JA. (1992). Effects of neem, Azadirachta indica, on six species of maize insect pests. Tropical Pest Management, 38(2), 190–195. doi:10.1080/09670879209371682.

5. Intercropping

5.1 Problem/Concern

Monocropping systems of food crops like rice, wheat or horticultural cash crops often face far greater problems related to soil, water, weeds, pests and diseases in comparison to diversified systems. Monocrops also adversely affect and alter the natural ecosystem. Further, mono crops are more vulnerable to climate change risks often leading to crop failure. For farmers such crop failures can result in devastating losses. Therefore, to maintain the natural resource base and mitigate risk of losing complete crop stands there is a need to diversify the cropping system through changing crop pattern or intercropping.

5.2 Solution: Intercropping

Intercropping is the practice of simultaneously cultivating two or more plant species in the same field in close proximity for a considerable proportion of their growing periods. Crop diversification through intercropping allows farmers to increase the productivity per unit area while utilizing available resources effectively. Based on row arrangement and growing period three major types of intercropping are row, relay, and strip intercropping (Jat et al. 2020). In row cropping, selected crops are arranged in distinct alternate rows. Relay intercropping means growing two or more crops simultaneously during part of the life cycle of each. Typically the second crop is planted with an already established first crop which has flowered but not been harvested yet. Strip intercropping means cultivating more than one crop simultaneously in different wide strips that permit independent cultivation but are also narrow enough for the crops to interact agronomically. Mechanization is easier in strip cropping (Li et al. 2013). The major benefits of intercropping are that it optimizes resource utilization, increases the rate of crop production and profitability with the advantage of simultaneously decreasing the risk of total crop reduction. It also helps in controlling weeds, enhances soil properties, improves nitrogen use efficiency (integration of legumes), and strengthens system resilience. Intercropping can also help households in attaining food and nutritional security goals.

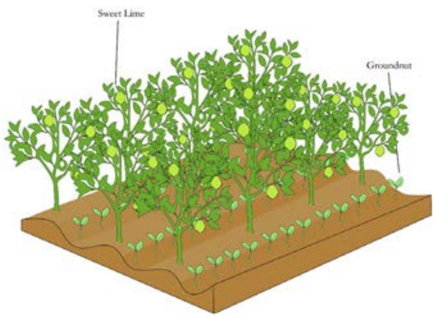


Figure 5.1 Alternating rows of Sweet Lime and Groundnut

Image 5.1 Intercrop of Citrus and Groundnut

5.3 Key Resources or Considerations

Crop selection is vital in intercropping. Planting crops from the same family may lead to nutrient depletion and also attract similar pests and diseases. Site and climatic conditions must be taken into account for crop selection. Plant density, root structure and above ground cover should also be considered to prevent overcrowding.

Farmers have to practice recommended fertilizer, water, and intercultural management practices. A new intercropping idea should be tested first on a relatively small area.


Image 5.2 Intercrop of vegetables with sunflower

5.4 Applicability

Intercropping can be practiced in both tropical and temperate climates and in the Indian subcontinent is suitable for both irrigated and rainfed ecologies.

5.5 Limitations/ Barriers to Adoption

The main challenge of intercropping lies in choosing compatible crops that can be cultivated together. There is a need to strengthen the knowledge base on crop diversification and inputs for newly introduced crops.

Figure 5.2 Crop diversification through intercropping.

5.6 Estimated Costs

The cost of intercropping depends upon the crops that are being cultivated and the agricultural management activities and processes that are employed.


Image 5.3 Local farming community

5.7 Proactive Agri-Leaders of Tomorrow

Usha Kiran, an enterprising thirty-five year old from a small village in Andhra, not only manages his day job in the Development Sector i.e., Smart Village Planning Department but takes keen interest in farming as well. Whereas most of his peers are into the corporate sector, Usha Kiran with a background in MCA always had an affinity towards climate smart agriculture. 'We have seen and felt climate change first hand i.e., 20 years back all the rivers and canals were full but now they have all dried up." Kiran pointed out. His father has been into agriculture for 30years and into maize cultivation for 25years. With 4.5acres of farms, Usha spotted an opportunity in proper utilization of land. He skillfully divided the same into 2 and 2.5acres. Usha continued cultivating maize in 2 acres of land and in the rest of 2.5acres, he decided to grow crops for their own consumption. He started experimenting with crops like sunflower, groundnut, garlic, tomato, onion, coconut. His initial hiccups were pests, weed, water and labor cost which he managed to resolve one at a time by investing in smarter and more efficient technologies and practices like utilizing rainhose for optimizing irrigation needs.

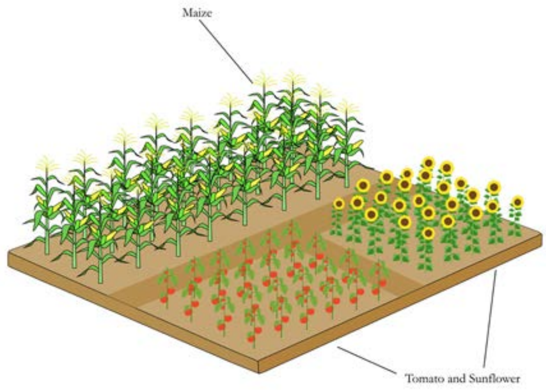


Figure 5.3 Maize crop intercropped with plants for personal consumpstion

In 2019, Kiran was identified as a Lead Farmer in a community meeting. With his entrepreneurial spirit, he was more than willing to be the change he wanted to see. Kiran proactively underwent multiple training, met agricultural scientists, etc. His education helped him in better comprehending and adopting all that he learnt i.e., from crop diseases management, pesticides application to implementation of various interventions. He went ahead and implemented several, including rain hose to optimize irrigation needs (for groundnut), Zero Tillage in Maize which gave him a yield of 35 quintals in one season, among others. In traditional maize cultivation, where there is a net profit of 15-20K INR/ season, he managed to make a profit of 48K INR with ZTM. In 2020, Kharif, he also tried out drum-seeding and in 2021 Rabi, he successfully implemented intercropping (cultivating multiple crops that complement the needs of each other) i.e., sunflower, papaya, chilies, onion, groundnut, garlic and napier grass. One of the major advantages of intercropping Kiran figured was that it allowed him to alleviate the risk of crop failure. Also, with the right combination, there was lesser uncertainty and an additional income. Kiran, now confident of his pursuits, plans on intercropping ginger in coconut fields. His success with DRF-introduced interventions like intercropping has been encouraging and now Kiran is not only willing to continue farming after his father but he is also willing to adapt, practice and innovate in agriculture. With his analytical capabilities, Kiran has a keen sense of identifying missed opportunities and innovating on potential solutions to improve the agricultural systems.. He sees a lot of potential in smart-farming for the younger generation and intends to lead the pack by example.

Image 5.4 Usha Kiran displaying his tomato and papaya intercrop

5.8 References

Li L., Zhang L. and Zhang F. (2013). Crop Mixtures and the Mechanisms of Overyielding.Encyclopedia of Biodiversity. Vol 2. pp. 382–395. doi:10.1016/B978-0-12-384719-5.00363-4

Jat ML., Jat HS., Agarwal T.,.......... and Ridaura, SL et al. (2020). A Compendium of Key Climate Smart Agriculture Practices inIntensive Cereal Based Systems of South Asia. P.42. International Maize and Wheat Improvement Center(CIMMYT), New Delhi, India.

6. Machine Transplantation of Rice

6.1 Problem/Concern

Paddy transplantation is an extremely labour intensive activity. Manual transplantation of paddy seedlings can require upto 6-8 workers for an acre of land. Not only is this an expensive activity, most rice growing belts including Telangana face severe shortage of labour during the transplantation season leading to delays in crop sowing and maturity.

