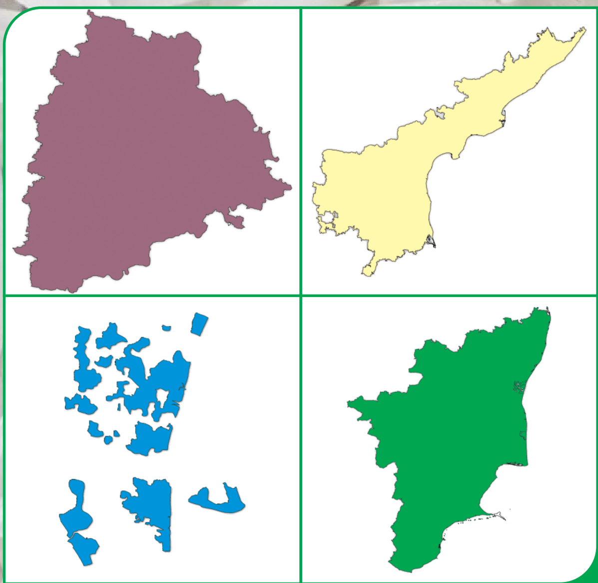
Stepping Towards Future Farming: Direct Seeded Rice with KVK Lense



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FOREWORD

The Indian Council of Agricultural Research (ICAR) through its Agricultural Extension division is steering the frontline extension efforts in agriculture across the country at district level through Krishi Vigyan Kendra's (KVKs) which are coordinated at the zonal level by Agricultural Technology Application Research Institutes (ATARIs). ATARI, Zone-X Hyderabad is mainly focussing on the resource conservation technologies in different crops grown in the four states *viz.,* Andhra Pradesh, Telangana, Tamilnadu and Puducherry.

Scientists of Zone-X are doing impressive work by focusing on the promotion of the resource conservation technologies in different crops to save the resources and reduce the cost of cultivation through front line extension programmes. The unparalleled work of the Zone-X scientists will be an inspiration and motivation to the scientific community who wants to excel in dissemination and adoption of technologies by the farmers. The compliments go to the KVKs of Zone-X for their dedicated work in motivating the farmers in adoption of direct seeding in the states Andhra Pradesh, Telangana, Tamilnadu and Puducherry. Water which is the essential resource for agriculture. Its scarcity warrants, promotion of the resource conservation technologies in rice and more efforts to be done in this area for wider adoption by the rice cultivating farmers.

My compliments to ATARI and KVK scientists in Zone-X for documenting the efforts of direct seeding in the states of Andhra Pradesh, Telangana, Tamilnadu and Puducherry. I am sure that this publication will help in bringing the awareness on the direct seeding to the farmers and scientists and other stake holders for making the rice cultivatiion profitable and sustainable.

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Date : 10.08.2023

PREFACE

Changing and increasingly variable climate is one of the challenges and it has brought a global attention due to its series of implication ranging from seasonal variations in temperature, rainy days, heat waves which is affecting the food and livelihood security in all the countries. To develop and promote resource conservation technologies all the organizations from Top to Bottom are working closely with farmers. At the gross root level, Krishi Vigyan Kendra's (KVKs) are playing a significant role in creating the awareness and popularization of various resource conservation technologies in different crops. Among the various resource conservation technologies (RCT) in agriculture, Direct seeded rice (DSR) appears to be an appealing option for the future rice farming having the potential for saving the resources like water and labour apart from achieving the sustainable yields under different agro-ecological environments.

The KVK's in states of Andhra Pradesh, Telangana, Tamilnadu and Puducherry falling under the ATARI, Zone-X have done an exemplary and remarkable work in promoting the resource conservation Direct Seeded Rice (DSR) technology among the farming community. The KVKs have done an outstanding contribution which brought the sea change in rice cultivating farmers for transforming from conventional transplanting and adopting the direct seeding rice technology. The untired efforts of KVK's have brought an approximate area of around 6.9 lakh hectares under direct seeded rice practiced by the farmers in both the seasons (*Kharif* and *Rabi*) and the area is increasing day by day through the consistent work of KVK's in conducting demonstrations, awareness and training programmes for attracting a greater number of farmers in adoption of direct seeding technology. KVK's role in adoption of RCTs like direct seeded rice technology by the farmers can substantially conserve resources at the field level by achieving good production levels with minimal impact on the soil, underground water, atmosphere and in improving the declining land, water productivity which are more important now than ever for a sustainable food future.

This publication is a document consisting of the knowledge on the way of practicing the direct seeded rice technologies and technology adopted by the farmers in the four states. Many success stories have been generated by the striving work of KVKs during the promotion of the direct seeded rice technology have also been put forth in this book which show case the key role played by the KVKs in promoting the direct seeded rice in a larger way among the farming community. I hope that this publication will encourage many other KVKs to develop and share such successes of the technologies promoted by them in improving the farming practices and socio-economic condition of the farmers.

Date : 10.08.2023

(Shaik. N.Meera)

CONTENTS

S.No	Particulars	Page No.
1.	Conservation Agriculture (CA) and Resource Conservation Technologies (RCTs) - Need and Importance	1
2.	Direct seeded Rice – A resource conservation technology to overcome water and labour scarcity	6
3.	Work done by KVK's of four states in promotion of Direct Seeding Rice	19
4.	Success Stories	26
5.	Research gaps and constraints in direct seeded rice	56
6.	Conclusions and Way forward	58
7.	References	60
	List of Contributors	67

Conservation Agriculture (CA) and Resource Conservation Technologies (RCTs) - Need and Importance

CHAPTER 1

Introduction

Global food supply has kept pace with demand in the past four decades due to impressive economic growth and linking global markets. During the second half of the 21st century, achievements of agriculture in South Asia in general and India in particular are among major global success stories. But, the real challenges have surfaced in the recent years with ever increasing food demand due to burgeoning populations, degradation of land, natural resources and changing climatic conditions. To compound the challenges further, global climate change is likely to impact crop and livestock production, hydrologic balances, input supplies and other components of agricultural systems making production much more variable than at present. Climate change is contributing to shift in growing seasons for major crops such as rice, the production of which could fall by 40% and also decrease the acreage of favorable wheat growing areas in the country. The current food crisis witnessed a dramatic increase in world food prices, causing political, economic instability and social unrest in both poor and developed nations. Therefore, for food and livelihood security, agricultural think tanks and United Nations have prioritized four major areas *i.e.*, natural resources, climate change, water and food (Jat *et al.*, 2011).

Broadcast seeding and harvesting meager yields was a common feature of ancient agriculture. But whereas, substantial yield gain through greater use of improved seeds, irrigation, chemical fertilizer, pesticides and mechanization (Foresight, 2011) was the main thrust of modern agriculture. Therefore, today's agriculture is an energy intensive farming system (Khan *et al.*, 2010). Though modern technology model remained successful in achieving targeted food demand, yet it has contributed to environmental problems in some situations such as loss of biodiversity, soil fertility, salinization and water scarcity (McIntyre *et al.*, 2009). Conventional or modern agriculture has largely been characterized by tillage which includes, soil loosening and levelling for seed bed preparation, mixing fertilizer into soil, weed control and crop residue management (Hobbs *et al.*, 2008). However, continuous use of conventional farming practices with conventional tillage (CT) and burning crop residues has degraded the soil resource base (Montgomery, 2007) and intensified soil degradation by about 67% with concomitant decreases in crop production capacity (World Resources Institute, 2000). More recently, yield growth has been diminishing, which is especially true for rice in Asia (Pandey *et al.*, 2010). The current scenario of escalating fuel, fertilizers and other input costs; necessitates the effective use of energy and other vital resources in agriculture. Without a new and more sustainable boost to productivity, agricultural supply will hardly be able to keep pace with the rapidly rising demand caused by population and income growth and changing consumer preferences (Foresight, 2011). Today's real agricultural challenges are resource fatigue with declining factor productivity, decreasing human resources and their rising costs and socio-economic changes (Erenstein, 2011; Gathala *et al.*, 2011a). Thus, there is dire need of an energy, water and labour efficient alternate system that helps to sustain soil, environmental quality and produce more at less cost (Jat *et al.*, 2011; Gathala *et al.*, 2011b).

Importance of Water in Agriculture:

Water is one of the most precious natural resources for agricultural production and agriculture accounts for 70 percent of water use (FAO, 2002). It is predicted that by 2025 water consumption will exceed "blue water" availability if current trends continue (Ragab and Prudhomme, 2002). In the Indian state of Punjab, characterized by intensive irrigated agriculture, the groundwater table is falling at a rate of 0.7 m per year (Aulakh, 2005). However, the decline of freshwater resources is due not only to increased consumption, but to careless management. Agriculture contributes to the problem by wasting water and by sealing and compacting the soils so that excess water cannot infiltrate and recharge the aquifer which is one of the causes of the growing number of flood catastrophes (DBU, 2002). In regions where water is already the limiting factor for agricultural production, this wasteful practice threatens the sustainability of agriculture. Rising temperatures and evapo-transpiration rates combined with more erratic rainfall further aggravate the water problems in rainfed agriculture (Met Office, 2005).

Conservation Agriculture (CA):

Conservation agriculture (CA) is a concept for resource saving agricultural crop production that strives to achieve acceptable profits with high and sustained production levels while conserving the environment. Conservation agriculture is based on enhancing natural biological processes above and below the ground. Interventions such as mechanical soil tillage are reduced to an absolute minimum and external inputs – e.g. agrochemicals and nutrients of mineral or organic origin are applied at an optimum level taking care to not interfere with or disrupt the biological processes. Conservation agriculture is characterized by three interlinked principles *i.e.*, minimum mechanical soil disturbance throughout the entire crop rotation; permanent organic soil cover and diversified crop rotations in the case of annual crops or plant associations in the case of perennial crops.

Need of Conservation Agriculture:

At present, the challenge for agricultural scientists is to increase food production to meet food security needs of ever-growing population of world. However, such production increases must be accomplished sustainably by minimizing negative environmental effects and equally important in providing increased income to help improve the livelihoods of those employed in agricultural production. The demand for food is still increasing, not only to meet food security for a growing population, but to provide nutritional security as well. Most of the sources of productivity growth *viz*., improved varieties, fertilizer and water used in the last 40 Green Revolution years are already being exploited. Future sources of productivity growth will be more complex and harder to find in maintaining ecological balance for supporting life and to make the resources available for present and future generation.

Competition for surface and groundwater resources will be more severe as domestic and industrial needs will compete for it apart from the shrinking agricultural land because of urbanization and its use for other purposes. Expansion is possible in some parts of the world, but the quality of the new land may be less than that already in use for agriculture. Fossil fuels will be more costly which is adding to production costs directly as well as indirectly. GHGs will increase with subsequent effects on climate, especially an increase in severe climatic events such as drought and floods etc. This will make the challenge more difficult and complex. The one and only obvious way to accomplish this sustainable food production objective is to make more efficient use of the natural resources that are needed to produce food; this includes soils, water, air, inputs and people.

Conservation Agriculture (CA) and Resource Conservation Technologies (RCTs)

Conservation Agriculture (CA) and Resource Conservation Technologies (RCTs) are meaningly same with little difference. Resource Conservation Technologies are those practices applied in agriculture which enhance resource or input-use efficiency. For example, new varieties that use nitrogen more efficiently may be considered RCTs. Zero or reduced tillage practices that save fuel and improve plot-level water productivity may also be considered RCTs, as may land levelling practices that help save water. The combination of resource conserving technologies working in synergy is commonly referred to as "Conservation Agriculture" (CA).

Resource Conserving Technologies

Resource Conserving Technology (RCT) is a broad term that refers to any management approach or technology that increases factor productivity including land, labour, capital and inputs. Resource Conservation Technologies include a wide range of practices including: no-till / minimum tillage, surface seeding, skip furrow irrigation inter-cropping, water harvesting, supplemental irrigation, mulching, residue management, live fences and vegetative barriers. It may be clarified that not all RCTs may be compatible with CA (e.g., land levelling in presence of residues).

Resource conserving technologies have been developed in order to reduce the use and damage to natural resources through agricultural production; and to increase the efficiency of resource utilization. Most of these technologies target the two most crucial natural resources: water and soil, but some also affect the efficiency of other production resources and inputs (e.g. labour, farm power and fertilizer). The conservation agriculture based RCTs, practiced over an estimated area of 100 M ha worldwide and across a variety of climatic, soil and geographic zones (Derpsch and Friedrich, 2009) have proved to be energy and input efficient, besides addressing the emerging environment and soil health problems (Saharawat *et al.*, 2010). The RCTs bring many possible benefits including reduced water and energy use (fossil fuels and electricity), reduced greenhouse gas (GHG) emissions, soil erosion and degradation of the natural resource base, increased yields and farm incomes and reduced labour shortages (Pandey *et al.*, 2012).

Some of the RCTs for Conservation Agriculture (CA) are Zero tillage, Crop residue cover, Cover crops, Precision farming, Use of GPS and GIS systems, Site-specific nutrient management (SSNM), Leaf color chart (LCC), Laser land leveler, Crop rotation and Cropping System, Diversification/Intensification, Integrated Farming Systems, Rainwater harvesting, In-situ water harvesting, Off season tillage or Summer Ploughing, Bed planting, Contour farming and Strip Cropping.

Conservation Agriculture (CA) and Resource Conserving Technologies (RCTs) in Rice Based Cropping Systems:

Irrigated rice has for a long time been considered a stable and sustainable cropping system, although it is far from being conservation agriculture (the puddling results in the destruction of the soil structure). However, irrigated rice is increasingly subject to pressures.

The high fuel costs of puddling and the reduced availability of labour mean that there is pressure to change from transplanted to direct-seeded rice. The water consumption of traditionally puddled rice is too high in many regions and alternatives must be found. the rice growing is already restricted in some areas: cultivation of summer rice grown prior to the monsoon season is not allowed in parts of northern India; in Karakalpakstan, adjacent to the Aral Sea in Uzbekistan, rice cultivation is restricted because of the scarce water resources and the high evaporation losses; in China, the paddy rice areas around the city of Beijing have been replaced by other crops due to the alarming fall in the ground water table. The release of greenhouse gases such as methane is high in traditionally flooded rice (Gao, 2006).

Rice cultivation has therefore been adapted to conservation agriculture in several countries. Rice can be cultivated without puddling or permanent flooding by adopting resource conserving technologies. FAO has been working on rice based conservation agriculture systems in China and the Democratic People's Republic of Korea. In the Indo-Gangetic Plains the Rice-Wheat Consortium RCTs has been successfully introduced into rice-based cropping systems. Neither puddling nor zero tillage in rice result in higher yields of the non-rice crops in the crop rotations. The reported water saving through RCTs is usually higher in rice than in other rotation crops (PDCSR, 2005).

Some of the more popular RCTs, particularly in irrigated or rice-based cropping systems are Laser levelling, System of Rice Intensification (SRI), Controlled traffic farming, Reduced tillage, Zero tillage, Mulching, Green manure and Direct Seeded Rice (DSR).

Direct seeding:

Direct seeding of rice when compared with transplanting was considered an RCT because of the following advantages:

- It saves labour and fuel.
- Seeding into dry soil saves water as there is no puddling.
- The total growing period from seed to seed is reduced by about 10 days.
- Yields and water efficiency of the subsequent rotation crops are increased (PDCSR, 2005).

On the other hand, the only problem in direct seeding is weed management which is more difficult in dry-direct seeded rice than in puddled and transplanted rice (RWC-CIMMYT, 2003).

Direct Seeded Rice (DSR)

Direct seeded Rice – A resource conservation technology to overcome water and labour scarcity

CHAPTER 2

Rice is a foremost vital staple crop for over half of world's population providing 21.0 % of global human per capita energy and 15.0 % of per capita protein. Most developing nations rely heavily on rice as a basic food. It is an important crop for 117 countries of the world hence called "Global Grain". The United Nations recognized the importance of this crop and declared 2004 as 'International year of Rice'. The term 'Rice is Life' is most appropriate for India as this crop plays vital role in country's food security and is the backbone of livelihood for millions of rural households.

Annual rice production should be increased to meet the demand of an ever-growing population. This increase in production must come despite the declining resources like land and water which is a daunting task. Water is becoming scarce for agriculture in the present situation. Rice is a major freshwater user and consumes about 50% of total irrigation water used in Asia and accounts for about 24-30% of the withdrawal of world total freshwater and 34-43% of the world's irrigation water. The Per capita water availability has dwindled from 5300 m^3 $year^{-1}$ in 1953 to 2500 m^3 $year^{-1}$ in 1990 and expected to further shrink to 1500 m^3 $year^{-1}$ by 2025 signifying considerable reduction in water availability. Conventional rice establishment system *i.e.*, transplanting requires substantial amount of water. It has been reported that up to 5000 litres of water is used to produce 1 kg of rough rice. This production system is labour, water and energy-intensive and is becoming less profitable as these resources are becoming increasingly scarce. Transplanting of rice entails adequate land preparation both for nursery and main field, consumes 25% of the total water requirement ha^{-1} (1240 mm) and requires 25 to 30 man days for its establishment manually depending on soil type.

Growing rice in transplanted paddy condition is a common practice across the globe in general and in India particularly. Since ages it is a traditional practice as it offers certain advantages like ease of transplanting, avoids weeds and reduces deep percolation losses of water. Of late due to increased cost of cultivation associated with traditional rice cultivation and with growing environmental conscious, countries like India with highest rice growing area are pointed out at global summits for their puddling activity and are blamed for environmental deterioration with release of methane and oxides of nitrogen.

The weather being the major aberration in the current agricultural scenario and due to vagaries of monsoon, rains are delayed. Under conditions of late onset of monsoon and insufficient water in tanks and canals, water supply being erratic ultimately leads to delayed transplanting and on receipt of water, there is frantic and high demand for labour for transplanting and other agricultural operations which in turn making the farmers to forcibly complete transplanting within a short time of water availability. Rice growers are increasingly facing water crisis for traditional rice cultivation and increasing labour cost challenges. Further, rapid withdrawal of labour from the agricultural sector, increased competition for labour have contributed to the current situation and may worsen in the future. Therefore, the sustainability of production in rice fields is severely dented and the ability to increase production in pace with population growth with reduced water and labour use are major concerns.

Conventional Transplanting method

Although transplanting has been a major traditional method of rice establishment, economic factors and recent changes in rice production technology have improved the desirability of direct-seeding methods. Conventional rice production systems (puddled transplanting) require large quantities of water which was ranging from 800 to more than 5000 litres of water and requires on an average 2500 litres of water to be applied to produce 1 kg of rough rice (Bouman, 2009). Both Dry-DSR and Wet-DSR are more water efficient and have an advantage over Conventional Transplanting (CT) (Bhuiyan *et al.*, 1995; Dawe, 2005; Humphreys *et al.*, 2005; Tabbal *et al.*, 2002).

The rising labour cost and the need to intensify rice production in economical way, farmers were encouraged to switch to direct seeding in both wet and dry condition. Because of high labour demand at the time of transplanting, increasing labour scarcity and rising wage rates are the reasons forcing farmers to opt for a shift in method of rice establishment from transplanting, which requires 25–50 person days ha^{-1} to direct seeding, which in comparison needs about 5 person days ha^{-1} (Balasubramanian and Hill, 2002; Dawe, 2005). These factors demand a major shift from puddled transplanting to direct seeding of rice. Direct seeding is gaining momentum as a pathway to address rising water and labour scarcity and to enhance system sustainability. Published studies show various benefits from direct seeding compared with puddled transplanting, which typically include (1) Similar yields-studies reported no difference in rice yield between Conventional Transplanting (CT) and Dry-DSR (Bajpai and Tripathi, 2000; Hobbs *et al*., 2002; Sharma *et al*., 1995, 2005) (2) Savings in irrigation water, labour and production costs (3) Higher net economic returns. Direct seeded rice can be practiced by two ways *i.e.* 1. Dry converted wet rice (Semi dry rice) 2. Direct seeded rice under wet condition (Both broadcasting and drum seeding).

Dry converted wet rice (Semi dry rice):

Dry converted wet rice is gaining popularity among the farmers in the recent years where farmers take up rice cultivation with the onset of monsoon by selecting a suitable variety without waiting for water availability in tanks, canal commands and or recharge of underground water in bore wells during *Kharif*. Dry converted wet rice cultivation is sowing rice under rainfed condition and later turning to lowland crop when rainwater is available from the tanks and/or from similar sources.

Climate and Soil Requirement:

Commonly rice cultivated soils with more clay content are best suited for dry converted wet rice. In general, first showers received in the second week of June, the land preparation will be completed and ready for sowing by the end of June. Due to South-West monsoon, heavy rainfall received in the month of July/August and by taking the advantage of showers the field will be converted to wet condition. Areas receiving copious amount of rainfall after seeding (around 200 mm/month, particularly in the months of July/August) having heavy textured soils with good water holding capacity are suitable for this system.

Land Preparation:

The land is prepared by ploughing twice with cultivator, followed by rotavator to ensure proper levelling for better seedling establishment and water management. Land preparation is very important to make the previous sown seeds to germinate and then making them to not to grow with the present sown seeds. It is also important to make the field weed free through good land preparation for better growth of the seedlings.

Dry direct seeding by broadcasting

Dry direct seeding by tractor operated seed drill

Dry converted wet rice fields at initial crop establishment

Dry converted wet rice fields after crop establishment (Tillering stage)

Varieties:

All the recommended varieties suitable for the particular climatic conditions can be used for sowing. Semi-dry (dry direct seeded) rice requires specially bred cultivars having good mechanical strength in the coleoptiles to facilitate early emergence of the seedlings, early seedling vigour for weed competitiveness, efficient root system for anchorage and to tap soil moisture from lower layers in peak evaporative demands along with yield stability, ability to germinate under anaerobic conditions, tolerance to early submergence, early heading and short intermediate height, high specific leaf area during vegetative growth and low specific leaf area with high chlorophyll content during reproductive phase. In general, long duration varieties with 140-150 days duration are most suitable for June sowing under this system.

Sowing and Seed rate:

In general, dry converted wet rice sowings will be done during 2nd fortnight of June to 1st fortnight of July as dry direct seeding or with limited rainfall received during this period. Initially, the crop is allowed to grow under rainfed conditions until water is available for ponding. Sowing can be done either by broadcasting (25-30 Kg ha^{-1}) or line sowing with locally available bullock drawn planter (gorru) or tractor operated seed cum ferti-drill (20-25 Kg ha^{-1}) based on the seed size of the variety. Seed rate can be varied based on the availability of water.

Studies suggested that higher seed rates caused significant reductions in weed dry matter, whereas higher than optimum seed rate (15–30 Kg ha^{-1}) caused reduction in yield. Of all the seeding rates used, 15–30 Kg ha^{-1} had the lowest grain-yield losses caused by weeds. Sudhir-Yadav *et al.* (2007) evaluated seed rates of 30, 40, and 50 Kg ha^{-1} for basmati rice (wet-DSR) in Punjab, India, and found that a seed rate of 30 Kg ha^{-1} yielded the highest. Wu *et al.* (2008) in China found a seed rate of 20–25 Kg ha^{-1} as optimum for DSR, including under zero-till conditions (ZT-dry-DSR). However, others found no difference in yield with a range of seed rates (Gravois and Helms, 1992; Johnson *et al.*, 2003; Jones and Snyder, 1987; Xue *et al.*, 2008). They emphasized that more research is needed, however, to study the interaction of seed rate, variety, seed depth, spacing and geometry. In India, under alluvial loamy sand soil, 50 Kg seed ha^{-1} produced maximum grain yield, which was found at par with 100 Kg ha^{-1} and 150 Kg ha^{-1} (Gill *et al.*, 2006). Reduced seed rate in DSR has further widened the scope of direct-seeded rice in that DSR can be grown using seed rates of 15 to 30 Kg ha^{-1}. This proposition should save farmers' input costs, particularly when farmers use hybrid rice seed (to exploit vigour trait) in DSR, which is very costly. It is pertinent to mention that use of lower seed rate (15 to 30 Kg ha^{-1}) in DSR is possible only with the direct seeded rice drill that has seed metering device.

Conversion to Wet:

Usually, districts in the Telangana and Andhra Pradesh which receives copious amount of water from South-West monsoons in the month of July and August will help in the availability of water in the water bodies like tanks and reservoirs. After availability of sufficient water in the irrigation sources, the field is converted into flooded rice which can save 15-45 days based on the rainfall situation.

Fertilizer management:

Except nitrogen management, remaining recommendations given by the universities in their particular locations are common for both the systems *i.e.*, dry direct seeding and conventional transplanted rice. A recent study also showed that Nitrogen requirement is higher for the DSR than for the transplanted rice (Mahajan *et al.*, 2011a). Under dry converted system, nitrogen requirement is more so it is suggested to apply 25% more nitrogen than the conventional method of planting. Entire recommended Phosphorous fertilizers and 50% Potash fertilizer should be applied during the last ploughing at the time of sowing. Nitrogen fertilizers should be applied in 3 equal splits, first at 15-20 days after sowing, second at tillering stage and third at panicle initiation stage. Remaining 50% potash fertilizers should be applied along with the third split application of nitrogen fertilizers. In this method of planting, Zinc and iron deficiencies may appear and may be corrected by spraying $ZnSO_4$ @ 2g l^{-1} and $FeSO_4$ @ 5g l + Citric acid @ 1g l^{-1} twice at 5 days interval, respectively.

Weed management:

In this system of cultivation, weed menace will be more as the land is not flooded with water like transplanted method. Hence, efficient weed management is must under dry converted wet rice method of planting. For the effective weed management, application of pre-emergence herbicide i.e., Pendimethalin 30% EC @ 2.5-3 l ha^{-1} or Pendimethalin 38.7% CS @ 1.75 l ha^{-1} within 48 hours of sowing at optimum moisture condition should be sprayed. Next, post-emergence application of wedicdes at 2-4 leaf stage of weed growth *i.e.*, at 15-20 days after sowing, spray Bispyribac sodium 10% SC @ 250-300 ml or Cyhalofop-Butyl 5.1% + Penoxsulam 1.02% OD @ 2-2.5 l or Triafamone 20% + Ethoxysulfuron 10% WG @ 225 g ha^{-1}. If the crop is sown in rows by seed drill or gorru, then the cono weeder/power weeder can be used for weed management. Proper weed management is not only helpful for making the field free from weed menace but also helps in the proper growth of the crop by avoiding the competition for water, nutrients and also helpful for proper aeration of the crop. Weed specific herbicides used in direct seeded rice mentioned in the following Table. 1 for use by the farmers.

Pest and Disease Management:

Compared to conventional method of planting, incidence of BPH will be less in dry converted wet method of rice planting. However, the recommended plant protection measures are to be followed for different pests and diseases based on the incidence and severity. Sometimes the attack of arthropod insect pests is reduced in DSR compared with TPR (Oyediran and Heiririchs, 2001) but a higher frequency of ragged stunt virus, yellow orange leaf virus, sheath blight and dirty panicle have been observed in DSR (Pongprasert,1995). The increased attack of brown spot disease in DSR compared with conventional tranplanting was also reported in the study (Savary *et al.*, 2005).