6.2 Solution: Machine Transplantation of Rice (MTR)

Machine or mechanical transplanting of rice is the process of planting young rice seedlings into puddled soil mechanically. MTR integrates the sowing and transplanting processes for cost and labour efficient rice cultivation. It requires less labour and is faster than conventional manual transplanting (IRRI 2020). It ensures timely planting and reduces cost of cultivation (Guru et al. 2018). It also establishes uniform spacing and optimum plant density between the seedlings which helps seedlings recover faster from transplanting shock and allows the tillers to grow and mature more uniformly. Yields and farmers' net income of such rice are also higher in comparison to traditional methods plus it lowers stress, drudgery and health risks for farm labourers as it is less physically taxing (CSISA 2015).

Image 6.1 Women working in paddy field

Figure 6.1 Transplanting Machine

Image 6.2 Women preparing trays for MTR nursery

6.3 Key Resources or Considerations

These are the key considerations for machine transplanting of rice crops. First, the seedling needs to be raised in a mat type or tray type nursery. Then before planting them in soil, proper land preparation and levelling is absolutely necessary. Lastly, fields should be accessible so that the machine can easily move around the farmland.

6.4 Applicability

Suitable for irrigated areas under puddled conditions. Success is dependent on availability of trained machine transplanter operators and knowledge of nursery preparation in special mats or trays.

6.5 Estimated Costs

6.6 Limitations/ Barriers to Adoption

MTR has certain limitations. Transplanting machines and their maintenance is expensive. Hence, affordability and accessibility for marginal and small farmers is still limited. Lack of trained machine operators makes it time consuming and expensive. Additionally, the lack of training about the processes of growing paddy nursery in trays and mats is also detrimental to MTR. Finally, MTR is more suited for irrigated areas since seedlings must be planted while still young.

Figure 6.2 Woman holding tray with saplings

Image 6.3 Preparing the trays for nursery preparation

Image 6.4 Women learning the process

There are two kinds of paddy transplanters;

1. The 'walk-behind' machines cost around Rs 2-2.5 lakh which covers 3-6 acres a day and
2. The 'self-propelled' transplanter costs around Rs 10 lakh and covers 10-12 acres per day.

The cost of operating a Central Rice Research Institute designed 4-row transplanter is Rs. 2,429.00 per hectare against Rs. 6,600.00 per hectare when applying conventional transplanting methods.

Image 6.5 Arranging mud on the trays

6.7 Trailblazers of the Community

From Kampasagar Telangana, comes the story of an incredible group of women farmers who are working towards transforming their lives with the help of innovative agricultural practices introduced by DRF. While women make up a large part of the labour force, their work is extremely labour intensive with very little compensation and a gendered difference in wages. A female labourer earns rupees four hundred in comparison to a man who earns six hundred. Also, in smallholder farms typically even though women work on the family's land, the labour is unaccounted for and there is no wage income.

In Rabi 2020, DRF introduced mat and tray type nursery preparation training, which is a critical step of Machine Transplantationof Rice (MTR) to a s group of twenty seven women in Thripuraram area, ten of whom were from Kampasagar including A Parvathi, B Lingamma, A Nagamma, A Yellamma, K Chillukamma, A Srilatha, M Rajitha and A Renuka. Traditionally nursery preparation is done by men, and women are only involved in transplanting of rice. However, with the help of DRF, women were able to upskill to an agricultural activity that is usually a male bastion. Not only does mat/tray nursery preparation require lesser physical labour than conventional transplanting it also helps women farmers cover more acreage per season. Two women can easily complete one acre of mat nursery sowing against six women who are needed to manually transplant rice in one acre. Also, conventional nursery preparation usually takes 4-5 days while mat nursery sowing takes 4-5 hours.

By upskilling these women in mat or tray type nursery making, the women can now provide their service to farmers who are going to transplant rice using a mechanical transplanter. DRF's MTR target through LFP alone in the area is about 400 acres. The successful introduction of such cost effective and drudgery reduction technology to women is absolutely essential since these women become master trainers and go on to uplift and upskill other women within their communities. Women farmers are also able to save upto Rs. 1600 per month through MTR and it also eases their workload, and health risks. Additionally, the time saved can now be utilized in other income generating activities and fulfilling kinship duties and domestic engagements. They are now the proud earning members of their families. In Parvati's words 'DRF enabled us i.e., the women farmers to be financially independent.'

Image 6.6 Women farmers who participated in MTR nursery training

6.8 References

Cereal Systems Initiative for South Asia, CSISA. (2015). Operational Manual for Mechanical Transplanting of Rice. New Delhi, India

Guru PK., Chhuneja NK., Dixit A., Tiwari P. and Kumar A. (2018) Mechanical transplanting of rice in India: status, technological gaps and future thrust. Oryza Vol. 55 No. 1, pp. 100-106.

IRRI (2020). Machine transplanting. Accessible online http://www.knowledgebank.irri.org/training/fact-sheets/crop-establishment/machine-transplanting

7. Mulching

7.1 Problem/Concern

The global temperature has been increasing over the years due to climate change. Increasing temperatures directly impacts soil health as it causes water loss from the soils through evaporation and increases soil temperature, consequently leading to decreased crop productivity. Further, increasingly intense heavy rainfall events due to climate change on unprotected soil surfaces are also detrimental to soil structure and can lead to soil erosion.

7.2 Solution: Mulching

Mulching is the practice of spreading a protective layer of organic (e.g. straw, bark chips, grass clippings, newspaper etc.) or inorganic (plastics, brick chips etc.) material on top of the soil. Mulch can be any material that is placed on a soil surface to retain moisture, reduce evaporation and soil erosion. It suppresses weed growth and provides the plant with nutrients as the mulch material decomposes. Organic mulch can improve soil fertility by slowly decomposing and increasing soil organic matter. Mulch manipulates crop-growing environments and the material is selected on the basis of the type of crop, management practices as well as climatic conditions (Kader et al. 2017). It is not a new practice in agriculture but, is one of the simple climate smart practices that supports soil moisture conservation, decreases evapotranspiration, reduces soil erosion and compaction during heavy rains, controls temperature fluctuation in soils, and reduces weed growth providing plants a conducive environment to grow (Mulumba & Lal 2008).

7.3 Key Resources or Considerations

The type of mulch used for the crop is determined by multiple factors such as the local climate, cost-effectiveness of the material and its benefit for the crop. Plastic mulching materials are preferred over organic materials to control the soil environment and increase crop yield. However, organic mulching materials are inexpensive, easily available and an environmentally friendly alternative (Cuello et al., 2015).

7.4 Applicability

Mulch can be utilized in diverse climatic conditions for soil conservation practices on agricultural and horticultural fields. In our field areas in Thripuraram mulching has been adopted in Citrus plantation.

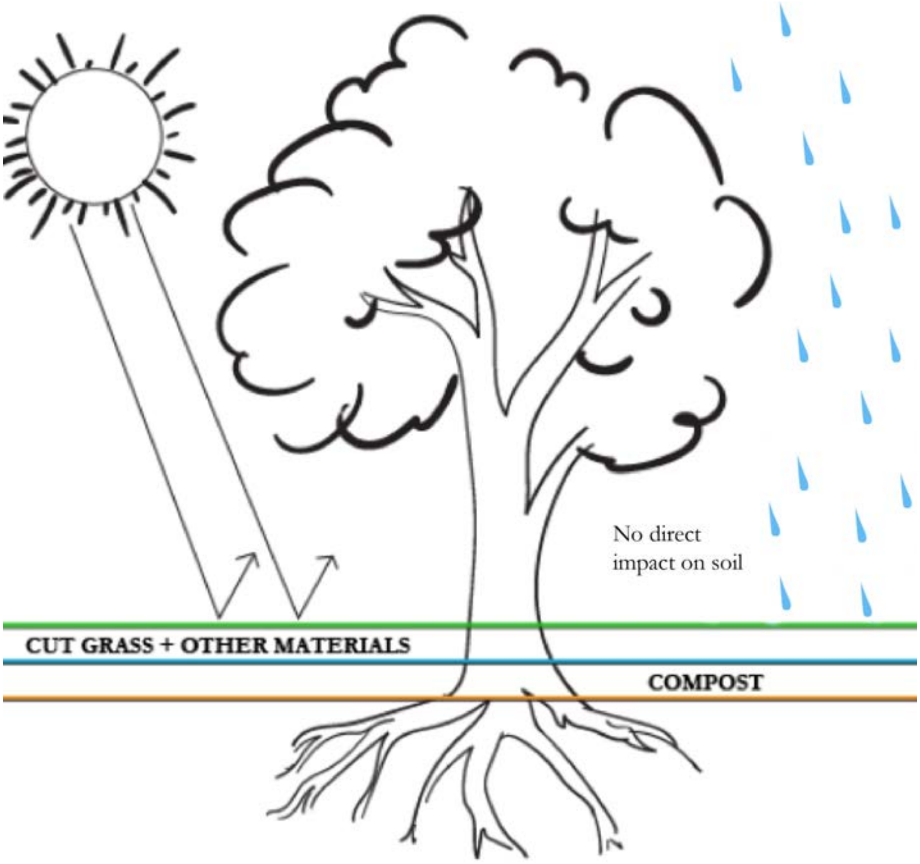


Figure 7.1 Mulching Process

7.5 Limitations/ Barriers to Adoption

The major adverse impact of the use of plastic mulch is generation of large amounts of non-biodegradable plastic wastes and the associated environmental impacts like decrease in soil organic matter and increase in GHG emissions (Cuello et al., 2015). However, organic mulches can sometimes be ineffective for weed control and can even lead to risks like excess moisture, pest attack and rotting of plant material (Boyhan et al., 2006).

7.6 Estimated Costs

Mulching costs depend on the material that is used by farmers. Organic mulches are cost-effective, environmentally sustainable and are more readily available as compared to plastic mulches. For organic mulches, a farmer can invest in a multi-purpose device called a brushcutter with mulching blades which can be used to cut and trim crops residues, weeds and grasses for mulch.

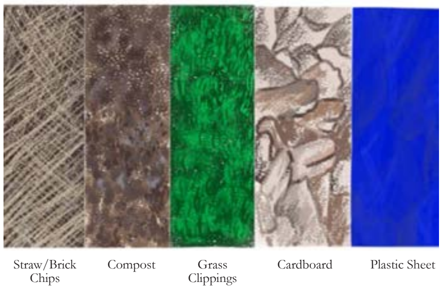


Figure 7.2 Types of mulches

7.7 Steady steps towards the future

A Lead Farmer with DRF, fifty eight year old, Santosh Reddy was keen to learn and adopt climate smart practices in his farms where he grows groundnut and citrus. According to Santosh, with every passing year he has observed that the temperature is slowly rising particularly during the dry summer months, due to which his soil was suffering from issues of low moisture and dryness. It had also led to increased irrigation needs for his citrus plantation. He was interested in undertaking scientifically backed agricultural practices which would not only help with his farming needs like reducing cost of cultivation but also would be beneficial to the environment. DRF's demonstration on Mulching in Citrus was one such climate smart intervention training that he participated in. Hence, he willingly experimented with organic mulching. He used a brush cutter for trimming excess weeds and grasses in his citrus plantation and used the trimmings itself as a protective mulch layer. This practice of using dry grasses as natural mulch is helping him conserve both moisture and nutrients in the soil. It has also allowed him to protect the soil surface from direct sunlight which reduces the chances of evaporation, erosion and provides a conducive environment for crop growth. He also hopes to experiment with different organic mulches like paddy straw and husk in the future to compare the benefits.

He believes that mulching is an easy low cost practice that has multiple advantages. The biggest advantage that Santosh himself has seen is that mulching doesn't allow weed growth. It also reduces labour costs and he can make an overall saving of upto rupees eighteen thousand. He believes that the ability of mulching to reduce weeds, save water and labor expenses makes it an attractive option for farmers. Already, inspired by him, 10-12 fellow farmers in his village have followed his suit and incorporated mulching as a part of their agricultural practice in their citrus plantation.. Ultimately, such small shifts to climate smart practices not only helps farmers like Santosh to increase their yields and save more, but also helps in providing multiple environmental co-benefits like improved soil health, which is critical for mitigating climate change.

Image 7.1 Reddy guiding a worker on using a brushcutter

7.8 References

Boyhan GE., Hicks R. and Hill CR. (2006). Natural mulches are not very effective for weed control in onions. Hort Technology 16, 523–526

Cuello JP., Hwang HY., Gutierrez J., Kim SY. and Kim PJ. (2015). Impact of plastic film mulching on increasing greenhouse gas emissions in temperate upland soil during maize cultivation. Appl. Soil Ecol. 91, 48–57.

Kader MA., Senge M., Mojid MA. and Ito K. (2017). Recent advances in mulching materials and methods for modifying soil environments. Soil and Tillage Research, 168, 155–166.

Mulumba LN. and Lal R. (2008). Mulching effects on selected soil physical properties. Soil and Tillage Research, 98(1), 106–111. doi:10.1016/j.still.2007.10.011.

8. Raised Bed

8.1 Problem/Concern

Water use efficiency is critical for sustainable farming systems. However, in India irrigation is often not well managed leading to high water losses. Further, improper irrigation practices even lead to sustained problems of water logging leading to lower productivity.

8.2 Solution: Raised Bed Planting

The raised bed planting system is an improved surface irrigation intervention, which makes the application of water in irrigated systems more efficient and increases water productivity. In these systems, crops are planted on top of ridges or beds and irrigated with water that goes through the furrows and is pulled upwards into the bed.

The raised bed planting method allows efficient use of water and fertilizer and produces more yield than other conventional methods. Furrow irrigation helps cut down water usage by 12–60%, improves drainage and also reduces methane emissions (Jat et al. 2016). Raised beds have been practised for both rice and non-rice based cropping systems. In non-rice based cropping systems this system helps minimize water-logging. Raised-beds are preferred over ground beds because it improves pathogen and insect control, aeration and addresses other nutritional concerns such as improved fertilizer placement which helps in overall yield. A raised-bed planting system can help save diesel, time and water requirements by up to 40%.

Image 8.1 Raised Bed Maize

8.3 Key Resources or Considerations

The key consideration for planning FIRB is to understand the crop spacing, crop density, bed height and furrow spacing. Availability of bed makers/ planters is also important in areas where labour availability is scarce.

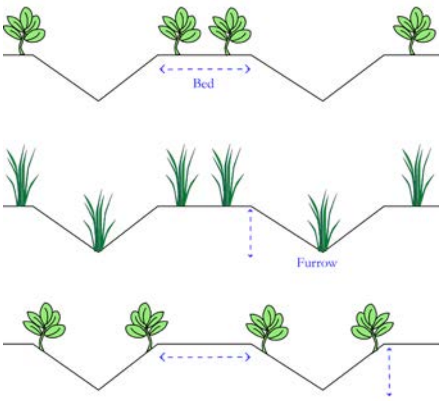


Figure 8.1 Raised Bed Farming

8.5 Limitations/ Barriers to Adoption

Raised bed planting is not an easily accepted practice among farmers in India because the cost of making beds and their subsequent maintenance is high. A bed-planter machine can only be operated by tractors with high horsepower and custom hiring is still not a popular practice in India. Farmers have also found it difficult to move through the narrow furrows while spraying herbicides (Chauhan et al. 2012).

Image 8.2 Saguna Rice Technique

8.4 Applicability

Raised bed planting can be applied to a wide range of soil types, both rice and non rice cropping systems and land slopes including row crops to reap the benefits of water management. It is especially useful for crops that could be damaged by waterlogging, such as tomatoes, groundnuts and broadcast crops such as wheat.