Advantages:

Dry converted wet method of planting is very advantageous than the conventional transplanting method of planting due to the following reasons

- Effective utilization of the early monsoon showers for sowings without waiting for the water bodies to be filled with required water as in case of conventional method.
- The cost incurred towards for nursery raising and transplanting is totally removed which saves a good amount to the farmer when compared to conventional method.
- Dry converted method of planting is very useful and benefit for the farmers who cultivate the rice under the water bodies like canals and reservoirs as it helps in timely sowing without any delay as in case of convention method where transplanting's can only be done after filling the water in the water bodies.
- Compared to conventional method of planting, in case of the dry converted wet method planting the crop maturity will be 7-10 days earlier which inturn helps in saving of time, water requirement and also helps in making arrangements for the next crop timely sowing thereby avoiding the *Rabi* crop to get protected from the unseasonal rains which occurs in the months of April and May months.
- As there is increased scarcity for resources like water and labour, in dry converted method of planting the problems will be addressed by avoiding the nursery, transplanting and not flooding the field with water in the initial days. 10–50% savings in water have been claimed with Dry-DSR compared with Conventional transplanting (CT) from India when irrigation application criteria after crop establishment (CE) were either the appearance of hairline cracks or tensiometer-based (-20 kPa at 20-cm depth) (Bhushan *et al.*, 2007; Jat *et al.*, 2009; Sudhir-Yadav *et al.*, 2011a,b). Similar to saving in water, DSR can reduce total labour requirements from 11% to 66% depending on season, location and type of DSR compared with Conventional transplanting (CT) (Isvilanonda, 2002; Kumar *et al.*, 2009; Rashid *et al.*, 2009; Santhi *et al.*, 1998; Tisch and Paris 1994; Wong and Morooka, 1996). Labour requirements for crop establishment decrease by more than 75% with direct seeding compared with transplanting (Dawe, 2005; Isvilanonda, 2002; Pandey and Velasco, 2002).
- Direct seeding avoids nursery raising, seedling uprooting and transplanting and thus reduces the labour requirement. Dry-DSR also avoids puddling operations

and thus further saves labour use. Since land preparation is mostly mechanized, there is more savings in machine labour than in human labour in this operation. Short to medium term on-station studies reported 34–46% savings in machine labour requirement in Zero tillage dry-DSR compared with Conventional Transplanting (CT) (Bhushan *et al.*, 2007; Saharawat *et al.*, 2010). In addition to labour savings, the demand for labour is spread out over a longer period in DSR than in transplanted rice. Conventional transplanting requires much labour in the critical operation of transplanting, which often results in a shortage of labour. The spread-out labour requirement helps in making full use of family labour and having less dependence on hired labour.

- The emerging energy crisis and rising fuel charges which inturn effecting the rising cost of cultivation can be reduced in case of dry converted method of planting where the field is not puddled and no nursery is maintained unlike conventional method of planting.
- A major reason for farmers' interest in DSR is the rising cost of cultivation and decreasing profits with conventional practice (Conventional Transplanting-CT). Farmers likely prefer a technology that gives higher profit despite similar or slightly lower yield. The largest reductions in cost occurred in practices in which reduced or zero tillage was combined with Dry-DSR. These cost reductions were largely due to either reduced labour cost or tillage cost or both under DSR systems. In regions where wages are high (e.g., Haryana and Punjab states of India), the labour cost savings in rice establishment can reach US$50 ha^{-1} (Kumar *et al.*, 2009).
- As there are changes in the urbanization there is migration of agriculture labour which is increasing the preference to non-agriculture work and getting the labour for the agriculture work is a big challenge. This problem is clearly addressed by dry converted method of planting by avoiding the transplanting operation.
- In the event of destroying soil physical conditions thus limiting the scope for raising the non-upland rice crops, dry converted method of planting is the best system suitable with little destruction of soil by avoiding the puddling operation.
- Seed which is the important input, the quantity of seed requirement for the dry converted method of planting is less as compared to conventional method of planting thereby reducing the cost incurred towards purchase of seed.
- As global warming is increased there is a need to reduce the greenhouse gases and in such there is less methane emission in dry converted method of planting compared to the conventional method of planting. Corton *et al.* (2000) reported that reduction in CH_4 emissions was higher in Dry-DSR than in Wet-DSR. Under

continuous flooding, the reduction in CH_4 emissions ranged from 24% to 79% in Dry-DSR and from 8% to 22% in Wet-DSR, whereas, under intermittent irrigation, the reduction ranged from 43% to 75% in Dry-DSR compared with Conventional Transplanting (CT). However, when DSR was combined with mid-season drainage or intermittent irrigation, the reduction in CH_4 emissions increased further compared with flooded Conventional Transplanting (CT).

- On the whole, compared to conventional method of planting in case of dry converted method of planting there is an increase in profit of about Rs.20,000-25,000 ha^{-1}.

Direct seeding under wet conditions:

Direct seeding under wet conditions can be done by two methods *i.e.*, broadcasting and drum seeder under puddled conditions to reduce the transplanting woes of the farmer.

Land Preparation for wet direct seeding

Wet Direct seeding by Broadcasting

Wet Direct seeding by Drum Seeder

Direct seeding paddy field

Soils:

Except the problematic soils, all other soils which are suitable for conventional method of planting are suitable for direct seeding under wet conditions.

Land levelling:

In direct seeding land should be leveled properly for water management and for good crop establishment.

Varieties:

All the recommended varieties suitable for the particular climatic and soil conditions can be used for sowing. In direct seeded rice seeds are sown in the main field instead of transplanting rice seedlings from nursery.

Seed Rate:

In both the methods of rice cultivation either direct seeding or by drum seeder 20-30 Kg of seed per hectare is required. Seed should be soaked in water for 24 hours and kept for sprouting for 12-24 hours. For drum seeding, germinated seedlings having slightly emerged radicle is best suitable for sowing otherwise the overaged radicle will face a difficult in sowing which gets struck in the holes of the drum seeded. For broadcasting, an overgrown elongated radicle can be sown without any problem.

Seed sowing:

Under broadcasting method of sowing, germinated seeds can be broadcasted in the levelled field by keeping small thin film of water. Before broadcasting, alleyways of 20 cm can be formed for every 2 meters in the field to drain out the excess water and also for unform broadcasting of the seed. This can facilitate uniform crop stand in the field.

In case of drum seeder sowing, drum seeder device will be having 4 plastic drums and each drum has two rows of holes with a spacing of 20-25 cm depending upon the requirement. There are 18 holes per row of two ends at a distance. Fill the germinated seeds in this drum by filling only the 3/4 full of seeds to allow the seeds to fall out. A drum seeder filled with seeds will sow the seeds in 8 rows with 20-25 cm between each row. About 3-6 seeds will fall at 5-8 cm in each row. The holes should be closed with stoppers depending on the type of seed size. Close the hole by leaving a hole for fine varieties.

Weed management:

For effective weed management, spraying of pre-emergence herbicide Pyrazosulfuron ethyl @ 200-250 g ha^{-1} at 3^{rd} or 4th day after sowing and application of post emergence herbicides, Bispyribac sodium 10% SC @ 250-300 ml or Cyhalofop-Butyl 5.1% + Penoxsulam 1.02% OD @ 2-2.5 l or Triafamone 20% + Ethoxysulfuron 10% WG @ 225 g ha^{-1} at 15-20 days after sowing will help in maintaining the field free from weeds and good crop growth (Table. 1).

Fertilizer management:

As per the respective universities recommendations, for both the direct seeding under wet condition and conventional transplanting, nutrient management is same except basal dose of nitrogen fertilizer application which has to be applied at 15 days after sowing.

Water management:

At the time of sowing under puddled conditions, small thin film of water may be maintained and drain out the excess water to avoid the rotting of the seeds. 2-3 times a thin film of water to be given upto the seedling establishment and sufficient water can be maintained after seedling establishment for better growth of the crop. Proper drainage should be provided throughout the crop period to drain the excess water.

Harvesting:

Compared to conventional method of planting, direct seeding under wet conditions will come to maturity for harvesting 7-10 days earlier which helps in saving the time, water requirement and also timely sowing of *Rabi* crop.

On the whole, compared to conventional method of planting in case of direct seeding under wet method of planting there is an increase in profit of about Rs.12,500-15,000 ha^{-1}.

Harvesting by Multicrop Harvester

The reasons for getting the lower yields in direct seeding:

On the contrary, Direct seeding is a good and profitable technology for getting the good yields there are some causes which are reported by various researches for getting the lower yields which include (1) Uneven or Poor Crop establishment (Rickman *et al.*, 2001) (2) Inadequate weed control (Johnson and Mortimer, 2005; Kumar *et al.*, 2008a; Rao *et al.*, 2007; Singh *et al.*, 2005) (3) Higher spikelet sterility than in puddled transplanting (Bhushan *et al.*, 2007; Choudhury *et al.*, 2007) (4) Higher crop lodging, especially in wet seeding and broadcasting (Fukai, 2002; Ho and Romli, 2002; Rickman *et al.*, 2001; Yoshinaga, 2005) and (5) Insufficient knowledge of water and nutrient management (micronutrient deficiencies) (Choudhury *et al.*, 2007; Humphreys *et al.*, 2010; Sharma *et al.*, 2002; Singh *et al.*, 2002a; Singh *et al.*, 2008; Sudhir-Yadav *et al.*, 2011a,b). In studies in which these constraints have been addressed, equivalent or higher yields are often reported under DSR than in Conventional Transplanting. (Bhushan *et al.*, 2007; San-oh *et al.*, 2004; Tabbal *et al.*, 2002; Yoshinaga *et al.*, 2001).

Table. 1 Commonly used herbicides in Direct Seeding Rice (DSR)

Herbicide and Weed species controlled	Time of application	Quanti-ty /acre	Brands
Pre-Emergence herbicides (within 2 days of sowing)			
Pendimethalin 30% EC			
Dry DSR: For broadleaved weeds, annual grasses and sedges	Within 2 days of sowing	1.2 litres	Stomp
Pendimethalin 38.7% SC			
Dry DSR: For broadleaved weeds, annual grasses and sedges	Within 2 days of sowing	700 ml	Stomp xtra
Pyrazosulfuron Ethyl 10% WP			
Wet DSR**:** For broadleaved weeds and sedges	Pre-emergence (3-5 DOS)	80 g	Saathi
Pretilachlor 30.0% + Pyrazosulfuron Ethyl 0.75% WG			
Wet DSR**:** For broadleaved weeds, annual grasses and sedges	Pre-emergence (3-5 DOS)	800 g	Eros gold
Post-Emergence herbicides (At 2-4 leaf stage of the weeds)			
Bentazone 48% SL			
DSR: For broadleaved weeds, annual grasses and sedges	Post emergence at 2-4 leaf stage of the weeds	800 ml	Basagran

Herbicide and Weed species controlled	Time of application	Quantity /acre	Brands
Bispyribac Sodium 10% SC			
Wet DSR: For broadleaved weeds and sedges	Post emergence at 2-4 leaf stage of the weeds	80-100 ml	Nominee gold, Taarak, Adora, Banister, Novelty gold, Janun
Cyhalofop Butyl 10% EC			
Wet DSR: *Echinocloa*	Post emergence at 2-4 leaf stage of the weeds	300 ml	Clincher, Tata Cylo, Dentil, Rap up
Fenoxaprop-P-Ethyl 10% EC			
Wet DSR: Annual grasses and *Echinocloa*	Post emergence at 2-4 leaf stage of the weeds	250 ml	Whip Super, Vego super, Naaka, Fycol, Pyraxanil
Metamifop 10% EC			
Wet DSR: grasses	Post emergence at 2-4 leaf stage of the weeds	400 ml	Citrel
Penoxsulam 2.67% OD			
Wet DSR**:** For broadleaved weeds, annual grasses and sedges	Post emergence at 2-4 leaf stage of the weeds	400 ml	Assert
Metsulfuron Methyl 10% + Chlorimuron ethyl 10% WP			
DSR**:** For broadleaved weeds, and sedges	Post emergence at 2-4 leaf stage of the weeds	8 g	Almix, Rymix
Penoxsulam 1.02 % + Cyhalofop-butyl 5.1% OD			
Wet DSR**:** For broadleaved weeds, annual grasses and sedges	Post emergence at 2-4 leaf stage of the weeds	800-900 ml	Vivaya
Triafamone 20% + Ethoxysulfuron l0% WG			
Wet DSR**:** For broadleaved weeds, annual grasses and sedges	Post emergence at 2-4 leaf stage of the weeds	90 g	Council activ

Source: AICRP on Weed Management, PJTSAU.

Work done by KVK's of four states in promotion of Direct Seeding Rice

CHAPTER 3

*Area spread under direct seeding rice in different districts under ATARI, Zone-X, Hyderabad:

KVK's have played a great role in promoting the direct seeding rice in their respective jurisdictions and also encouraged the farmers in adoption of the technology and its spread in the district. The following is the details of the areas where direct seeding is being practiced in the *Kharif* and *Rabi* season in different districts, where the efforts of KVK's is the important notable contribution in the adoption as given in Table.2

In *Kharif,* KVK's promoted 2.53 Lakh hectares area under direct seeded rice which includes 1.52 lakh hectares of direct seeded under dry converted wet rice, 58 thousand hectares of direct seeding by broadcasting in wet condition, 42 thousand hectares of drum seeding in wet rice condition in different districts under ATARI, Zone-X, Hyderabad. Whereas in *Rabi*, 4.3 lakh hectares of area under direct seeded rice under which 3.0 lakh hectares of area under dry direct seeded rice, 81 thousand hectares direct seeding by broadcasting in wet condition, 54 thousand hectares of drum seeding in wet rice condition.