Image 8.3 Raised Bed Maize

8.6 Estimated Costs

The relative cost of Raised bed cropping systems is considerably higher than other technologies. Although raised beds can be dug manually by the farmers, it is a labour intensive process and a permanent bed maker costs around 30–35,000 INR.

Image 8.4 CK Reddy at his field demonstrating Saguna Rice Technique

8.7 From Village Leader to Lead Farmer

Chiluka Subhash Reddy is the sarpanch of his village Gannaram. Hardworking and humble, he has not only managed to send his son to the United States to pursue a career in software engineering, he has ensured that his daughter completes her MBA degree as well. However, this leaves Chiluka to handle his farms by himself, which traditionally was a household activity. He cultivates a total of 17 acres of land, of which 10 acres are his own and 7 acres he has leased from his cousin. Chiluka wanted to implement advanced interventions to produce quality yield and reduce labour dependence. He is one of the 6 farmers to demonstrate FIRB in Rice called SRT.

Saguna Rice Technique (SRT) is a raised bed planting system developed for rice-based cropping in Maharashtra. The results from SRT reported 30% to 40% savings in the cost of production and a 50% decrease in labour needs during transplantation. SRT has also shown an improvement in soil fertility owing to reduced tillage and puddling practices in Maharashtra. While his children may not be able support him in tending his farms, he is confident that interventions like SRT can make his farm more self-sustaining and resource efficient. Similar stories of the younger generation moving away from agriculture resonates throughout the region. Thus, he is willing to take the risk of implementing new climate friendly agricultural pilots on his farm for his benefit as well as for the development of the agricultural community.

Chiluka's drive and efforts to bring in technological change in agriculture has been recognised by the community and the program. He realised that in order for SRT to be adopted by more farmers it required both awareness and the correct guidance, the kind he had received from DRF. As the sarpanch, he has taken the initiative to promote the implementation of such new technologies through on-field demonstrations and capacity building training with the support of the panchayat and DRF. Chiluka who is currently a fellow farmer is now on his way to become a lead farmer because of his willingness to embrace change and actively share his learnings with the community.

Image 8.5 C.K Reddy inspecting crops

8.8 References

Chauhan BS., Mahajan G., Sardana V., Timsina J. and Jat ML. (2012). Productivity and Sustainability of the Rice–Wheat Cropping System in the Indo-Gangetic Plains of the Indian subcontinent. Advances in Agronomy, 315–369. doi:10.1016/b978-0-12-394278-4.00006-4

Dept. of Agriculture, Government of Maharashtra (2016). Saguna Rice Technique – SRT. Accessible online <https://rkvy.nic.in/Uploads/SucessStory/MAHARASHTRA/2016/2016010918Saguna%20Rice%20Technique%20(SRT)%20-%20Jaouli%20Satara.pdf>

Jat ML., Singh S, Rai HK., Chhokar RS., Sharma SK. and Gupta RK. (2005). Furrow Irrigated Raised Bed Planting Technique for Diversification of Rice-Wheat System of Indo-Gangetic Plains. Journal of Japan Association for International Cooperation for Agriculture and Forestry, 28 (1), pp. 25-42

9.Integrated Soil Moisture Conservation System

9.1 Problem/Concern

Increasing incidences of untimely heavy rainfall due to climatic changes prevents water infiltration into the soil, increases surface water runoff, causing soil erosion and significant loss of nutrients like Nitrogen (N) due to leaching from agricultural fields including high-value horticultural plantations. All these consequently impacts agricultural yield. Hence, employing a mix of sustainable soil and water conservation techniques become critical for retaining soil moisture and fertility.

9.2 Integrated Soil Moisture Conservation System

There are multiple soil moisture conservation techniques amongst which (1) engineering structures that also harvest water and reduce runoff, such as contour banks, trenches, dams, earthen bunds and concrete structures, and (2) vegetative barriers, such as the use of grasses for soil and moisture conservation are common in developing countries (Critchley and Sieger 1991, IFAD 2011, Oshunsanya and Aliku 2017).

A similar system of a combination of engineering structures and vegetative barriers can be utilized for helping soil moisture conservation in coconut plantations. A total of 4 interventions are combined in this system: (1) Semi-circular bunds; (2) Contour ploughing; (3) Deep furrows and (4) Transplanting Napier grass.

In semi-circular bunding, a semi-circular trench and bund is dug up around individual coconut trees. These bunds are small earthen barriers constructed of soil and stones,along the contour line to help slow down and collect rainwater surface run-off. It is a micro-catchment technique that increases water infiltration and prevents soil erosion and also helps retain the nutrients (Critchley and Sieger 1991, Waelti and Spuhler 2020). These bunds can be designed to a variety of dimensions ranging from small structures with a radius of 2m to very large structures with a radius of 30m; and with height of the bund kept between 0.1 to 0.5 m (Critchley and Sieger 1991, Anschuetz et al. 2003, Barron and Salas 2009).

Conservation or Contour ploughing and deep furrows are a well-established agriculture practice that contributes to soil and water conservation. The soil is ploughed along the contour instead of up- and downward which decreases the velocity of runoff and thus soil erosion by concentrating water in the downward furrows (Krüger et al. 1997). It also builds a barrier against rainwater runoff which is collected in the furrows (Tidemann 1996). Contour ploughing makes the system more resilient against weather hazards like flash floods (FAO 2008). Water infiltration rates increase with this practice and more water is kept in place, hence leading to greater soil moisture conservation. It also preserves soil structure and nutrients which consequently has a positive impact on the agro-system and helps improve potential yield, thus benefiting farmers´ livelihood (FAO 2008).

Lastly, Napier grass can be planted in coconut farms. Napier grass (***Pennisetum purpureum***) is a fast-growing perennial grass that is widely grown across Africa and Asia and other tropical and subtropical regions of the world. It is a multipurpose forage crop, primarily grown to feed cattle in cut and carry feeding systems (Negawo et al. 2017). It has multiple benefits besides being a fodder crop, namely it helps in controlling soil erosion because of its extensive root system (Magcale-Macandog et al. 1998); is resistant to broad spectrum of pests and diseases and shows potential for soil carbon mitigation (Sundaram et al. 2012).

Image 9.1 Semi circular bunding and deep furrows

9.3 Key Resources or Considerations

The trench and the area around the trench must be stabilized. Growing fodder or grasses like Vetiver or Napier on bunds can enhance stability of the structures as their roots fix the soil (Waelti and Spuhler 2020). The semi-circular bunds are usually constructed in areas with rainfall between 200-750 mm. Additionally, the first rains after construction is a critical period for the structures operation. Any breakages must be repaired immediately. To limit maintenance to a minimum, it is important that the primary construction is done well. Deposited silt and earth have to be regularly removed from around trees and the structures usually have to be dug out again only after five years (Anschuetz et al. 2003). The napier grass used must be a sterile variety.

9.4 Applicability

This is a process that requires some amount of manual labour but well designed systems can be applicable to different plantations and field crops

9.5 Limitations/ Barriers to Adoption

The major limitation is that they need to be built manually and therefore can be time-consuming and labour intensive.

9.6 Estimated Costs

It is a simple, inexpensive and easy structure to construct especially if manual labour is easily available. It does not require too much technical or mechanical inputs for implementation making it cost-efficient. The costings are as follows:

(1) Conservation ploughing (@ Rs. 800)

(2) Semi-circular trenches (64 per acre @ Rs. 200)

(3) Deep furrow making (@ Rs. 500)

(4) Transplanting Napier grass (5 rows per acre @ Rs. 500 + Napier slips for an acre @ Rs.1500). Napier can easily be propagated vegetatively through Napier grass slip and hence, is a cost effective vegetative barrier.

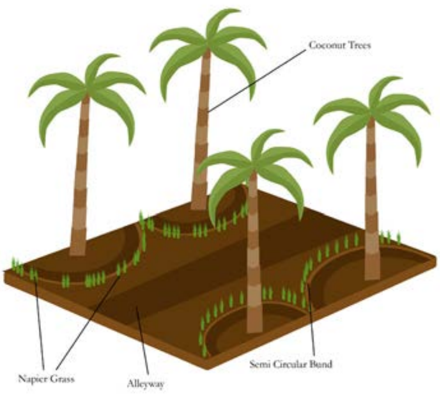


Figure 9.1 Integrated soil moisture conservation system

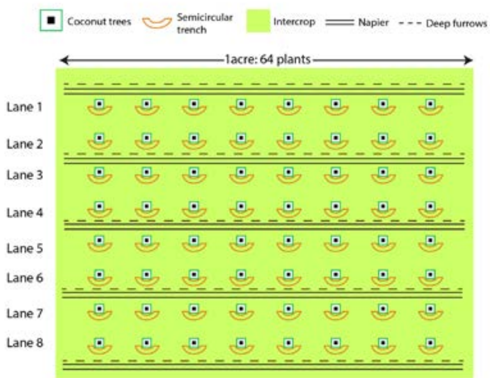


Figure 9.2 Conceptual layout of Integrated SMC system.

Image 9.2 Cow eating Napier Grass

Image 9.3 Planting Napier Grass

9.7 Winning Against Climate Change

Venkat Durga Subramanium is a Fellow Farmer from Kamavaram village. He grows crops i.e., coconut, bananas, and other vegetables on 5 acres of land. However, like many other farmers, his crops too were suffering from the adverse effects of climate change. Erratic and unreliable weather conditions such as untimely heavy rainfall was causing topsoil from his farms to erode and also preventing water percolation into the soil. This meant that the crops were not receiving the appropriate amount of water and nutrients. This led him to introduce the integrated soil moisture conservation system designed and promoted by DRF and the local KVK in his coconut plantation. He integrated semi-circular bunds, contour ploughing, deep furrows and napier grass to prevent soil erosion in his plantation. Thereby, helping his coconut farms increase soil moisture levels thus improving plant health and yield. Additionally, he also stated that using Napier grass as fodder for his cattle is improving their milk yield.

Seeing the improvement in his soil and the overall yield, Venkat has begun accommodating additional crops such as bananas and vegetables into the same system which also provides him with an additional income. He has worked alongside DRF since 2018 and since the interventions promoted by them have been successful, he is more aware and receptive towards newer practices now. He has tried multiple other Climate Smart interventions like rain hose, drum seeder and seed drill as well. Now with the success of the soil moisture conservation intervention he is also considering investing in 5 more acres of coconut land on lease and is confident about the outcome of the same. He is also inspiring others to adopt SMC in their coconut orchards to combat the erraticity in rainfall in the region.

Image 9.4 Venkat Durga Subramanium in the field

Image 9.5 Lenka Krishna, local Napier grass supplier

9.8 References

Anschuetz J., Kome A., Nederlof M., Neef R.de., Ven T. van de. (2003). Water Harvesting and Soil Moisture Retention. Wageningen: Agromisa Foundation

Critchley W. and Sieger K. (1991). A Manual for the Design and Construction of Water Harvesting Schemes for Plant Production. FAO:Rome. Accessible online at< http://www.fao.org/3/u3160e/u3160e07.htm>

Hai M. (1998). WaterHarvesting: An Illustrative Manual for the Development of Micro-catchment Techniques for Crop Production in Dry Areas. Nairobi, Kenya: Regional Land Management Unit (RELMA), Swedish International Development Cooperation Agency (Sida).

IFAD (2011). Regreening the Sahel: Developing agriculture in the context of climate change in Burkina Faso. IFAD:Rome

Oshunsanya SO. and Aliku OO. (2017). Vetiver Grass: A Tool for Sustainable Agriculture. In: Benefits, Diversities and Functional Roles, Amjad Almusaed and Sammera Mohamed Salih Al-Samaraee, IntechOpen, DOI: 10.5772/intechopen.69303.

10. Rain Hose Spray Irrigation

10.1 Problem/Concern

Agricultural water demand (irrigation) amounts to almost 80% of the total fresh water demand in India. Conventional flood irrigation used by farmers not only has very low water use efficiency, it also delivers lesser crop yields in comparison to more efficient micro-irrigation practices which can save large amounts of water. However, micro-irrigation systems like subsurface drip or sprinklers can be expensive investments in India even with subsidies for marginal farmers.

10.1 Rain Hose Spray irrigation

The rain hose spray irrigation technology is a low-cost alternative to the sprinkler irrigation system. It consists of a flexible hose with a pattern of laser punched drip holes which allow a uniform flow of water on the crops. It can be easily installed and maintained and is a portable system that can be installed for small land parcels. The biggest advantage of rain hose irrigation technology is that one can achieve optimum irrigation by dispersing small amounts of water uniformly and frequently which helps control leaching and reduces nitrogen application (Ayyadurai et al., 2020).

Image 10.1 Rainhose installed in SRT

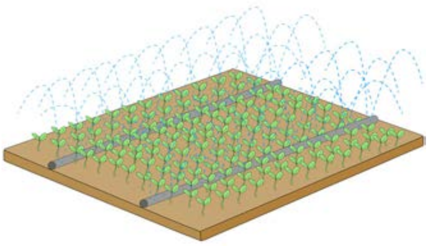


Figure 10.1 Rain hose spray

Image 10.2 Spray irrigation using rain hose

Image 10.3 Uniform water distribution using rain hose

10.3 Key Resources or Considerations

It has four main components that are required for installation namely (1) Rain hose, (2) Tee Take Off connector, (3) Straight connector (or) Jointer, and (4) End cap.

10.6 Estimated Costs

In comparison to other irrigation systems, the rainhose is an affordable alternative that costs around Rs. 16000 -20000 per acre. KSNM Drip charges Rs. 2500 for their Do It Yourself (DIY) kit for 500 sq. mt. or one-eighth of an acre system.

10.4 Applicability

Rain hose works well on fairly level land and is suitable for closely spaced and low height crops like onions and other vegetables such as leafy greens, groundnut etc. In comparison, to subsurface drip irrigation, it does have a lower potential in yield and water use efficiency, but the cheaper price point of rain hose helps increase its adaptability for small and marginal farmers and leads to greater area coverage.

Image 10.4 Rain hose spray irrigating groundnut.

10.5 Limitations/ Barriers to Adoption

The rain hose irrigation system is not suitable for crops that are over 30 cm in height, on undulating lands, in areas with high wind speeds and limited possibility of fertigation. It is also susceptible to more damage from dogs, rats and other pests.

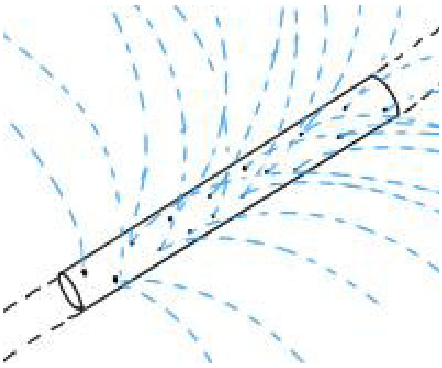


Figure 10.2 Laser punched hole in rain hose pipe

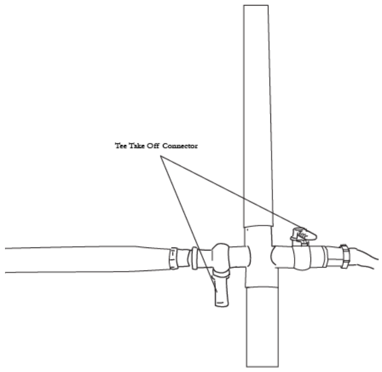


Figure 10.3 Connectors for Rainhose system

Image 10.5 Valve controlling water flow

10.7 Forerunners in Agri-Tech

Technology has been changing lives everywhere. It is no different when applied to agriculture. For Erramada Venkat Reddy spray irrigation was an excellent system that changed the way he cultivated groundnut crops in his field. A 48 year old farmer from Dacharem, Reddy cultivates a total of 15 acres of land with paddy, citrus and groundnut. He adopted the new rain hose technology in 1 acre of his groundnut crop.