Table. 2 Details of area spread under Direct Seeding Rice (DSR) in different districts under ATARI, Zone-X, Hyderabad

S. No	Name of the State	District	Name of the KVK	Direct seeding area (Dry) (ha)		Direct seeding area - Broadcast (Wet) (ha)		Drum seeding area (Wet) (ha)		Total direct seeding area (ha)	
				Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
1	Andhra Pradesh	Tirupati	Tirupati District	0	1066	244	7785	434	527	678	9378
2	Andhra Pradesh	Chittoor	Chittoor District	0	0	27	17	142	136	169	153
3	Andhra Pradesh	NTR District	Krishna Garikapadu	0	0	100	100	900	1200	1000	1300
4	Andhra Pradesh	Prakasam	Prakasam Darsi	0	0	20	26	0	0	20	26
5	Andhra Pradesh	Srikakulam	Srikakulam (Amadalavalasa)	69010	2541	9650	100	350	250	79010	2891
6	Andhra Pradesh	Anakapalli	Visakhapatnam BCT	4702	0	48	0	72	0	4822	0
7	Andhra Pradesh	Vizianagaram	Vizianagaram RK Bai	0	0	10051	1273	46	0	10097	1273
8	Andhra Pradesh	West Godavari	West Godavari Undi	0	0	408	457	0	8	408	465
9	Andhra Pradesh	E.Godavari	E.Godavari (Pandirimamidi)	15	5	220	200	20	10	255	215
10	Andhra Pradesh	Krishna	Krishna (Ghantasala)	47961	2355	0	0	0	0	47961	2355
11	Telangana	Karimnagar	Karimnagar Jammikunta	180	0	2600	3280	509	825	3289	4105
12	Telangana	Khammam	Khammam, Wyra	9345	0	9945	10009	243	200	19533	10209
13	Telangana	Wanaparthy	Mahaboobnagar YFA	24	39	237	444	634	957	895	1440
14	Telangana	Sangareddy	Medak DDS	0	0	546	32	10	0	556	32
15	Telangana	Nizamabad	Nizamabad Rudrur	240	0	16	32	20	8	276	40
16	Telangana	Mahabubabad	Warangal Malyal	240	0	760	300	200	20	1200	320
17	Telangana	Peddapalli	Karimnagar (Ramgirikhilla)	60	9	600	1683	804	920	1464	2612
18	Telangana	Nagarkurnool	Mahaboobnagar (Palem)	0	0	0	0	22	119	22	119
19	Telangana	Nalgonda	Nalgonda (Kampasagar)	1260	828	6400	8530	6250	6800	13910	16158
20	Telangana	Warangal	Warangal (Mamnoor)	0	0	6007	12000	820	1050	6827	13050

S. No	Name of the State	District	Name of the KVK	Direct seeding area (Dry) (ha)		Direct seeding area - Broadcast (Wet) (ha)		Drum seeding area (Wet) (ha)		Total direct seeding area (ha)	
				Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
21	Telangana	Mancherial	Adilabad / Mancherial-2	15	0	3825	4180	1020	1260	4860	5440
22	Telangana	Bhadradri Kothagudem	Kothagudem	2240	2130	1460	1650	1840	1582	5540	5362
23	Telangana	Medak	Medak -2 Tuniki	0	0	50	20	250	100	300	120
24	Tamil Nadu	Ariyalur	Ariyalur	0	100	40	100	10	40	50	240
25	Tamil Nadu	Coimbatore	Coimbatore	0	0	131	0	142	0	273	0
26	Tamil Nadu	Dindigul	Dindigul	0	0	10	189	0	27	10	216
27	Tamil Nadu	Chengalpattu	Kancheepuram	0	0	1800	3343	1096	2035	2896	5378
28	Tamil Nadu	Kanyakumari	Kanyakumari	4500	0	50	100	50	150	4600	250
29	Tamil Nadu	Madurai	Madurai	0	100	2000	5550	2550	6520	4550	13070
30	Tamil Nadu	Nagapattinam	Nagapattinam	12967	42460	0	0	0	0	12967	42460
31	Tamil Nadu	Pudukottai	Pudukottai	0	33906	0	0	0	0	0	33906
32	Tamil Nadu	Ramanathapuram	Ramanathapuram	0	136286	0	0	0	0	0	136286
34	Tamil Nadu	Salem	Salem	0	0	0	859	154	0	154	859
35	Tamil Nadu	Shivagangai	Shivagangai	0	63027	0	254	0	214	0	63495
36	Tamil Nadu	Theni	Theni	0	0	420	250	80	50	500	300
37	Tamil Nadu	Tirunelveli	Tirunelveli	0	0	0	0	91	264	91	264
38	Tamil Nadu	Tiruvallur	Tiruvallur	0	5647	0	0	2630	0	2630	5647
39	Tamil Nadu	Thiruvannamalai	Tiruvannamalai	0	1488	0	15550	21180	27580	21180	44618
40	Tamil Nadu	Trichy	Trichy	0	0	0	40	0	0	0	40
41	Tamil Nadu	Tuticorin	Tuticorin	0	0	0	0	0	810	0	810
42	Tamil Nadu	Virudhunagar	Virudhunagar	0	7000	0	1200	0	550	0	8750
43	Puducherry	Karaikal	Karaikal	26	1157	532	1731	0	0	558	2888
			Total	152785	300144	58197	81284	42569	54212	253551	435640

*Major varieties which are being cultivated under direct seeding rice in different states under ATARI, Zone-X, Hyderabad:

Farmers of different districts are cultivating various varieties under direct seeding in which major varieties are released from the universities and some are private varieties. The details of the commonly cultivated varieties by the farmers under direct seeding in the different states is furnished below in the Table.3.z

Table. 3 Major varieties which are being cultivated under Direct Seeding Rice (DSR) in different states under ATARI, Zone-X, Hyderabad

S. No.	Name of the State	Varieties Cultivating under Direct Seeding
1	Andhra Pradesh	MTU-1061, MTU-1064, MTU-1262, MTU-1224, MTU-1318, MTU-1010, MTU-1121, MTU-1153, BPT-5204, NLR-34449, NDLR-7, ADT-37, ADT-39, ADT-43, KNM-1638, RNR-15048.
2	Telangana	BPT-5204, WGL-44, RNR-15048, KNM-1638, JGL-24423, MTU-1061, MTU-1262, MTU-1224, MTU-1318, MTU-1010, MTU-1153, KNM-118, WGL-962.
3	Tamilnadu	ADT-38, ADT-39, ADT-45, ADT-50, ADT-51, ADT-54, ADT-55, ASD-16, CO-50, CO-51, CO-52, IR -20, TKM-13, TKM-15, TPS-3, TPS-5, CR-1009, BPT-5204, MTU-1010, RNR-15048.
4	Puducherry	ADT-37, CO-51, TKM-9, BPT-5204, IWP, CR Sub-1, ADT-54, VGD -1.

*Sowing time and seed rate under Direct Seeding Rice (DSR) in different states under ATARI, Zone-X, Hyderabad:

Sowing time:

The sowing time of direct seeding (both dry and wet) varies from state to state and also from district to district within in the state based on the onset of the monsoon, receipt of the rainfall, water received under different irrigation sources and duration of the varieties. In general, farmers sow the seeds from June to August during *Kharif* and October to January during *Rabi* in the states of Andhra Pradesh, Telangana and Tamilnadu based on the recommendations of the concerned state Agricultural Universities. Whereas in the state of Puducherry, the sowing time of direct seeding during *Kharif* is from May to June and during *Rabi* it is from August to September. In general, under dry converted wet system of cultivation, farmers will sow dry seeding immediately after onset of the monsoon and they will convert into wet system after receipt of the water in the water bodies whereas under wet direct seeding farmers will take up the direct seeding only after receipt of sufficient water in the water bodies. The details of the sowing time by the farmers under direct seeding in the different states is furnished in the Table .4.

Table. 4 Details of sowing time under Direct Seeding in different states

S. No.	Name of the State	Sowing time under Direct Seeding	
		Kharif	***Rabi***
1	**Andhra Pradesh**	June to August	November to January
2	**Telangana**	June to August	November to January
3	**Tamilnadu**	June to August	October to December
4	**Puducherry**	May to June	August to September

Seed rate and Seed treatment:

In direct seeding, seed rate varies from direct seeded rice under dry condition and wet condition. Even in wet condition also. It varies from broadcasting and drum seeding and also type of variety used *i.e.*, fine grain type and coarse grain type. In general, farmers in four states following 30-40 Kg ha^{-1} under dry direct seeding based on variety used and in wet direct seeding 20-30 Kg ha^{-1} based on variety used. Many farmers are using carbendazim @ 3g Kg^{-1} seed for dry seed treatment and 1g Kg^{-1} seed for wet seed treatment.

Dry Seed Treatment

Wet Seed Treatment

Labour use :

Direct seeded rice is a labour-saving technology compared with conventional transplanting. Labour dependence is largely varied in direct seeded rice compared to transplanted rice technology because of lack of transplanting operation in direct seeding where the requirement of labours is more. Since the absence of transplanting operation in direct seeding, the required labours for transplanting in general will be shifted to other operations in direct seeding rice compared to conventional transplanting. This will facilitate for timely operations in direct seeding in the event of labour scarcity. In addition to labour savings, the demand for labour is spread out over a longer period in direct seeded rice than in transplanted rice. The spread-out labour requirement helps in making full use of family labour and having less dependence on hired labour in direct seeded rice. In all the three states, it was reported that labour dependence is more in conventional transplanting method compared to direct seeding.

Yield and Economics (*Kharif*)

In direct seeded rice (*Kharif*) under dry direct seeding the yield (Kg ha^{-1}), cost of cultivation (Rs.) and B:C ratio ranging from 3980.0 to 5991.3, 46200 to 55500 and 1.72:1 to 2.32:1, respectively (Table.5) whereas in wet direct seeding under drum seeding the yield, cost of cultivation and b:c ratio ranging from 5584.4 to 6428.8, 48933.6 to 54019.2 and 2.15:1 to 2.59:1, respectively and in case of wet direct seeding under broadcasting the yield (Kg ha^{-1}), cost of cultivation (Rs.) and B:C ratio ranging from 4120.0 to 6233.6, 40100.0 to 57300.0 and 1.83:1 to 2.49:1, respectively (Table. 6.a and Table.6.b).

Table. 5 Yield and economics of Dry direct seeding versus Transplanting during *Kharif*

Name of the State	Dry direct seeding			Transplanting		
	Yield (Kg ha^{-1})	Cost of Cultivation (Rs.)	B:C ratio	Yield (Kg ha^{-1})	Cost of Cultivation (Rs.)	B:C ratio
Andhra Pradesh	5283.3	55487.0	1.91:1	5470.0	66532.8	1.59:1
Telangana	5991.3	48295.8	2.32:1	6315.9	60017.0	2.04:1
Tamilnadu	4807.5	55500.0	1.86:1	5598.6	57939.2	2.00:1
Puducherry	3980.0	46200.0	1.72:1	4260.0	50250.0	1.69:1

Table. 6.a Yield and economics of Wet direct seeding (Drum seeding) versus Transplanting during *Kharif*

Name of the State	Wet direct seeding (Drum seeding)			Transplanting		
	Yield (Kg ha^{-1})	Cost of Cultivation (Rs.)	B:C ratio	Yield (Kg ha^{-1})	Cost of Cultivation (Rs.)	B:C ratio
Andhra Pradesh	5615.4	53176.1	2.23:1	5470	66532.8	1.59:1
Telangana	6428.8	48933.6	2.59:1	6315.9	60017.0	2.04:1
Tamilnadu	5584.4	54019.2	2.15:1	5598.6	57939.2	2.00:1

Table. 6.b Yield and economics of Wet direct seeding (Broadcasting) versus Transplanting during *Kharif*

Name of the State	Wet direct seeding (Broadcasting)			Transplanting		
	Yield (Kg ha^{-1})	Cost of Cultivation (Rs.)	B:C ratio	Yield (Kg ha^{-1})	Cost of Cultivation (Rs.)	B:C ratio
Andhra Pradesh	5209.5	57134.4	1.83:1	5470.0	66532.8	1.59:1
Telangana	6233.6	49454.8	2.49:1	6315.9	60017.0	2.04:1
Tamilnadu	5592.0	57300.0	2.14:1	5598.6	57939.2	2.00:1
Puducherry	4120.0	40100.0	2.15:1	4260.0	50250.0	1.69:1

In transplanted rice, Benefit and Cost ratio is less compared to direct seeded rice both under dry direct seeding and wet direct seeding (drum seeding and broadcasting) conditions which indicates that direct seeding is a cost reducing and profitable technology for rice cultivating farmers and a futuristic option for the rice cultivating farmers in the event of labour scarcity and resource conservation. Many practicing farmers of the direct seeded rice also opined that, direct seeded rice is a cost reducing, labour saving, resource conservating and profitable technology. Majority of the direct seeded rice farmers also expressed their views that under the *Kharif* situation, compared to wet direct seeding dry direct seeding is an easy and best technology to adopt for getting good yields.

Rabi:

In direct seeded rice (*Rabi*) under wet direct seeding (drum seeding) the yield (Kg ha^{-1}), cost of cultivation (Rs.) and B:C ratio ranging from 5411.6 to 5989.2, 48870.4 to 51792.8 and 2.16:1 to 2.64:1, respectively whereas in case of wet direct seeding (broadcasting) the yield (Kg ha^{-1}), cost of cultivation (Rs.) and B:C ratio ranging from 4260.0 to 5759.7, 39450.0 to 50500.0 and 2.05:1 to 2.47:1, respectively (Table.7.a and Table. 7.b).

Table.7.a Yield and economics of Wet direct seeding (Drum seeding) versus Transplanting during *Rabi*

Name of the State	Wet direct seeding (Drum seeding)			Transplanting		
	Yield (Kg ha^{-1})	Cost of Cultivation (Rs.)	B:C ratio	Yield (Kg ha^{-1})	Cost of Cultivation (Rs.)	B:C ratio
Andhra Pradesh	5989.2	51792.8	2.16:1	6310.7	64525	1.81:1
Telangana	5922.9	48870.4	2.64:1	5735.5	58419	2.06:1
Tamilnadu	5411.6	50378.3	2.28:1	5434.3	59185	1.99:1

Table.7.b Yield and economics of Wet direct seeding (Broadcasting) versus Transplanting during *Rabi*

Name of the State	Wet direct seeding (Broadcasting)			Transplanting		
	Yield (Kg ha^{-1})	Cost of Cultivation (Rs.)	B:C ratio	Yield (Kg ha^{-1})	Cost of Cultivation (Rs.)	B:C ratio
Andhra Pradesh	5642.0	49934.0	2.05:1	6310.7	64525.0	1.81:1
Telangana	5759.7	50269.8	2.47:1	5735.5	58419.0	2.06:1
Tamilnadu	5232.0	50500.0	2.09:1	5434.3	59185.0	1.99:1
Puducherry	4260.0	39450.0	2.42:1	4150.0	39450.0	2.36:1

Under the *Rabi* situation, direct seeded rice under wet conditions is a more suitable and profitable technology across the zone compared to transplanted rice as seen from the benefit and cost ratios. Majority of the direct seeded rice farmers also expressed their views that under the *Rabi* situation, wet direct seeding is an easy and best technology to adopt for getting good yields and more net returns apart from conserving the resources like seed, labour and water.

A. Success Stories on Dry Direct Seeding

1. Dry Converted Wet Rice in Khammam District, Telangana State-A Futuristic Option for Rice Cultivation

Situation analysis/Problem statement: In Khammam district, rice cultivation farmers are increasingly facing water shortage due to deficit monsoon, delayed and limited release of water from reservoirs. Transplanting of rice entails adequate land preparation for nursery and main field, consumes 20% of the total water requirement ha^{-1} (1240 mm) and requires 25 to 30 man days for its establishment manually depending on soil type.

Plan, Implement and Support: KVK, Wyra scientists have introduced dry converted wet rice cultivation as an alternative to the transplanted rice.

Land levelling: Land preparation is done by ploughing twice with cultivator followed by rotavator to ensure proper levelling for better water management and stand establishment.

Seed Rate: Sowing can be done either by broadcasting or line sowing with locally available bullock operated gorru or tractor operated seed cum ferti drill with a seed rate of 20-30 Kg ha^{-1} depending on the seed size.

Weed management: Spraying of pre-emergence herbicide Pendimethalin @ 2.5-3.0 lit ha^{-1} after sowing and Bispyribac sodium @ 250-300 ml ha^{-1} at 15-20 DAS.

Fertilizer management: In this technology, it is advised to apply 25% additional nitrogen than the recommended. Compared to transplanted method, dry converted wet rice saves around 25-30% of irrigation water and the crop matures early by 7-10 days.

Output: KVK, Wyra scientists' intervention along with Department of agriculture officials extended the support to the farmers for implementation of the technology by motivating the farmers.

- ✓ The cost of cultivation has been reduced by Rs. 21,612.5 ha^{-1} by adopting dry converted wet rice.
- ✓ Benefit: cost ratio was higher in the dry converted wet rice method 2.95 compared to 1.88 in transplanted rice.

Outcome: KVK, Wyra scientists in coordination with Department of Agriculture has disseminated the practice of direct seeding method in Khammam district and the area now occupied is more than 7000 ha.

Impact: The Additional income obtained from Dry Converted Wet Rice was Rs.25,842 ha^{-1}. The technology has spread in an area of 7000 ha and hence an additional income from 7000 ha was Rs. 18.00 Crores.

Dry Converted Wet rice from land preparation to harvesting

Blog on Dry Converted Wet Rice published in (https://blog.mygov.in/dry-converted-wet-rice-cultivation-an-affordable-alternative/) and Smriti Z Irani, Ministry of Women and Child development retweeted the tweet kept by MyGov India on the technology of Dry converted wet rice in Khammam, District

District Collector, Sri. R.V. Karnan, IAS visit to dry converted wet rice fields and addressing the farmers on the dry converted wet rice promotion

2.Line sowing of paddy with ferti cum seed drill in Paddy to enhance productivity and to reduce the cost of cultivation in Srikakulam district of Andhra Pradesh

Situation analysis/Problem statement: Majority of the farmers cultivate paddy in conventional method of transplanting and direct broadcasting in Srikakulam district. Conventional method of transplanting is labour intensive which requires 10 farm women and 8-10 men labour for nursery pulling for one acre. Transplanting window is 15 to 20 days only so that labour availability become the critical issue to complete the translating in time, and cost of labour also high during peak transplanting period there by escalating the cost of cultivation. Hence 50% of paddy farmers are adopting direct seeding of paddy by broadcasting method in Srikakulam district. However, yield levels of paddy are very low compared to conventional method of transplanting. In this context KVK, Amadalavalasa demonstrated and promoted "line sowing of paddy with ferti cum seed drill in Paddy" to enhance productivity and to reduce the cost of cultivation in the district.

Plan, Implement and Support: To promote the technology KVK, Srikakulam taken up different strategies and organized extension activities
Extension activities

- On Farm Trial (OFT) were organized during the year 2013-14 and 2014-15, the technology assessment, awareness programmes, weed management has been focused.

- Front line demonstrations (FLDs) were organized for 4 years *i.e.*, from 2015-16 to 2018-19.
- Series of training programmes, skill demonstrations organized in collabouration with department of Agriculture.
- Cluster frontline demonstrations organized in collabouration with ATMA and department of Agriculture during 2021-22 and 2023.

Demonstration of Seed drill in Srikakulam district of Andhra Pradesh by the scientists of KVK, Amadalavalasa

Critical inputs supplied: Pre and post emergence herbicides were supplied to the farmers.

Technical support: Technical support given to the farmers and Extension functionaries' of department of Agriculture through regular field visits.

Field days, exposure visits, farmer and scientist interfaces: Field days were organized with support of ATMA and department of Agriculture.

Output: Results of Frontline demonstrations in comparison with direct broad casting.12.2% yield increase was observed compared to broadcasting method and net returns increased was Rs.9220 per hectare.

Outcome and Impact: The technology has been spread in an area of 218 acres during the year 2019-20 to 670 acres during the year 2022-23.

3.Success Story on Direct sown paddy by KVK Interventions in Ariyalur district of Tamilnadu

Situation analysis/Problem statement: Ariyalur district has 290 ha of direct sown paddy from 26,182 ha of total paddy cultivation area. The most of the direct sown paddy growers doing cultivation in samba season under wet seeded direct sown condition. The problems are poor weed management, imbalanced use of fertilizer, poor adoption of drought mitigation causes get low yield (4600 Kg ha^{-1}) than normal planting practices.

Plan, Implement and Support: ICAR KVK, Ariyalur was conducted demonstration on direct sown dry seeded paddy at Amirtharayankottai village of T.Palur block for the year 2018 during *Rabi* season. In this demonstration, 10 farmers were selected in an area of 4ha. Our KVK expert made periodical field visits and gave advisories during crops cultivation. KVK had conducted the following intervention are:

1. Introduction of Anna 4 paddy variety
2. Demonstration of Seed treatment with Bio fertilizers
3. Soil test based fertilizer application
4. Method demonstration on Seed sowing by using tractor drawn dry seeded seed drill and drum seeder
5. Demonstration on drought mitigation techniques like 0.1% PPFM spray

Demonstration of Drum Sedding in Ariyalur district of Tamilnadu by the scientists of KVK, Ariyalur

Visit to direct seeding fields by Dr. Bhaskaran, Principal Scientist, ATARI, Hyderabad

Output: By series of interventions provided by ICAR – KVK, Ariyalur the productivity level in the demonstration field has increased sizably along the economic benefits. The productivity has increased from 4.6 q ha^{-1} before adoption to 5.4 q ha^{-1} after adoption of the technology. The income has increased from Rs.52,624 ha^{-1} before adoption to Rs.68,904 ha^{-1} after adoption of the technology.

Outcome: Based on the knowledge and skill enhancement, improved adoption of various technologies by the participating farmers and their income level increase, the farmers in the neighbouring villages and nearby blocks started adopting those technologies in paddy cultivation.

Impact: By adoption of different technologies disseminated by KVK and the technology spread to 560 acres.

4. Success Story of Dry Direct seeding Rice cultivation farmer in Bhadradri Kothagudem district of Telangana State

Situation analysis/Problem statement: Conventional transplanting of aged nursery in the district due to late onset of south west monsoon there by majority of the farming community has suffered with late transplanting of aged nurseries resulted in low yields. Hence there is scope for getting maximum returns with Dry direct seeding rice cultivation adopting by the farmers in Bhadradri Kothagudem through the frontline demonstrations through KVK.

Plan, Implement and Support: Sri. Garidepalli Krishna Rao, cultivated Dry Direct Seeding Rice in his own 6 acres land since 3 years. He got good yield and higher net returns with direct seeding rice cultivation by adopting good agricultural and best weed management practices. Timely weed control was improved and enhanced the maximum yield. The farmer was avoiding the labour scarcity as well as he influenced other neighbor farmers for implementation of Dry Direct Seeding Rice under rain fed conditions.

Output: With the encouragement of KVK Scientists Garidepalli Krishna Rao has benefited by creating awareness on the Dry Direct Seeding rice cultivation and avoided the delayed transplanting as well as labour shortage and improve the economic status of the farmers.

Outcome: He has got total yield of 138 Quintal of rice yield in 6 acres with gross returns of Rs, 2, 89,000 /- and B: C ratio of 2.41:1.

Impact: Sri. Garidepalli Krishna Rao has improved his income and economic value through Dry Direct Seeding rice cultivation by avoiding late transplanting with aged nursery in his own land and the farmer created awareness on best weed management practices as well as timely suitable field operations in direct seeding rice to the neighbouring farmers and motivated towards direct seeding.

Impact of Dry DSR technology: Dry direct seeding rice method of rice establishment was taken up in 1200 acres during 2022-23 in Bhadradri Kothagudem district. Due to delayed transplanting, the yields were very low and hence the farmers were shown interest on Dry Direct Seeding Rice (DDSR) in the district to go for timely sowings and reduced the labour scarcity as well as water saving up to 400-500 mm during crop period.

Showcasing the technology of Dry Direct seeding to the farmers by the scientists of KVK, Bhadradri Kothagudem

5. Dry sown paddy with ferti cum seed drill- A Farmer success Story of Anakapalli district of Andhra Pradesh

Background: Sri Kandregula Kannababu is an innovative farmer from Haripalem village, Atchutapuram mandal, Ankapalli district of Andhra Pradesh. He is very much interested in adopting new technologies & new varieties in different crops. He is cultivating paddy in 4 acres (2 acres own and 2 acres on hired basis). The Paddy cultivation became labour intensive especially at peak Season of transplanting led to high cost of cultivation and reduced net income.

Plan, Implement and Support: To overcome this problem, Kannababu practiced direct sowing of paddy but failed in getting uniform germination and unable to manage the weeds. At that time, he attended the training program at BCT-KVK, where the topics on land preparation, mechanization and weed management in paddy was covered. He immediately practiced the line sowing of paddy with seed cum fertilizer drill with technical support of KVK scientists.

Sowing of paddy seed through tractor operated seed drill

Dry direct seeding paddy field at tillering stage

Output: Under the guidance of BCT KVK, he used rotavator for land preparation and hired the ferti cum seed drill from KVK for line sowing and followed the suggestions of scientists in using of pre-emergence and post emergence herbicides. With this he is able to reduce the seed cost upto 40% and also observed the less incidence of pest and diseases. Finally, he got an enhanced yield of 10% compared to others.

Outcome: Before intervention of BCT-KVK, he was able to generate a net income of ₹ 0.16 lakhs from his two acres of paddy field. By following the land preparation with Rotovator, line sowing with seed cum fertilizer drill, spraying pre and post emergence herbicide, which in turn results in getting annual net income of 0.40 lakhs and land preparation for Paddy with Rotovator shown impact on germination and increase in yield.

Impact: By seeing the success of Mr Kannababu the fellow farmers showed interest to adopt the Line sowing with ferti cum Seed drill technology in 230 acres in Haripalem village of Atchutapuram mandal. They are able to overcome the labour problem in peak period of the season.

B. Success Stories on Wet Direct Seeding

1. Direct Seeding Rice in Khammam District, Telangana State- An Affordable Alternative for Rice Farmers

Situation analysis/Problem statement: In Khammam district most of the farmers are practicing transplanted method of rice cultivation under tanks and canals as source of irrigation. Due to monsoon vagaries, release of water under canal system is major problem. Rapid withdrawal of labour from the agricultural sector, diversion of land for other agricultural and non-agricultural purposes, increased competition for water and labour have contributed to the current situation and may worsen in the future. Therefore, the sustainability of rice eco-system and the ability to increase production in pace with population growth with reduced water and labour use are the major concerns.

Plan, Implement and Support: KVK, Wyra scientists have introduced direct seeding techniques like Broadcasting & Drum seeding under puddled conditions to reduce the transplanting woes of the farmer.

Land levelling: Land should be leveled properly for water management and for good crop establishment.

Seed Rate: In direct seeding or by drum seeder 20-30 Kg of seed ha^{-1} is required. Seed should be soaked in water for 24 hours and kept for sprouting for 12-24 hours .

Weed management: Spraying of pre-emergence herbicide Pyrazosulfuron ethyl @ 200 g ha^{-1} at 3rd or 4th DAS and post emergence herbicide (Bispyribac sodium @ 250 ml ha^{-1}) at 15-20 DAS.

Fertilizer management: Nutrient management is same as of transplanting method except basal dose of nitrogen fertilizer application, which has to be applied at 15 days after sowing. Compared to transplanted crop , direct seeded rice crop can be harvested early by around 7-10 days.

Output: KVK, Wyra scientists intervention along with Department of agriculture officials extended the support to the farmers for implementation of the technology by motivating the farmers

- By adopting the direct seeding, Cost of cultivation reduced by Rs. 16,972.5 ha^{-1}.
- Benefit: cost ratio was higher in the direct seeding method (2.72) compared to 1.88 in transplanted rice.

Outcome: KVK, Wyra scientists in coordination with Department of Agriculture has disseminated the practice of direct seeding method in Khammam district and the area now occupied is more than 12,500 ha.

Impact: The Additional income from Direct Seeded Rice was Rs.24,022.50 ha^{-1}. The technology is spread in an area of 12,500 ha and hence the Additional income from 12,500 ha was Rs. 30.00 Crore.