Groundnut needs frequent and light irrigation to maintain high soil moisture. With rain hose irrigation technology, small amounts of water could be dispersed more frequently which helped in better crop growth thus maximising yield. According to Venkat, this form of irrigation wasn't just a convenient alternative, rather it was a step above the conventional sprinkler irrigation. It is easier to use with no clogging problems, less cumbersome as regular relocation of the position of sprinkler heads is not needed and it irrigates an acre of land in less time in comparison to sprinkler systems. Further, it requires lesser investment for covering the same parcel of land. With the success of this intervention he has become more receptive towards progressive resource efficient technology. Reddy now keeps a tab on recent agri-tech developments and he wants to implement new things like drone sprayer technology in the near future.

Spray irrigation has not only saved time, water and labour investments, it also ensured better loose soil texture which is optimal for groundnut cultivation. After witnessing Venkat Reddy's success, many other fellow farmers are adopting rainhose. With the DRF association, these farmers have found various cost-effective, and resource efficient solutions to their agricultural needs. Especially with the uncertainty of the pandemic, these technological interventions have given a boost to their overall income.

Image 10.6 Venkat Reddy in his field

10.8 References

Ayyadurai et al., 2020. Rain Hose Irrigation Technology in Groundnut- A New Innovation in Irrigation System. Biotica Research Today 2(8): 842-843

KSNM (2020). Spray Irrigation Kit/ 40 mm - 500 sqm. Available online < https://www.ksnmdrip.com/spray-irrigation-kit-rain-hose-rain-pipe>

Schneider AD. and Howell TA. (1999). LEPA and spray irrigation for grain crops. Journal of irrigation and drainage engineering, Vol 125 (4), pp 167 -172.

11. Waste Decomposer

11.1 Problem/Concern

Agriculture crop residue burning particularly paddy is a major problem in India. It is a cause for concern as it leads to severe air pollution and smog which are detrimental to human health. Also, the impact of agricultural fires is often not limited to the proximate areas but can spread to distant regions.

11.2 Solution: Waste Decomposer

Waste decomposer is a consortium of beneficial microorganisms that is able to decompose organic agricultural and livestock waste within 30-50 days, depending on the type of waste. It is a simple and easy solution developed by the National Centre of Organic Farming (NCOF) for agricultural residue management instead of the highly polluting activity of crop residue burning. ICAR has also developed similar waste decomposing consortia in the form of capsules called PUSA decomposer. Applications of the Waste decomposer solution are also useful for seed treatment, regular disease control, improving soil health and making crops unpalatable for animals like Nilgai.Further, itt can be used as a foliar biopesticide spray, as a biofertilizer and even helps to generate earthworm population in the soil.

Image 11.1 Waste Decomposer being mixed in vat

11.3 Key Resources or Considerations

Farmers can prepare the waste decomposer solution simply by mixing the culture with jaggery and water in a drum that can be used repeatedly. The solution can be diluted and made multiple times from the first batch of culture and lasts a farmer almost 3 years.

11.4 Applicability

The process is simple and no special equipment or major financial investment is required. It is recommended for all types of crops and in all soil types.

11.5 Limitations/ Barriers to Adoption

It is a low hanging fruit. There are no obvious challenges or limitations besides the lack of awareness among farmers and the difficulty in adopting the intervention in regions where the gap in between two agricultural seasons is very short.

11.6 Estimated Costs

Waste Decomposer when directly purchased by the farmers through NCOF and Regional Organic Farming Centres (RCOF) centres costs Rs. 20/- per 30gm bottle and PUSA decomposer is priced at Rs.20 for 4 capsules.

Image 11.2 Mallaiah holding a bottle of Waste Decomposer

Figure 11.1 Waste Decomposer Bottle

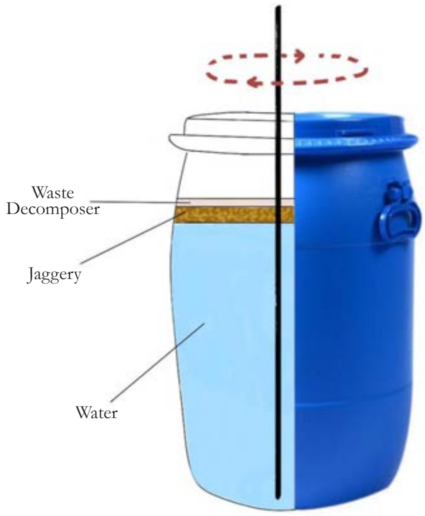


Figure 11.2 Waste Decomposer being prepared in a vat

11.7 The Agri-Advisor of Borraipelam

From Borraipalem, Telangana, forty-eight-year-old Peddaboina Mallaiah chose progressive ways to tackle agricultural waste in his farms. According to him before 2018, post paddy harvest, the entire village used to burn paddy straws in the fields. However, after his selection in DRF's Lead farmer program, he introduced Waste decomposer as an alternative to paddy residue burning. The adoption of this previously unheard intervention was met with skepticism in his village. However, he chose a path that most of the people weren't convinced of. Though the effect of the waste decomposer took a complete season to show positive results, his patience and trust in the scientific approach paid off and its usage helped him combat the persistent issue of residual waste disposal. Further, since the decomposer is high in beneficial microorganisms it also helped enhance the quality of his soil and became an effective alternative for harmful pesticides. Along with the waste decomposer Mallaiah also implemented complementary practices like green manuring and drum seeding which helped him significantly increase his paddy yields.

Image 11.3 Mallaiah making WDC mixture for his field

Mallaiah's success has made him a well respected advisor among the farmer peer group for adoption and demonstration of new technologies. He regularly advises others on how to revive low soil fertility once the soil testing is done. Even the district collector and local administration visited his field and appreciated his work. He says "Now more than 60 farmers are following me in my village. Also, I never thought I would have had the opportunity to speak with the district collector and the credit for all of these successes goes to DRF." Mallaiah was recently felicitated by the State Bank of India on World Farmer's Day. He also addressed 500 people in Raitu Sadassu in the first quarter of 2021. Mallaiah continues to lead by example as he is not only helping 6 fellow farmers implement the waste decomposer intervention but is also in the process of training 10 more farmers to practice the same.

11.8 References

Agriculture world (2020). This 5 Rs. Capsule Will Solve Stubble Burning Problem, Reduce Pollution & Make Soil Fertile. Available online <https://krishijagran.com/agriculture-world/this-5-rs-capsule-will-solve-stubble-burning-problem-reduce-pollution-make-soil-fertile/>

NCOF (2019). Waste Decomposer. Available online <https://ncof.dacnet.nic.in/Training_manuals/Training_manuals_in_English/Waste-Decomposer-Eng.pdf>

12. Zero Tillage

12.1 Problem/Concern

Maize is the third most important cereal crop in India, cultivated in over 9 million hectares. However, in India, the average productivity of maize is much lower than world average, at just about 30 quintals per hectare while the world average is 58 quintals. Cultivating maize in India faces major challenges including water scarcity, labour shortage and rising production costs.

12.2 Solution: ZTM - ZERO TILLAGE MAIZE

Zero-tillage (ZT) cultivation, also known as no-till farming, is a popular conservation agricultural technology which eliminates tilling and minimizes soil disturbances by sowing crop seeds through direct drilling into unplowed fields. In India, ZT has been adopted for wheat and maize extensively in wheat–rice and maize-rice double-cropping system (Jat et al. 2016). ZT helps in reducing water use, improves C sequestration, gives similar or higher crop yield and increased income, reduces fuel consumption and GHG emission, and makes cropping systems more tolerant to heat stress (Jat et al. 2016, Parihar et al 2018). It maintains crop residues on the soil surface and protects the ground against wind and water erosion and is a cost saving technology. In India, either tractor drawn zero-till-seed drill (in Western IGP), low cost manual hand drawn seed drill or surface broadcasting (in wet soft soils of eastern IGP) is used to seed wheat/maize directly (Laxmi and Ernestein 2008).