Wet Direct seeding by Broadcasting

Wet direct seeding by Drum Seeder

2. Technology of Wet Direct Seeded Rice (DSR) in Mahabubabad District of Telangana State

Problem: In Mahabubabad district, most of the farmers are following conventional method of cultivating rice *i.e.*, transplanted rice under tanks and wells as source of irrigation. Farmers often resort to delayed planting due to monsoon vagaries, labour shortage. Sowing and planting beyond the sowing/planting windows are resulting in problems like increased pest and disease incidence, reduced yields.

Plan, Implement and Support: In order to overcome this problem, KVK, Malyal has introduced wet direct seeding paddy cultivation (Drum seeding and broadcasting) in the districts, which lead to higher yield with reduce cost of cultivation, thereby increasing net returns and also help to conserve the natural resources. KVK, Malyal demonstrated the drum seeding and broadcasting method of Paddy cultivation through different extension approaches like method demonstration, on farm trial, FLD, field days, trainings, exposure field visits to farmers' fields.

Interventions: Major interventions highlighted about the concept include:
Seed rate: 20-30 Kg ha^{-1}. In either method of paddy cultivation- direct broadcasting or drum seeding, seed should be soaked in water for 24 hours and kept for sprouting for 12 hours. Land should be levelled properly for sowing.

Weed management: Generally, weed problem is more in direct seeded rice hence application of weedcides ensures weed free field. Advocated application of pyrazosulfuron ethyl (Pre emergence herbicide) at 3-4 days after sowing @ 200g ha^{-1} and Bispyribac sodium @ 250 ml ha^{-1} (Post emergence herbicide) at 20-25 days after sowing.

Nutrient management: Nutrient management for both the Drum seeding and conventional transplanting is same except that basal dose of nitrogen fertilizer application has to be applied at 15 days after sowing.

Water management: Soil moisture should be kept approximately at field capacity for first 20 days followed by irrigation at 7-10 days interval depending upon rainfall, up to around 80-85 days growth. Later on, again soil moisture should be kept at field capacity up to maturity. Irrigation should be stopped 7-10 days prior to harvest.

Output and outcome:

- Direct seeding Paddy cultivation has spread to 1200 ha in Kharif and 320 ha in *Rabi* in district approximate area in Mahabubabad district, majority of the area being in Bayyaram and Garla mandals.
- The technology was also introduced in KVK adopted villages.
- Through this, farmers are able to harvest the crop 7-10 days early and could save around Rs. 21,000/- to Rs. 27,000/- ha^{-1}.
- In the 2018-19, direct seeding paddy was 240 ha in the district, while by 2022-23, it has increased to 1520 ha in the district.

Demonstration of drum seeding Paddy in different locations in the Mahabubabad District

Field visit to direct seeding paddy fields along with district officials

Training programmes to farmers on direct seeding technology in Paddy

Field day conducted on direct seeding Paddy Bayyaram and Garla Broadcasting

3. Direct seeding of Rice with Drum seeder in Medak district of Telangana State

Domain of the study/ Rationale: Over the past few years, labour shortages have been crippling rice farming in Medak district of Telangana. Implementation of employment guarantee scheme, and reluctance of youth to engage in farm operations have created an imbalance in the supply and demand for labour. Though the contract system for undertaking transplanting, weeding, and harvesting evolved during this period. The careless attitude of contract labours aggressive pulling of seedlings from the nursery resulting in root damage and transplanting at more depth to complete the work in the shortest possible time impacted the productivity of rice, reduction in income and quality.

Apart from the inconsistency in work done and work force engaged, the labours have been asking for more wages. In response to these practical problems faced by the farmers of Medak district. KVK Medak conducted awareness programs among the SC farmers & introduced direct seeding method in rice using an eight-row drum seeder in 2022.

Activities Implemented by KVK: KVK, Medak conducted Awareness programs, trainings, farmer scientist interaction programs and exposure visit to create awareness to SC farmers on direct seeding of rice with drum seeder. After that, Front line demonstration was conducted on direct seeding of rice with drum seeder in *Kharif* season, 2022 in 1 acre the field of a farmer (Sri. Yosepu, kolcharam Village & Mandal, Medak district). The KVK, Tuiki, Medak supported to the farmer by supplying of Drum seeder, paddy power weeder and given technical support on ICM & IPM practices in paddy.

The trial was successful as the net returns were Rs. 14,500 acre^{-1} in traditional method and Rs. 22,500 acre^{-1} in drum seeder method.

The success of assessment trial on drum seeder technology in 2020 encouraged KVK to popular it through training farmers (Village, Mandal and District levels) and extension staff conducting demonstration in farmers field organizing field days and exposure visits, developing publications etc.

Output: Sri. Yosepu progressive farmer of Kulcharam Village & mandal of Medak district was earlier growing paddy crop by manual transplantation which used to require more labour, seed and time. He came to know about the implement (Drum seeder) for direct seeding of paddy and contacted KVK, Medak from where he got details of its application on the field. Now he is growing paddy successfully using 8 row manual operated drum seeder under the supervision of KVK Scientist's.

The paddy seed is soaked in water for 24 hours after that seed treatment is performed and the sprouted seeds are field in boxes of the seeder before soaking the seed paddling of the field is completed. The paddy seed is sown at a row distance of 20 cm. It saved the seed, labour cost of transplanting weeding cost and time requirement is less. The crop matured 10 days in advance and about 10 percent yield increased is observed The increase in yield was observed to be 24 to 27 q acre^{-1} and thus the total income from growing paddy using this technology has increased to the tune of Rs. 8000/- acre^{-1}.

Outcome and Impact: KVK has introduced this technology in Havelighanpur, Chilipched, Shivampet, Narsapur, Kowdipally, Kulcharam and other mandals of Medak district, a total of 150 farmers were adopted this technology of direct seeding of rice with drum seeder in the district in an area of 60 ha. This technology has reduced cost of cultivation by Rs.7000 to Rs.10,000 acre^{-1} in drum seeder method compared to conventional method of rice cultivation and hence direct seeding method using drum seeder is profitable for farmers even if the farmers are getting same normal / regular yields. There is a growing acceptance of drum seeder version due to factor like low seed rate low irrigation water requirement, skipping of nursery and transplanting operations and subsequently reduction in drudgery early crop maturity by 7-10 days and higher productivity in drum seeder method. This evident from rise in area under drum seeder method in medak district from 0.1 ha in 2020 to 60 ha in 2022.

Demonstration of direct seeding through drum seeder in Medak district of Telangana State by scientists of KVK, Medak

4. Direct seeding in rice using drum seeder in Chittoor district of Andhra Pradesh

Situation Analysis: Rice is one of the major crops in Chittoor district of Andhra Pradesh cultivated normally in an area of about 54,000 ha annually with an average productivity of 2700 Kg ha^{-1} . Majority of the area is under borewells followed by tanks and open wells. Since rice is grown in standing water (approximately 5000 litres of water required for producing 1 kg of grains), ground water depletion is usually high. Ground water table is deepening every year due to insufficient and ill distributed rainfall. In addition to the water shortage, non-availability of agricultural labour in time is increasing the cost of production. Even some farmers are giving up rice cultivation owing to its lower productivity and high labour costs. In conventional rice production, farmers are recommended to transplant seedlings at the age of 20 to 35 days but in practice, seedlings are often transplanted later. This not only increases the incidence of insect pests and diseases but also reduces the yield drastically.

Resilient Practice/Technology: In this scenario, a look at newer production methods that are relatively cost effective and use water more productively becomes imperative. Direct seeding of sprouted paddy seed using drum seeder under puddled condition is suitable alternate method which requires less or no labour but also contributes in water conservation as it requires less water compared to traditional method. It requires less cost of cultivation as it avoids raising of nursery, pulling and transport of seedlings and transplanting in the main field.

Plan, Implement and Support: KVK has conducted capacity building programmes at campus and in the villages and created awareness about direct seeding method in paddy and its advantages. Supplied eight row drum seeders for sowing, cono weeders for weeding to farmers in different mandals of erstwhile Chittoor district with the support of ATMA and NABARD. Organized demonstrations on direct seeding in 564 villages with 2389 farmers (*Rabi* 2010 to *Kharif* 2013) in an area of 1008 ha in erstwhile Chittoor district. Visited demonstrations plots and given suggestions to farmers on crop production and protection management practices in direct seeded paddy. Field days were conducted to create awareness to more number of farmers and extension functionaries. Wide scale publicity was given through press coverage about the technology. A video was developed on direct seeding in rice using drum seeder and supplied to farmers as well as extension functionaries.

Output: The results revealed that about 10.8% increase in yield, 53% higher net returns and 13.1% less cost of cultivation was recorded in direct seeding method than traditional transplanting method. Direct seeding method recorded (6478 Kg ha^{-1} where as it was 5846 Kg ha^{-1} in traditional transplanting method. Gross returns and net returns (Rs. 98,412/- and Rs. 48,809/- ha^{-1}) were more in the direct seeding method (Rs. 87,981/- and Rs. 31,871/- ha^{-1}) than the traditional method. Low cost of cultivation in direct seeding method is due to skipping of practices like nursery raising and manual transplanting. It is also observed that crop duration was reduced by 7-10 days when compared to traditional practice.

Outcome: Direct seeding technology was spread to entire *erstwhile* Chittoor district in more than 4500 ha as it over comes labour shortage, requires less water, more yield per unit area and low cost of cultivation. At present farmers are adopting this technology in 800 ha in both Tirupati and Chittoor districts.

Impact: Farmers from other districts contacted our KVK and implemented direct seeding method in rice in their fields. Other KVKs also disseminated the technology through different extension means in their own districts. Farmers and Officials from Department of Agriculture from Tamil Nadu and Odisha also visited our demonstration units to know about the technology and adopted the direct seeding practice using drum seeder in paddy.

5. Direct sowing in paddy in West Godavari district of Andhra Pradesh

Situation analysis/Problem statement: Rice crop is the major cereal crop of West Godavari district cultivated in area of 1.0 lakh ha in *Kharif* and 0.86 lakh ha in *Rabi* season. Shortage and high cost of labour and late release of canal water in some tail end areas, the sowings were going late and crop harvesting was coincide with the rains.

Plan, Implement and Support: To address this problem KVK, Undi conducted demonstrations in paddy on direct sowing with drum seeder and by broadcasting with MTU 1010 variety at Matsyapuri village. The trial was implemented in 50 locations and issued critical input seed at the rate of 15 Kg acre^{-1}. Conducted thirteen trainings *viz.*, pre-seasonal, seasonal and field day at harvesting stage. Around 100 farmers of Matsyapuri and surrounding villages visited the fields and satisfied with the technology.

Demonstration of direct seeding through drum seeder in West Godavari district of Andhra Pradesh by the scientists of KVK, Undi

Output: In direct sown paddy fields, the harvest was 7 days earlier than the normal transplanted paddy this facilitated the escape from the rains at the time of threshing, and farmers got 8,800 Kg ha^{-1} of yield against 8,090 Kg ha^{-1} in transplanted plot, the yield was 8.8 percent more than normal transplanted paddy and the cost of cultivation was reduced @ Rs. 14,500 ha^{-1}. Farmers stored seed for next *Kharif* season after taking necessary storage precautions.

Outcome: By seeing the performance of the direct sown paddy, farmers in the whole village are interested to adopt the direct sowing. Total number of farmers covered with technology was 50 farmers.

Impact: In direct sown paddy, harvest was 7 days earlier than the normal transplanted paddy with 8.8 percent increased yield than normal transplanted paddy and the cost of cultivation was reduced @ Rs. 14.500 ha^{-1}.

6. Drum seeded Rice (DSR) and Broad casting of Paddy in NTR district of Andhra Pradesh

Situation analysis/Problem statement: Tropical Climate conditions with extreme hot summer and cold winter prevail in NTR district. April to June is the hottest months with high temperature in May. The monsoon usually breaks in the middle of June and brings good rains up to middle of October. The normal rainfall of this district is 916.3 mm, Endowed with a rich variety of soils, the district occupies an important place in Agriculture which is the most important occupation and paddy is the main food crop produced. Rice crop coverage in 2022-23 is for an area of 49,628 ha in *Kharif* and 22,953 ha in *Rabi*. Generally, three types of soils *viz.*, Black soil which constitute 57.6% of the villages, Sandy Clay-loams with 22.3% and Red loamy with 19.4% of the villages are prevalent in this district, while small sandy soils constitute 0.7% fringes on the sea coast. In current situation labour problem is more in the area an cost of cultivation is increasing in district. So, farmers are shifting to drum seeder paddy and broadcasting and its growth is increasing year by year in district.

Plan, Implement and Support: To overcome with this situation, conducted demos on drum seeder paddy and broad casting paddy in 2022 and popularized drum seeded rice more, as it is easy to maintain spacing and other agronomic practices easily. The technology of drum seeded rice was popularized by conducting training programmes, awareness programmes and through demonstrations.

- Further, the drum seeders are supplied through KVK to do sowing operations on free of cost, and cono weeders are supplied on free of cost for doing weeding operations and also provided agromet advisories regularly through DAMU.

- As majority of farmers are facing weed problem in DSR paddy, FLD's are going to organize for providing best technology on weed management

Output: Out of 5 villages and 20 farmers, two farmers namely Ramakrishna Achari from Balusupadu of jaggayapeta division and Narashimha Rao of takkellapadu of Jagayyapeta division achieved good success in maintaining of weed management, nutrient management, timely application of agro chemicals for pest and disease and earned good yields. Before intervention, the farmers got net returns of Rs. 33,573/- ha^{-1} and Rs. 39,100/- ha^{-1}, respectively. After intervention, the farmers got net returns of Rs. 39,513/- ha^{-1} and Rs. 40,100/- ha^{-1}, respectively.

Outcome: By seeing the performance of the technology by local visits of farmers and mouth publicity of fellow farmers and conducting of field day at farmer fields made interest in adopting the technology by other farmers for coming seasons.

Impact: The technology saves 7-10 days of crop duration and also helps in reducing labour cost which occurs mainly during nursery maintenance and during transplanting. On an average Rs. 12,000 - 14,000/- is saved by adopting this technology.

7. Direct seeded paddy in tribal area of Alluri Seetharamaraju district of Andhra Pradesh

Situation analysis/Problem statement: In the agency area of Rampachodavaram division of Alluri Seetharamaraju district, Rice crop is being cultivated under rainfed condition during *Kharif.* Soils are red sandy loams with low fertility status in nitrogen, medium in phosphorous and potassium. The major problems include

- Continuous cultivation of short and medium duration old rice varieties like MTU-1010, MTU- 1001, BPT -5204, RGL (2624) and PL etc., results in low yields and pest and disease incidence.
- Late *Kharif,* Poor tillage, aged nursery and poor management practices in agency area.
- Nursery raising and transplanting.
- Lack of awareness on high yielding varieties.
- Poor management practices and low fertile soils.
- Farmers are not applying FYM and fertilizers.
- Lack of knowledge in crop cultivation practices and pest and disease management.

Plan, Implement and Support: In this area, farmers always used to cultivate short and medium duration old rice varieties like MTU-1010, MTU-1001, BPT-5204, RGL -2624 and PL etc., results in low yields and pest and disease incidence. In order to overcome this situation, promising new paddy variety MTU-1153 has been introduced through OFTs for its higher yield potential and moderate resistance against Blast.

Most of the farmers are practicing transplanting method instead of direct sowing. Farmers unaware about the benefits and method of cultivation of direct seeding paddy through drum seeder. Hence, Krishi Vigyan Kendra, Pandirimamidi beside introducing of high yielding and new paddy variety MTU-1153 also introduced direct seeded paddy in agency area of Rampachodavaram division for economic benefit of the farmer. As a part of the programme 10 awareness cum training programmes conducted on direct seeded paddy cultivation method. During the trial Krishi Vigyan Kendra, Pandirimamidi also distributed critical inputs like MTU-1153 seed material 25 Kg acre^{-1} and drum seeder for direct sowing of paddy.

Demonstration of direct seeding through drum seeder by promotion of the new paddy variety in Alluri Seetharamaraju district of Andhra Pradesh by the scientists of KVK, Pandirimamidi

Output: This variety recorded higher effective tillers (12.7), grains panicle^{-1} (198) and test weight (24.8 g) and also recorded highest grain yield 49 q ha^{-1} under line sowing practice which was 4.5 per cent higher yield than local check (MTU 1010). The improved technology of HYV Chandra gave higher gross return of Rs. 78400 ha^{-1} with benefit cost ratio of 2.72 under line sowing practice and additional net return of Rs.3200 ha^{-1} as compared to local check. But, highest additional returns of Rs.3200 ha^{-1} was obtained with benefit cost ratio of 2.89 under drum seeding practice as compared to farmer's practice.

Outcome: New paddy variety showed good vegetative growth and no pests and disease incidences under proper crop management and also gave higher yield than local old varieties under rainfed condition. By adopting direct seeding through drum seeder the farmers got more economic benefits than other paddy farmers.

The technology distributed to the neighbouring farmers and villages and the paddy farmers in the cluster villages slowly adopted the technology. Even though the farmers got lower yields through direct sowing, they got higher economic benefits (net income) by reduction in cost of cultivation.

Impact: The paddy growing tribal farmers in the adopted villages slowly adopted the direct seeded rice technology through drum seeder. Providing of drum seeder to the paddy growing farmers in the village cluster has great impact on the paddy cultivation and economy of the paddy farmers. Due to this technology, cost of cultivation for transplanting greatly reduced and simultaneously weeds, pest and diseases incidence also decreased. Inter cultivation operations also become more feasible in paddy cultivation by introduction of technology. Due to the multiple benefits, ease in adoption, high B:C ratio and net income the farmers showed more interest towards the technology and disseminated technology to the farmers community and villages successfully.

8. Direct Sowing by Drum seeder in Madurai district of Tamilnadu

Situation analysis/Problem statement: As soon as the water is released from the reservoir, the paddy cultivation is started simultaneously in all the areas which results in acute labour shortage for the various operations. Moreover, transplanting is tedious and time-consuming (up to 30 person days ha^{-1}) and planting labourers can suffer from back problems (health risk). It's very difficult to get enough labour at peak periods to plant on time and also to maintain optimum spacing and uniform plant density, especially with random transplanting and contract labour.

Demonstration of Direct seeding through drum seeder in Madurai district of Tamilnadu

Plan, Implement and Support: To solve this major problem, the various training programmes were conducted regarding direct sowing by drum seeder. The results obtained from the training programme were good enough to solve the problem of labour scarcity. The farmers have also got convinced of the direct sowing by drum seeder technology and were enthusiastic about opting for farm mechanization. So, during this year different blocks of Madurai district to extend this technology to wider area.

Output: The cost of cultivation per hectare for existing practices is Rs. 75,000/- (Rupeees Seventy Five Thousand only). But by the direct sowing by drum seeder intervention innovation, the cost of cultivation is only Rs. 55,500/- (Rupees Fifty Five Thousand and Five Hundred only). There is 27 per cent reduction in cost of cultivation by this innovation. The gross income of Rs. 85,500/- was got ha^{-1} in existing practice. But in Rs. 1,15,625/- as gross income have got by the farmer by adopting the innovative technologies. The cost benefit ratio was higher in the direct sowing by drum seeder technology (2.10) as compared to existing method (1.14).

Outcome: Maximum yield with the use of reduced inputs, Adoption of all crop production technologies, skills in direct sowing by drum seeder, optimum use of fertilizers, adoption of integrated pest management technologies. The horizontal spread of 150 ha was made by the farmer Th. Bazir Mohmed by direct sown rice using drum seeder.

Impact: On seeing the success of technology, a progressive farmer Sri. Bazir Mohmed from Mangulam, Madurai East block has practiced direct sowing method by drum seeder. By the technical guidance of KVK, most of the paddy farmers are very much interested in using drum seeder in paddy cultivation. In the forthcoming seasons it is planned to increase the area up to 200 ha.

9. Direct sown paddy cultivation using Drum Seeder in Thiruvanna malai district of Tamilnadu

Problem Statement: Paddy is an important food crop of Thiruvannamalai district and growing in an area of 1,70,608 ha in both the seasons. The farmers were following conventional methods of paddy cultivation. The conventional method leads to high investment cost, non-availability and higher costs on labour at the critical crop stages resulted higher cost of cultivation and yield reduction.

Plan, Implement & Support: Awareness created on machineries used in paddy cultivation by the KVK as well as the State Department of Agriculture. In Thiruvannamalai district, the paddy growers are intensively using machineries including drum seeder with the subsidies by state department of agriculture for the past ten years.

- The Paddy Drum Seeder plays a vital role in bringing the true mechanization in paddy cultivation. As there is no need for nursery preparation, the farmers can save the costs on nursery raising, transplanting and weeding. It also reduces the seed cost when compared to the traditional method as the seed required is less (12 Kg $acre^{-1}$).
- The KVK had conducted 8 Front Line Demonstrations, 37 training programmes, 4 farmer field schools and 11 awareness programmes on direct seeded rice technology using drum seeder since 2014. A total of 1126 farmers benefitted directly through the KVK activities and 71,970 farmers benefitted indirectly.

Demonstration of Direct seeding through drum seeder in Thiruvannamalai district of Tamilnadu

Demonstration of cono weeder for weed management in direct seeding fields through drum seeder

Output: The DST technology drastically reduced the man power during nursery preparation and transplanting practice. The labour required for direct seeding in one acre area is only 2 Kg where as it is 30 in normal transplanting method.

- The average seed cost (12.5 kg) involved in drum seeder per acre is about Rs.500.00 against 30 kg of seed worth of Rs. 1200.00 in the traditional method of cultivation.
- The crop duration reduced by 6-7 days when compared to the traditional method.
- The cost of cultivation was also reduced by 20% and the net income increased by 30%

Outcome: The direct sowing of paddy using drum seeder technology has spread over an area of 48,760 hectares in the district due to the efforts by KVK in collabouration with State Department of Agriculture. The KVK itself supplied 420 nos of paddy drum seeder to the farmers since 2014. The technology has given good relief to the paddy growers from labour shortage during the peak seasons.

10. Direct seeding (Broadcasting) method of rice cultivation- A Woman Success Story of Karimnagar district, Telangana State

Problem: In Karimnagar district, most of the farmers are practicing conventional method of rice cultivation *i.e.*, transplanted rice under tanks and canals as source of irrigation. Rapid with drawl of labour from the agriculture sector, diversion of land for other agricultural and non-agricultural purposes, increased competition of water and labour have contributed to the current situation and may worsen in the future. Therefore, the sustainability of rice eco-system and the ability to increase production in pace with increasing population growth with reduced water and labour use are the major concerns.

Plan, Implement & Support: To address this gap, Rupireddy Laxmi practiced Broadcasting method of rice cultivation to reduce the transplanting woes of the farmer.

Year of Initiation: In the Year 2013-14 Smt.Rupireddy Lakshmi (Age: 40years) w/o Thirupathi reddy have started paddy cultivation through broadcasting method (Direct Seeded Paddy) in their 11 acres (4.4 ha) land.

Interventions: In normal condition farmers are used to spray chemicals through hand pump in agricultural lands. But, here smt R.Lakshmi has adopted a new method that is spraying chemicals with Hoose pipe connected power sprayer and due to this she reduced labour cost and saved time.

Implementation: In general, most of the farmers follows conventional method paddy cultivation (raising nursery and transplantation). But here smt.R.Lakshmi adopted & implemented broadcasting method in her field *i.e.*, soaking of paddy seed for 24 hrs in water & soaked paddy grains were broadcasted in her puddled field. Due to this she is able to save the time and labour when compared with conventional method.

Support: Due to the unavailability of labour and high cost of cultivation, they were unable to cultivate paddy. During these situation Smt. R.Lakshmi approached Krishi Vigyan Kendra (KVK), Jammikunta Scientists & Dept.of Agriculture persons for alternate low cost technologies and finally adopted this Broadcasted method of rice cultivation.

Land preparation and direct seeding through broadcasting

Field day on promotion of direct seeding through broadcasting

Output: The total cost of cultivation is Rs 56,875/- ha^{-1} under normal method of rice transplantation against Rs 45,250/- ha^{-1} with the practice of Broadcasting method of rice cultivation. Benefit cost ratio under broadcasting method and under normal practice was 1:2.76 and 1:2.30. In comparison to the existing method, this technique saves labour and time to a great extent.

Outcome: Disseminated the practice of direct seeding method through field days and media (Print & electronic), conducted more visits to her field by other farmers, and nearly 200-250 farmers were inspired and adopted this method of cultivation in their agriculture lands. Under the direct seeded method of paddy cultivation, cost of cultivation was reduced and saved Rs.11,625/-.

Impact: Enhanced area under direct seeding in the district increased to 6200 acres. Nearly 200-250 farmers were inspired and adopted this method of cultivation in their agriculture lands. The percentage of adaptability of the technique is 15-20%. The total cost of cultivation is Rs 56,875/- ha^{-1} ha under normal method of rice transplantation against Rs 45,250/-ha^{-1} with the practice of Broadcasting method of rice cultivation.

11. Direct seeding techniques in paddy using drum seeder - Mechanised cultivation of paddy by Farmer of Nagarkurnool district of Telangana State

Situation analysis/Problem statement: Draft animals and human labours continue to be the major power source for agricultural production in small and marginal land holdings. With the increase in maintenance cost and also reduction in population of draft animals, human energy is predominantly used in agriculture for all operations starting from seedbed preparation to threshing and transportation. In order to improve the efficiency of human labours, simple, suitable and efficient machines or implements should be available to raise the agricultural production in the above-mentioned areas.

Paddy is the primary food crop in all areas of Nagarkurnool district with covering 85236 acres of area. The transplanting of rice seedlings which is a highly labour-intensive and expensive operation can be replaced by direct seeding that can reduce labour needs by more than 20 per cent in terms of working hours requirements. Paddy drum seeder is one of the implements which can reduced human drudgery and can successfully implements in the farmers field successfully. The seeder consists of a seed drum, main shaft, ground wheel, floats, and handle and joining smaller ends of frustum of cones makes the seed to drop from the seed drum. Eight numbers of seed metering holes of 1 cm diameter are provided along the circumference of the drum at the both ends for a row-to row spacing of 20 cm. Two floats are provided on either side to prevent restrict the sinkage and to facilitate easy pulling of the seeder

Plan, Implement and Support: Sri K.Venkateswar reddy, s/o Ram reddy, (48 years) having 9 acres rainfed red sandy loamy soils. He was regularly cultivating field crop like paddy with conventional method in rainy season with 3 acres land and Mango with 6 acres from past 25 years. He started paddy cultivation by adopting or using drum seerder technology from 20220-21 and he was very enthusiastic in farming. He undergone training programme on drum seeder technology in paddy by the KVK, Palem scientists' team and he visited demo field visited at KVK, Palem during 2020-21. He was interacted with KVK, Palem team SMS regarding innovative technologies in paddy cultivation. Farmer realized high net returns and was further motivated to adopt this technology on a large scale.

The farmer started paddy cultivation by adopting or using drum seerder technology from 2020-21 and he was very enthusiastic in farming. The farmer undergone training programme on drum seeder technology in paddy by the KVK, Palem scientists' team and visited demo field visited at KVK, Palem during 2020-21. Further, the farmer interacted with KVK, Palem team of SMSs regarding innovative technologies in paddy cultivation. Farmer realized high net returns and was further motivated to adopt this technology on a large scale.

Output & Outcome: The farmer has realized the net returns of Rs.76,440 ha^{-1} with B:C ratio of 2.44:1 in direct seeding as compared to 1.75:1 in conventional transplanting

Demonstration of direct seeding through drum seeder in Nagarkurnool district of Telangana

Direct seeding (Drum seeder) paddy field

Sceintists of KVK, Palem promoting the direct seeding

Impact: Seeding with drum seeder method differs from transplanting method in nursery raising, seed rate, transplanting, weeding and irrigation operations. The rest of the things like fertilization, plant protection, harvesting, threshing and bagging remain same in both cases. The cost of cultivation is reduced by Rs.15,364/- ha^{-1} in drum seeder method compared to traditional method of rice cultivation and hence direct seeding method using drum seeder is profitable for farmers even if the same normal/regular yields they are getting.