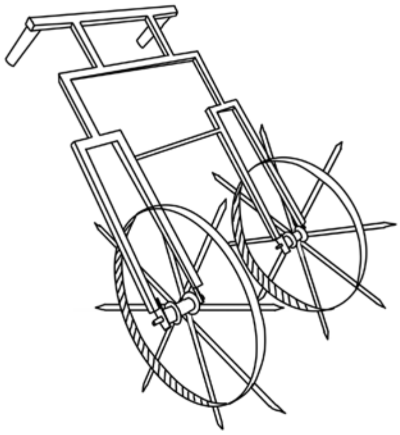


Figure 12.1 Double Wheel Marker for ZTM

Image 12.1 ZTM at harvesting stage

Image 12.2 Women working in ZTM

Image 12.3 Farmers working on ZTM field

12.3 Key Resources or Considerations

Certain conditions are necessary for ZT. Farmers need to ensure good soil moisture before they begin sowing activities. Seeds and fertilizers should be used as per the soil texture and field conditions. Suitable furrow openers, seed metering systems, seed drill and the right type of planters are crucial to successful cultivation via the no-till technology.

12.4 Applicability

In India, ZT can be adopted extensively for wheat and maize in existing wheat–rice and maize - rice double-cropping system.

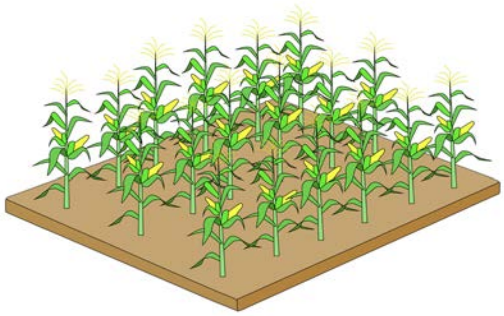


Figure 12.2 Zero Tilled Maize

12.5 Limitations/ Barriers to Adoption

There is a lack of appropriate seeders for small and medium-scale farmers. Local fabricators who can help manufacture manual seeders at village level are also absent or not identified. Along with that, a lack of information and awareness on ZT and other conservative agricultural practices are a major barrier.

Image 12.4 Maize Produce

12.6 Estimated Costs

DSR using Rice-Wheat Seeder was evaluated against the transplanting method in a farmer's field by ICAR. It showed that DSR led to enhancement in yield by 5 - 25 % at different locations with net saving of about Rs. 10,450 / ha. DSR cost Rs. 8200/ha in comparison to Rs. 20400/ha for TPR (ICAR 2017).

Image 12.5 Double wheel marker used for zero tillage maize

12.7 Farmers of the Future

P. Simhachalam and his family from Srikakulam District of Andhra Pradesh have been involved in agriculture for generations. Maize was a major Rabi crop grown in his region. However, in the last few years increasing conditions of drought and cost of cultivation were leading to crop failure. The intensive tillage method was expensive as it involved multiple ploughings and cattle drawn ploughing often caused damage to the seeds planted. Persistent water shortage also led to low percentage of germination of seeds. These conditions pushed him to undertake zero tillage for maize cultivation during Rabi 2017.

ZTM was a groundbreaking solution for the issues he was facing. Unlike the conventional system, which needed him to plough his land five to six times, ZTM didn't require any ploughing at all. He only had to make holes uniformly on his land, using a simple wooden tool in his untilled field and do a onepass planting and fertilizer application. That's all! Not only did Simachalam manage to harvest 45 quintals from a hectare. He was also able to save 18% i.e. 33000 litres of water per acre, decrease the need for labour by 60% and use 30 % less fertilizer. And all this including harvest was possible a whole one month earlier - by the end of April itself. Most importantly the success of ZTM made him and his fellow farmers more receptive towards new technologies and innovating. Local farmers from the area independently started taking the initiative to make the practice more efficient like modifying the existing tedious wooden peg marker into the current double wheel marker. This locally fabricated double wheel marker makes ZTM both faster and easier than before.

Simhachalam, as the lead farmer for ZTM's success, was able to get 30 fellow farmers interested in the intervention which resulted in over 40 acres of farmland being converted into ZTM. With his efforts and knowledge he soon stepped up as the agri-tech influencer in his village. It is not just the increase in yield and income that has motivated him, but rather his journey of learning about these progressive and effective interventions. The district acknowledged his efforts by felicitating him with the best farmer award in his constituency for the year 2019. His popularity grew and even his uncle became the sarpanch of the village. Now together with the support of the panchayat, Simhachalan shares his experience and his knowledge with fellow farmers so as to make these progressive practices more popular. The continual association with DRF and the KVK scientists allows farmers like Simhachalam to keep up with the changing times and be the farmers of the future.

Image 12.6 P. Simhachalam in his field

12.8 References

Jat ML., Dagar JC., Sapkota TB., Yadvinder-Singh, Govaerts B., Ridaura SL, Stirling C. (2016). Climate Change and Agriculture: Adaptation Strategies and Mitigation Opportunities for Food Security in South Asia and Latin America. Advances in Agronomy, 127–235.

Laxmi V., Erenstein O., and Gupta RK. (2007). Impact of Zero Tillage in India's Rice-Wheat Systems. Mexico, D.F.: CIMMYT

Parihar CM., Yadav MR., Jat SL., Singh AK., Kumar B., Pooniya V., Pradhan S., Verma RK., Jat ML., Jat RK., Parihar MD., Nayak HS., Saharawat YS. (2018). Long-term conservation agriculture and intensified cropping systems: Effects on growth, yield, water, and energy-use efficiency of maize in northwestern India. Pedosphere. 28(6): 952–963.

13. Wet Direct Seeded Rice (W-DSR)

13.1 Problem/Concern

Problem: The conventional method of transplanted rice (TPR) is a labour intensive and a time consuming practice. TPR also usually requires more water for both nursery and main field preparation. Water shortage during transplanting can lead to delay and use of over aged seedlings with limited tillering capacity which consequently impacts yield. However, farmers cultivating transplanted rice in irrigated and rainfed areas in India are increasingly facing water shortages due to erratic rainfall, declining groundwater and untimely release of irrigation water from canals. In order to tackle both labour and water scarcity farmers are encouraged to take up Wet Direct Seeding of Rice.

13.1 Wet Direct Seeded Rice (W-DSR)

Wet direct seeding of rice (W-DSR) is the process of sowing pre-germinated seeds in wet puddled soils and is an alternative to the conventional system of rice transplanting. W-DSR is primarily done by sowing seeds into the mud with the help of a drum seeder. A drum seeder is a handheld agricultural implement used to sow paddy seeds in wet fields. Pre-germinated paddy seeds are filled in drums made up of fibre/plastic material which dispenses seeds uniformly in lines spaced 20 cm apart in puddled and levelled fields. One of the major advantage of using a drum seeder is that it is lightweight, simple and easy to handle. It reduces labour costs and one hectare can easily be sown in a day. (IRRI 2020). Wet seeding, also helps in more timely crop establishment, crop matures 7-10 days earlier, and crop yields can increase by upto 10-15% (higher than transplanted rice) since the crop is not subjected to the stress of being pulled and manipulated. It is also a climate smart agricultural technology since there is a lower methane emissions and saving in water consumption in comparison to transplanted rice (Balasubramanian and Hill 2002).

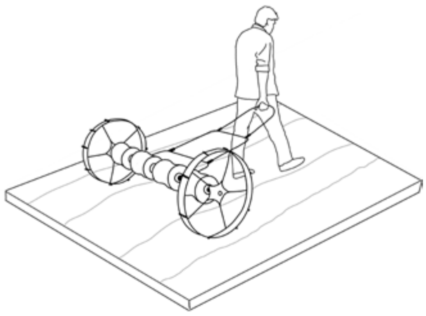


Figure 13.1 Drum seeder being pulled by farmer

Image 13.1 Drum seeder being pulled by farmer

Image 13.2 Wet seeded rice

13.3 Key Resources or Considerations

Key considerations for successful wet seeding of rice include factors such as good land preparation, levelling, and water management. Care should also be taken not to delay sowing of the pre-germinated seeds as long shoot growth is not suitable for drum seeding. Drum seeded rice requires weeding which may be done using a single wheeled cono weeder. Basal doses of phosphatic fertilizers. nitrogenous and potassic fertilizers may be applied as top dressing starting 20 days after sowing.

13.4 Applicability

Wet seeding of rice is commonly applicable in irrigated areas. It is a simple and easy to use technology that can be adopted by farmers after basic training.

13.5 Limitations/ Barriers to Adoption

Weeds and pests like snails are a serious limitation in wet seeding of rice. Heavy rainfall immediately after wet seeding may wash away the newly sown seeds and can lead to failure of crop establishment. In areas of standing water, seed emergence is also a problem.

13.6 Estimated Costs

A 8 row drum seeder used for W-DSR costs up to Rs 6000 per unit (KSNM 2020). Also, the returns per rupee of investment was higher in DSR when compared with TPR.

Image 13.3 Drum seeding field team

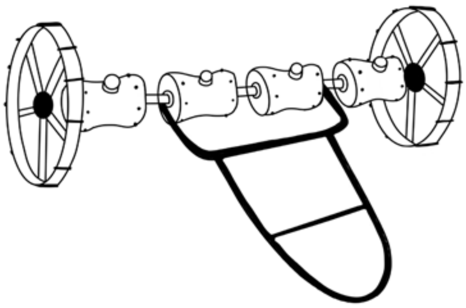


Figure 13.2 Drum Seeder

Image 13.4 Bhupal Reddy

Image 13.5 Drum Seeder

13.7 A far-sighted approach to farming

Bhupal Reddy is an enterprising 37 year old Lead Farmer with a total land holding of twenty acres of paddy farms i.e., ten acres of his own and ten acres on lease. Bhupal was one of the first farmers to implement DRF introduced Wet DSR intervention in paddy. His key concerns were mainly around labour shortage i.e., transplanting of seeds getting stalled because labourers were not turning up, or were not being efficient enough. Wet DSR in paddy was a welcome change for Reddy.

He took up wet seeding of paddy with an eight row drum seeder, using which he could easily cover seeding of two and a half to three acres of land in a day with one acre needing about two to two and a half hours of time. Whereas, in transplanted rice (TPR), Bhupal could only complete one to one and a half acres and had to employ at least five to six labourers in a day. A single equipment like the drum seeder enabled Reddy and his wife to manage the farms better and get the job done much quicker in comparison to the traditional method of manual transplanting. Most importantly, it helped Reddy eradicate the aspect of inconsistency that came with manual labour and was more time and cost efficient.

Drum seeding required a lesser quantity of seeds (10 kg/acre) compared to convetional TPR (25 kg/acre). Also, since seeds were sown directly, costs that were otherwise incurred on nursery preparation and manual transplanting of upto Rs. 5000 per acre could be saved as well. To add to the advantages of W-DSR, spraying of fertilizers and pesticides were also lesser in this system, which again significantly reduced the production cost per acre. W-DSR is also water efficient as it uses alternate wetting and drying, that is practiced for a month after seeding as against continuous flooding of paddy fields in TPR.

W-DSR has also decreased the burden on women i.e., it is no more a tedious task and 20 acres of paddy can also easily be transplanted in two days using 3 drum seeders, added Bhupal's sister who is also the Head Kisan of the village.

According to Bhupal's observation, the crop had better growth, there were more productive tillers and higher grain numbers in panicles. On an average W-DSR paddy yielded Reddy 40-46 bags of rice in comparison to 35-40 bags usually got in manually transplanted rice. Considering that a bag of HMT Superfine variety Chintudhan seed costs around Rs.1700/. Hence, by implementing the intervention his yield increased by 1.5 - 2 quintals per acre which led to an additional income of Rs. 2500 per acre over the years. Bhupal's success with W-DSR also encouraged him to try out nutrient management practices in his fields. Simultaneously, he intends to shift to organic farming and is trying his hands on pesticide-free natural farming considering it to be the need of the hour.

Bhupal Reddy by being an early adopter of drum seeding practice has managed to make a name for himself in the village, being able to save more, make a better living for himself and his family. He is now better able to fund his children's education i.e., both his children attend private English medium schools in Nalgonda. As a lead farmer, Reddy also inspired twenty more farmers to take up these small-scale interventions that in the long run are more cost-effective and help tackle multiple issues like the younger generation being more inclined towards white collar jobs, lack of helping hands in the farms,

Image 13.6 Bhupal Reddy in his field

13.8 References

Balasubramanian V. and Hill JE. (2002). Direct seeding of rice in Asia: emerging issues and strategic research needs for the 21st century. In: Pandey, S., Mortimer, M., Wade, L., Tuong, T.P., Lopez, K., Hardy, B. (Eds.), Direct Seeding: Research Strategies and Opportunities. Inter. Rice Res. Inst., Los Ban˜os, Philippines, pp. 15–42.

ICAR (2017). Profitable Paddy Cultivation through Direct Seeding Technology by Rice-Wheat Seeder. Available online <https://icar.org.in/content/profitable-paddy-cultivation-through-direct-seeding-technology-rice-wheat-seeder>

IRRI (2020). Direct seeding. Available online <knowledgebank.irri.org/step-by-step-production/growth/planting/direct-seeding>

KSNM (2020) Drum Seeder Cost. Available online <https://www.riceseeder.com/paddy-drum-seeder.html>

Conclusion

The agriculture sector is not only one of the biggest contributors to climate change, but the farming community is one of the most vulnerable to its impacts. However, with climate-friendly agriculture practices, agriculture can become one of the key players towards mitigation & adaptation to climate change. With an ever-increasing consumption pattern, agriculture production needs to increase by 70% by 2050 to meet global demand for food, which in turn will increase degradation of natural resources catalyzing the climate change process and leading to instability of agriculture productivity.
Sustainable agriculture practices encompass steps to conserve natural resources helping mitigation and adoption of climate change at the same time increase productivity and income of the farming community.
This compendium showcases the implementation of climate-smart interventions covering the full spectrum of farm household activities. The interventions which fall under the following categories - (1) water-smart practices, (2) carbon smart practices, (3) nutrient smart practices, (4) energy & labor smart practices, and (5) knowledge smart activities help build adaptive capacity of the farming community and increase yields & income while reducing agriculture's environmental footprint. It also discusses the challenges encountered at the implementation stage and the opportunities that need to be leveraged for scaling any CSA intervention.

The literature, through its case stories, emphasizes the importance of the identification of progressive farmers with strong leadership qualities who have the capacity and willingness to take some degree of risk that comes along with piloting new practices/technologies, and with a strong interlink between ease of implementation and access to locally available resources, nurturing entrepreneurial qualities in the farming community and building strong social networks with the system can help in the scaling of options. For example, with a local farmer becoming a fabricator of double wheel marker more farmers could adopt zero tillage maize intervention. Further, no CSA-based program can be nurtured if there isn't a strong relationship of trust between the farming communities and the on-field support teams promoting the activities. Hence, awareness and trust-building activities are also pre-requisite for strong climate action work in agriculture. Lastly, partnerships and multi-stakeholder networks are at the core of any successful climate action program. CSA requires collaborative efforts and the support of a strong network of multi-stakeholder partners working in the regions ranging from the government (local KVKs, agriculture and horticulture dept.), agribusinesses (e.g. PCI, KSNM) to local research and agricultural universities.