Farmers Feedback: The farmer opined that, the drum seeder technology in paddy gave maximum returns than traditional way farming. The land preparation cost, labour cost, weed problem and irrigation water were reduced with increased yield by adopting this technology.

12. Direct seeding (Drum seeding) method of rice cultivation- A Farmer success story of Bellampalli district of Telangana State

Problem: In Mancherial district, around 1.50 lakh acres of area cultivated under paddy and majority of the farmers cultivating through transplantation method. The availability of the labour at the time transplantation, cost of the labour nursery raising are the major problems faced by the farmers through transplantation method. Sometimes, transplantation were delayed due to timely availability of the labour with resulted in low yields in the paddy. The cost of the labour increased from season to season ultimately increases cost of cultivation of the paddy reduces the net returns of the farmers.

Plan, Implement & Support: To address this issue, the farmer named Sri. Duguta. Thirupathi, practices the direct seeding of rice under wet conditions through drum seeding method.

Year of Initiation: During the year 2019-20 Sri. Duguta. Thirupathi (Age: 50 years), S/o Sri. Lingaiah from Malagurijala (v), Bellampalli (m) started sowing the paddy through drum seeding method.

Demonstration of direct seeding through drum seeder in Bellampalli district of Telanagana by scientists of KVK, Bellampalli

Implementation: The farmer adopted and sown the paddy through drum seeding method by soaking of paddy seed for 24 hrs in water & soaked paddy grains were broadcasted in his puddled field.

Support: The farmer approached Krishi Vigyan Kendra, Bellampalli, Mancherial to know the alternate practice for transplantation of rice. KVK, Bellampalli provided technical support to the farmer regarding the drum seeding method of sowing, precautions to be followed for drum seeding, seed rate, wild management and etc,. The farmer sown the crop in the presence of KVK staff.

Output: The farmer got an average of 55 quintals per hectare of rice under drum seeding method of sowing and in case of 56 quintals transplanting method. The total cost was Rs. 57,500/- ha^{-1} whereas Rs. 49,500/- in case of drum seeding method. The average net returns is Rs. 58,250/- and Rs. 47,025/- ha^{-1} in case of drum seeding and transplanting methods respectively.

Outcome: The technology was disseminating through demonstrations, awareness programmes and print and electronic media. KVK, Bellampalli conducted field visits and also given technical support to the farmers from time to time in the farmer saved around Rs. 9,550/- ha^{-1} and also the crop was harvested one week earlier then transplanting method.

Impact: Slowly the farmers are adopting this direct seeding method of sowing of rice in the district. Nearly 100 -200 farmers were inspired and adopted direct seeding of rice cultivation method. Overall around 8,000-12,000 acres of area covered with direct seeding of rice in the district. The average cost of cultivation reduced around Rs. 6,000 – 8,000 /- ha^{-1}.

13. Reduction in cost of cultivation of Paddy by using Drum Seeder-A Farmer Success story of Thoothukudi district of Tamilnadu

Introduction: Mr.P. Chandramohan is a progressive farmer in Mankalakurichi village, Srivaikundam block of Thoothukudi district, cultivating paddy for the past twenty years. He was doing traditional method of raising paddy i.e. he used to prepare nursery for paddy and transplanted it manually with the help of labours. During peak crop season, scarcity of labour, delayed monsoon and scanty rainfall etc., increased the cost of cultivation which resulted low net return from paddy cultivation

KVK intervention: Looking into the problem of labour scarcity during peak season and high cost of transplanting KVK scientists suggested mechanized paddy cultivation *viz.*, accurate levelling of field and drum seeder usage (wet condition) for direct sowing of seeds. Drum seeder has been designed and fabricated for 8

Demonstration of direct seeding through drum seeder in Thoothukudi district of Tamilnadu

row sowing of pre germinated paddy seeds. This equipment has come as a boon to the small and marginal rice farmers because of its low cost, adaptability, easy to handle and easy to fabricate by the local artisans. The device helps to maintain plant to plant spacing and row to row spacing which in turn facilitates to do the intercultural operations like weeding using cono weeder. It helps to save 95% of labour requirement in transplanting and 25% of water. In case of delayed monsoon, water stress and labour scarce areas, this equipment is of great help to the rice farmers. There is no yield decrease is noticed by using drum seeder when compared with manual and mechanical transplanting methods. Since it costs only Rs. 5,000/- to Rs. 6,000/- the small and marginal farmers can afford to buy this equipment. Mr. P.Chandramohan adopted this technology and reduced the cost of cultivation which helped to gain more yield & income.

Output: As a result of using the above technology for three years continuously Mr. Chandramohan saved an average Rs.9000/-ha^{-1} as compared to manual transplanting. The yield also increased by 10 %. The B:C ratio 1.7 by drum seeder as compared to 1.5 by manual transplanting .

Outcome: The direct sown paddy through drum seeder has attracted all categories of farmers due to easy operation, less weight, line sowing with less seed rate (9-12 Kg ha^{-1}) more tillers, early maturity etc., apart from savings in transplanting cost. The line sowing of paddy has also helped the farmers to utilise conoweeder for weeding. The drum seeder available at KVK is also used by farmers of Thamarabarani river command area of Thoothukudi districts.

Impact: The direct sown paddy has spread over 800 ha in and around his neighbouring villages too after seeing the results of this technology.

Research gaps and constraints in direct seeded rice

CHAPTER 5

Though the direct seeding is a good technology for the rice cultivating farmers which helps in labour and energy saving, reduce water use, reduce cost of cultivation, improves the net returns and also resilience to climate change and greenhouse gas mitigation. In view of these many advantages, to keep the technology to move forward, spread in the larger area and to make widely adopted by the farming community, the research gaps to be identified and effective strategies to be developed.

- Development of new rice varieties for direct seeding along with proper management practices can help in adoption of DSR. The quest for short duration, short-statured, long-rooted, resistance-to-lodging, blast and early vigour varieties remains (Ikeda *et al.*, 2008). Cultivars with improved resistance to adverse soil conditions such as mineral toxicity and deficiency, short mesocotyls for herbicide tolerance, and resistance to rice blast need to be identified and developed. To reduce weed competition in direct seeded rice, early vegetative vigour in combination with early maturity is also important, particularly for high grain yields in intensified double cropping systems (Coffman and Nanda, 1982). Yun *et al.* (1997) studied growth and yield of cultivars of japonica-indica crosses under DSR upland fields. They concluded that indica cultivars had higher yields than japonica cultivars and must be included in breeding programs for Direct seeded rice.
- Weeds are the major constraint towards the success of DSR (Caton *et al.*, 2003; Rao *et al.*, 2007). In wet-seeded and dry-seeded rice, weed growth reduced grain yield by up to 53 and 74%, respectively (Ramzan, 2003) and up to 68–100% for direct seeded rice (cropping season in Bangladesh) (Mamun, 1990). More than 50 weed species cause yield losses in DSR (Gianessi *et al.*, 2002). More than 50 weed species infest direct-seeded rice, causing major losses to rice production worldwide (Rao *et al.*, 2007; Tomita *et al.*, 2003). Hence, integrated weed management strategies on sustainable basis to be developed. Likewise, production of transgenic herbicide-resistant rice is a pragmatic approach to popularize DSR culture. Although there are research efforts to develop herbicide-resistant rice transgens, so far there has been little success (Rao *et al.*, 2007).
- Proper management of microelements is also desirable since availability of microelements is reduced by direct seeding of rice. Micronutrient deficiencies are of concern in DSR – imbalances of such nutrients (e.g. Zn, Fe, Mn, S and N) result from improper and imbalanced N fertilizer application (Gao *et al.*, 2006; Saleque and Kirk, 1995). It seems imperative to assess the dynamics of macro- and micronutrients in direct seeded rice system and develop appropriate management strategies in order to harvest maximum crop returns

on a sustainable basis. Approaches to improve NUE are also being investigated to incorporate the nitrogenase enzyme into the rice plant chloroplast and to engineer plants to nodulate with N-fixation bacteria (Ladha and Reddy, 2000).

- Selection of proper soil type along with précised levelling can help to enhance water use efficiency and productivity. Further, the selection of crop varieties with characters like early crop vigour and short statured cultivars with short duration can further increase water use efficiency. Improvement of genetic resistance to biotic stress is another important and effective breeding approach to water-saving cultivation of rice.

- Strategies to reduce NO_2 emissions in dry direct seeded rice can be worked out in wetland rice systems (both water seeding and transplanting in flooded soils), large quantities of CH_4 are emitted which account for 8.7–28% of total anthropogenic emissions (Mosier *et al.*, 1998). Emission of GHG from rice fields is very sensitive to management practices, so rice is an important target in this regard (Wassmann *et al.*, 2004). Direct seeding has the potential to decrease CH_4 emissions (Ko and Kang, 2000). For example, in a field experiment in the Philippines, DSR reduced CH_4 emissions by 18% compared with Transplanted Rice (Corton *et al.*, 2000). Wassmann *et al.* (2004) proposed that CH_4 emissions may be suppressed by up to 50% if DSR fields are drained mid-season. The net effect of direct seeding on GHG emissions also depends on N_2O emissions, which increase under aerobic conditions. Wassmann *et al.* (2004) opined that measures to reduce CH_4 emissions often lead to increases in N_2O emissions, and this tradeoff between CH_4 and N_2O is a major hurdle in reducing global warming risks and hence strategies must be devised to reduce emissions of both CH_4 and N_2O simultaneously.

- Breeding and biotechnological approaches may be effective to develop lodging-resistant rice genotypes better adapted to direct-seeding cultures. The use of molecular markers and genomics platforms offer unique opportunities to develop early maturing and high-yielding rice varieties with resistance to lodging.

- Seed priming technology can help to get rid of the problem of poor establishment of crop and can be further improved. Seed priming tools have the potential to improve emergence and stand establishment under a wide range of field conditions. These techniques can also enhance rice performance in direct seeded rice.

- Development of multiple pest and disease resistant varieties which are having good yield and suitable for the direct seeded rice conditions (both dry and wet) to be developed.

Conclusions

CHAPTER 6

- Today, conventional puddled transplanting is the most common practice of rice production in Asia. Transplanting after repeated puddling is the conventional method of rice (*Oryza sativa*) growing which is not only intensive water user but also cumbersome and labourious. Different problems like lowering water table, scarcity of labour during peak periods, deteriorating soil health demands some alternative establishment method to sustain productivity of rice as well as natural resources.
- Direct seeded rice is technically and economically feasible, eco-friendly alternative technology to conventional puddled transplanted rice. Direct seeded rice (DSR), probably the oldest method of crop establishment, is gaining popularity because of its low-input demand. It offers certain advantages viz., it saves labour, requires less water, less drudgery, early crop maturity, low production cost, better soil physical conditions for following crops and less methane emission which provides better option to be the best fit in different cropping systems. Comparative yields of direct seeded rice can be obtained by adopting proper management practices and allows timely planting of subsequent crop due to early harvest of direct seeded rice crop by 7–14 days.
- The potential risks with direct seeded rice like sudden rain immediately after seeding which adversely affect crop establishment, reduced availability of soil nutrients such as N, Fe, and Zn especially in Dry-Direct seeded rice, increased dependence on herbicides, nitrous oxide emissions from soil in dry direct seeded rice, relatively loss of soil C loss due to frequent wetting and the major constraints associated with shift from conventional transplanting to direct seeded rice is high weed infestation. Effective weed management in Direct seeded rice depends on the timing and method of land preparation, effectiveness of herbicides relative to the dominant weed species and soil conditions at the time of application and the effect of weather on weeds. By overcoming these constraints, Direct seeded rice was proven to be a very promising, technically and economically feasible alternative to conventional transplanting. The technology has the potential to provide several benefits to farmers and the environment over conventional practices of puddling and transplanting.
- In the present scenario of global scarcity of water and increasing labour wages, when the future of rice production is at stake, Direct seeded rice is the most viable option for getting sustainable yields by adopting proper management practices without any over exploitation of the available natural resources.

Way Forward

- Direct seeding is the resource conservation technology based efficient and environmentally friendly alternative management methods to increase water productivity in rice cultivation. Water is undoubtedly one of the most precious natural resource; however water is becoming increasingly scarce globally. Rice production and food security largely depend on the irrigated low land rice system, but whose sustainability is threatened by fresh water scarcity, water pollution and competition for water use. Since ground water resources are under severe stress and direct seeded rice as it improves water productivity, farmers in the state need to be trained by other experienced farmers on direct seeded rice, scientists on how to adopt this system for groundwater sustainability and also exposure visits to the successful adopted areas.

- Need and importance of the direct seeding in the event of increasing labour costs, labour scarcity and increased cost of cultivation to be clearly explained to farmers by the scientific community on their question of why to adopt the direct seeded rice.

- Furthermore, the government should incentivize farmers who are adopting the direct seeded rice to influence the other fellow farmers for adoption or further subsidize agricultural inputs for wider adoption of direct seeded rice.

- KVK's need to focus on creating the awareness amongst farmers regarding new rice varieties for direct seeding along with proper management practices can help in successful adoption of DSR.

- District level training-cum workshop and village level awareness programme on direct seeded rice can be organized by the KVK's in coordination with Agriculture and allied departments.

- The apprehensions and the misconception regarding the practice of direct seeding among the farming community should be cleared by explaining the advantages and benefits of direct seeded rice through the demonstrations or videos or distribution of literature by the KVK's and Agriculture department.

- As many farmers fear about the weed menace problem while switching from conventional transplanting to direct seeded rice, integrated weed management strategies to be addressed to the farming community for wider adoption of direct seeded rice.

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